STRUCTURAL AND FUNCTIONAL MAGNETIC RESONANCE IMAGING AS A DIAGNOSTIC TOOL FOR EVALUATING NEUROPLASTIC CHANGES IN PATIENTS WITH BRAIN TUMORS

Dissertation
zur Erlangung des Doktorgrades
der Humanwissenschaften
(Dr. sc. hum.)

der
Fakultät für Medizin
der Universität Regensburg

vorgelegt von
Katharina Hense
aus
Geseke

im Jahr
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ABBREVIATIONS

AVM	Arteriovenous malformation
BET	Brain extraction tool
BOLD	Blood oxygenation level dependent
CBF	Cerebral blood flow
CBV	Cerebral blood volume
CNS	Central nervous system
CSF	Cerebrospinal fluid
CT	Computed tomography
D-TGP	Diffuse tumor growth pattern
DWI	Diffusion-weighted imaging
FA	Fractional anisotropy
FC	Functional connectivity
FDR	False Discovery Rate
FLAIR	Fluid-attenuated inversion recovery
fMRI	Functional magnetic resonance imaging
FsFast	FreeSurfer Functional Analysis Stream
FSL	FMRIB Software Library
FoV	Field of View
FWHM	Full width half maximum
GBM	Glioblastoma multiforme
GLM	General Linear Model
HCP	Human Connectome Project
HRF	Hemodynamic response function
IDH	Isocitrate dehydrogenase
LI	Lateralization index
M	Mean
MGMT	O6-methylguanine-DNA methyltransferase
MRI	Magnetic resonance imaging
PET	Positron emission tomography
PSC	Percent signal change
RF pulse	Radiofrequency pulse

ROI	Region of interest
rsfMRI	resting state fMRI
SD	Standard Deviation
SDC	Sørensen–Dice coefficient
SE	Spin echo
SNR	Signal-to-Noise-Ratio
SPM	Statistical Parametric Mapping
T1	T1-weighted image
T1C	Contrast-enhanced T1-weighted image
T	Tesla
TE	Echo Time
TERT	Telomerase reverse transcriptase
TR	Repetition Time
TTFields	Tumor Treating Fields
U-TGP	Uniform tumor growth pattern
VASARI	Visually AcceSAble Rembrandt Images
WHO	World Health Organization

ABSTRACT

Brain tumors represent a special challenge for modern medicine and science due to their localization in the central nervous system (CNS), their often diffuse and unregulated growth as well as their heterogeneity. Therefore, it is a constant endeavor to investigate and understand this disease. In this field, especially in the last decades, research has contributed significantly to the improvement of diagnostics and treatment of patients. In addition to the discovery of molecular markers, which affect the prognosis of a patient and are the starting point for targeted and tailored forms of therapy, the establishment of preoperative fMRI for visualizing eloquent brain areas in the vicinity of the tumor has also been shown to have a positive impact on the treatment of patients. In this context, the integrity of the blood oxygenation level dependent (BOLD) signal in patients with brain tumors has often been critically questioned in the literature. This can have severe consequences, especially in the clinical context, as damage to such eloquent cortex areas during surgical resection of the tumor can lead to a long-term neurological deficit. Therefore, it seems all the more important to investigate the influence of the tumor on the acquired MRI signal on the basis of patient data and thus gain a better understanding of this process. The three studies performed within the scope of this doctoral thesis are aimed to contribute to this overall goal.

The first study addressed the question how the presence of a brain tumor or space-occupying brain lesion in the occipital lobe affects fMRI eccentricity mapping of the central, middle, and peripheral visual fields. Based on a sample of 19 patients (12 patients with brain tumor and 7 patients with space-occupying brain lesion) and 19 age-matched control subjects, the feasibility of retinotopic mapping of central and peripheral visual fields in such patients was investigated for the first time. The results of the study suggest that patients with brain tumor as well as with space-occupying brain lesion still show a retinotopic organization of the visual cortex despite their disease, although the extend of cortical activations appears reduced compared to a healthy control group. In addition, local region of interest analyses showed that the patients with space-occupying brain lesions had higher values of percent signal change in the calcarine fissure than the tumor patients. These values were comparable to those of the control subjects. In contrast, these patients showed a noticeable reduced pattern in the cluster size of activated voxels compared to patients with a brain tumor. Overall, the results of this study indicate that a space-occupying brain lesion seems to have less effect on the level of the

BOLD signal and more on the volume of cortical activation, whereas the opposite was observed in patients with brain tumor.

The second study aimed to create and evaluate a preprocessing protocol that allows three-dimensional reconstruction of T1-weighted anatomical images of patients with glioblastoma in FreeSurfer, which has so far led to erroneous results as a result of poor detection and handling of pathological changes due to the tumor. The MRI data of 27 patients with glioblastoma as well as 33 control subjects were analyzed to evaluate the feasibility of a novel preprocessing protocol developed in this study. The results showed that the modification of the T1-weighted image, in which tumor-affected areas were replaced with healthy tissue from the contralateral hemisphere, enabled the three-dimensional reconstruction in FreeSurfer. Here, the time required for reconstruction and the abortion rate did not differ from those of a healthy control group. Comparisons of the analyses of functional MRI data with the results from the established SPM12 software showed that the results during volume-based analysis of both methods yielded comparable results. In addition, the effect of modification of the T1-weighted image on the results of functional MRI analyses was shown to be marginal. It can be concluded from the results that the modification of the T1-weighted image with the preprocessing protocol presented here is an appropriate approach to use FreeSurfer for data analysis of patients with a brain tumor, while providing new potentials to analyze patient data.

The third study focused on investigating structural and functional differences between glioblastoma patients with different morphological tumor growth patterns. Based on the pattern of the accumulation of contrast agent, a sample of 97 patients in total was subdivided into two groups, which have been shown to be prognostically relevant in previous studies. The results indicated structural differences within the tumor between the three different tumor compartments necrosis, contrast enhancement and edema (intra-tumor heterogeneity), but not between the two groups of patients with uniform and diffuse tumor growth pattern (inter-tumor heterogeneity). Examination of differences in the BOLD signal showed that the patients with a prognostically more favorable uniform tumor growth pattern had higher percent signal change values in most regions of interest in both language fMRI and motor fMRI, but these differences were statistically not significant. Analyzing the lateralization of cortical activation, the two groups of patients showed little difference in the language paradigms, whereas in the motor paradigms the prognostically less favorable group of patients with diffuse tumor growth pattern showed higher values of the lateralization indices. Although these differences were statistically not significant, they indicate a more pronounced shift of the normally bilateral activation in motor-relevant areas in this group toward a more unilateral activation pattern. This may

represent evidence for the stronger influence of the prognostically less favorable tumor growth pattern on cortical activation. Regarding the additionally investigated functional connectivity, only minor and mostly balanced and unsystematically distributed differences between the two patient groups with uniform and diffuse tumor growth pattern were found. Overall, it can be concluded from the results that minor differences between both patient groups seem to be present on a functional level, but do not appear significant on a statistical level.

Altogether, the results of the three studies of this thesis illustrate the importance of continuous research and development of new methods for the improvement of preoperative imaging in patients with brain tumors. In this context, the focus should also lie on the critical questioning of the validity of the collected data in order to maximize the benefit of these methods while minimizing the risk of postoperative deficits for the patients.

ZUSAMMENFASSUNG

Hirntumore stellen aufgrund ihrer Lokalisation im Zentralnervensystem (ZNS), ihres oft diffusen und unkontrollierten Wachstums sowie ihrer Heterogenität eine besondere Herausforderung für die moderne Medizin und Wissenschaft dar. Daher ist es ein ständiges Bestreben, diese Krankheit zu erforschen und zu verstehen. Auf diesem Gebiet hat die Forschung vor allem in den letzten Jahrzehnten erheblich zur Verbesserung der Diagnostik und Behandlung der Patienten beigetragen. Neben der Entdeckung molekularer Marker, die die Prognose eines Patienten beeinflussen und Ausgangspunkt für gezielte und personalisierte Therapieansätze sind, hat sich auch die Etablierung der präoperativen fMRT zur Visualisierung eloquenter Hirnareale in der Nähe des Tumors positiv auf die Behandlung der Patienten ausgewirkt. In diesem Zusammenhang wird jedoch die Integrität des BOLD-Signals (blood oxygenation level dependent) bei Patienten mit Hirntumoren in der Literatur häufig kritisch hinterfragt. Dieser Aspekt kann vor allem im klinischen Kontext schwerwiegende Folgen haben, da die Schädigung solcher eloquenter Kortexareale bei der chirurgischen Resektion des Tumors zu einem dauerhaften neurologischen Defizit führen kann. Umso wichtiger erscheint es, den Einfluss des Tumors auf das aufgenommene MRT-Signal anhand von Patientendaten zu untersuchen und so ein besseres Verständnis dieses Prozesses zu gewinnen. Die drei Studien, die im Rahmen dieser Doktorarbeit durchgeführt wurden, sollen einen Anteil zu diesem übergeordneten Ziel beitragen.

Die erste Studie beschäftigte sich mit der Frage, wie sich das Vorliegen eines Hirntumors oder einer raumfordernden Hirnläsion im Okzipitallappen auf die fMRT-Exzentrizitätskartierung des zentralen, mittleren und peripheren Gesichtsfeldes auswirkt. Anhand einer Stichprobe von 19 Patienten (12 Patienten mit Hirntumor und 7 Patienten mit raumfordernder Hirnläsion) und 19 altersangepassten Kontrollprobanden wurde zum ersten Mal die Durchführbarkeit der retinotopen Kartierung zentraler und peripherer Gesichtsfelder bei solchen Patienten untersucht. Die Ergebnisse der Studie deuten darauf hin, dass sowohl bei Patienten mit Hirntumor als auch mit raumfordernder Hirnläsion trotz ihrer Erkrankung die retinotope Organisation des visuellen Kortex erhalten ist, obwohl das Ausmaß der kortikalen Aktivierungen im Vergleich zu einer gesunden Kontrollgruppe reduziert waren. Darüber hinaus zeigten lokale Region-of-Interest-Analysen, dass die Patienten mit raumfordernden Hirnläsionen höhere Werte in der prozentualen Signalveränderung in der Fissura calcarina aufwiesen als die Tumorpatienten. Diese Werte waren mit denen der Kontrollprobanden

vergleichbar. Im Gegensatz dazu zeigten diese Patienten eine deutlich geringere Ausprägung in der Clustergröße der aktivierten Voxel im Vergleich zu den Patienten mit Hirntumor. Insgesamt deuten die Ergebnisse dieser Studie darauf hin, dass eine raumfordernde Hirnläsion geringere Auswirkungen auf die Höhe des BOLD-Signals, sondern vielmehr auf das Volumen der kortikalen Aktivierung zu haben scheint, während bei Patienten mit Hirntumor das Gegenteil beobachtet wurde.

Die zweite Studie verfolgte das Ziel, ein Vorverarbeitungsprotokoll zu erstellen und zu evaluieren, welches die dreidimensionale Rekonstruktion von T1-gewichteten anatomischen Bildern von Patienten mit Glioblastom in FreeSurfer ermöglicht, was bisher aufgrund einer mangelhaften Identifikation und Verarbeitung von pathologischen Veränderungen durch den Tumor zu fehlerbehafteten Ergebnissen geführt hat. Die MRT-Daten von 27 Patienten mit Glioblastom sowie 33 Kontrollprobanden wurden analysiert, um die Durchführbarkeit eines in dieser Studie entwickelten neuen Vorverarbeitungsprotokolls zu evaluieren. Die Ergebnisse zeigten, dass die Modifikation des T1-gewichteten Bildes, bei der vom Tumor betroffene Bereiche durch gesundes Gewebe der kontralateralen Hemisphäre ersetzt wurden, die dreidimensionale Rekonstruktion in FreeSurfer ermöglichte. Dabei unterschieden sich die für die Rekonstruktion benötigte Zeit sowie die Abbruchrate nicht von denen einer gesunden Kontrollgruppe. Vergleiche der Analysen von funktionellen MRT-Daten mit den Ergebnissen, die mit der etablierten SPM12 Software berechnet wurden, weisen darauf hin, dass die volumenbasierte Auswertung vergleichbare Ergebnisse für beide Methoden lieferte. Darüber hinaus zeigte sich, dass der Einfluss der Modifikation des T1-gewichteten Bildes auf die Ergebnisse der funktionellen MRT-Analysen marginal ist. Daraus lässt sich schließen, dass die Modifikation des T1-gewichteten Bildes mit dem hier vorgestellten Vorverarbeitungsprotokoll eine geeignete Herangehensweise ist, um FreeSurfer für die Auswertung von Daten von Patienten mit einem Hirntumor zu nutzen, und gleichzeitig neue Möglichkeiten zur Analyse von Patientendaten bietet.

In der dritten Studie lag der Fokus auf der Untersuchung struktureller und funktioneller Unterschiede zwischen von Patienten mit Glioblastom. Anhand des Musters der Kontrastmittelanreicherung wurde eine Stichprobe von insgesamt 97 Patienten in zwei Gruppen aufgeteilt, welche sich in vorherigen Studien als prognostisch relevant erwiesen haben. Dabei ergaben sich strukturelle Unterschiede innerhalb des Tumors zwischen den drei verschiedenen Tumorkompartimenten Nekrose, Kontrastmittelanreicherung und Ödem (Intra-Tumor-Heterogenität), nicht aber zwischen den beiden Patientengruppen mit uniformem und diffusem Tumorwachstumsmuster (Inter-Tumor-Heterogenität). Die Untersuchung der Unterschiede im

BOLD-Signal zeigte, dass die Patienten mit einem prognostisch günstigeren uniformen Tumorwachstumsmuster eine höhere prozentuale Signalveränderung in den meisten Regions of Interest sowohl im Sprach- als auch im Motorik-fMRT aufwiesen, diese Unterschiede jedoch statistisch nicht signifikant waren. Bei der Auswertung der Lateralisierung der kortikalen Aktivierung zeigten sich in den Sprach-Paradigmen kaum Unterschiede zwischen den beiden Patientengruppen, während sich in den Motorik-Paradigmen höhere Werte der Lateralisierungsindizes in der prognostisch ungünstigeren Gruppe der Patienten mit diffusem Tumorwachstumsmuster zeigten. Obwohl diese Unterschiede statistisch nicht signifikant waren, deuten sie auf eine stärkere Verschiebung der sonst bilateral ausgeprägten kortikalen Aktivierung in motorisch relevanten Arealen in dieser Gruppe zu einem eher unilateralen Aktivierungsmuster hin. Dies könnte ein Hinweis auf den stärkeren Einfluss des prognostisch ungünstigeren Tumorwachstumsmusters auf die kortikale Aktivierung sein. Hinsichtlich der zudem untersuchten funktionellen Konnektivität zeigten sich nur geringe und meist ausgeglichene und unsystematisch verteilte Unterschiede zwischen den beiden Patientengruppen mit uniformem und diffusem Tumorwachstumsmuster. Insgesamt kann aus den Ergebnissen gefolgert werden, dass auf funktioneller Ebene geringfügige Unterschiede zwischen den beiden Patientengruppen vorhanden zu sein scheinen, die jedoch auf statistischer Ebene nicht signifikant sind.

Insgesamt verdeutlichen die Ergebnisse der drei Studien dieser Doktorarbeit, wie wichtig eine kontinuierliche Forschung und Entwicklung neuer Methoden zur Verbesserung der präoperativen Bildgebung bei Patienten mit Hirntumoren ist. Dabei sollte der Fokus auch auf der kritischen Hinterfragung der Validität der erhobenen Daten liegen, um den Nutzen dieser Methoden zu maximieren und gleichzeitig das Risiko von postoperativen Defiziten für die Patienten zu minimieren.

1 INTRODUCTION

Brain tumors represent a special challenge for modern medicine and science due to their localization in the central nervous system (CNS), their often diffuse and unregulated growth as well as their heterogeneity. Therefore, it is a constant endeavor to investigate and understand this disease in order to use this knowledge to further improve the treatment of these patients.

This doctoral thesis aims to contribute to this research. It is divided into the following sections: First, a general introduction will be provided to explain the important basic topics of this dissertation. Since the analysis of magnetic resonance imaging (MRI) data is the main method of this thesis, the basic principles of this imaging technique will be explained. Subsequently, brain tumors as well as neuroplasticity and the importance of MRI in the preoperative treatment of these patients will be addressed.

Furthermore, the three studies included in this thesis will be described. For each study, the specific context and the current state of research is explained in an introduction. In the section on materials and methods, the study design and experimental procedure of the patient and control subject measurements will then be specified. Additionally, the methods that were used to analyze the MRI data and to evaluate the statistics will be delineated. The calculated results will be described and presented graphically in the next section. These will then be evaluated and discussed, taking into account the current state of research. In addition, possible limitations will be reviewed in this section.

Finally, the three studies described will be embedded in the overall topic of the thesis in a general discussion and an outlook on research projects based on these studies will be given.

1.1 Magnetic resonance imaging

Although magnetic resonance imaging has only been used for about 45 years in the field of medical examinations, it has already become established as an important imaging technique during this time. Compared to computed tomography (CT), it has a better resolution and works without radiation exposure (1).

Attention should be paid to contraindications, as the static magnetic field and radiofrequency fields can considerably impair the functioning of a pacemaker, defibrillator or neurostimulator. This also affects other implanted electronic devices such as a cochlear implant or drug pumps. After an MRI, it is imperative that these devices are checked and reprogrammed if necessary.

In addition, ferromagnetic implants such as stents, vascular clips, or other metal fragments may cause heating of the surrounding tissue or even changes in localization, resulting in injury (2). In everyday clinical practice, magnetic resonance tomographs with a field strength of 1.5 Tesla (T) and increasingly also 3T are predominantly used in the field of neuroimaging. The advantages of increasing the field strength are an improvement in signal-to-noise ratio (SNR) and in spatial resolution as well as a reduction in measurement duration (3).

1.1.1 Principles of magnetic resonance imaging

Magnetic resonance imaging is based on the principle that all atomic nuclei with an odd number of protons have a magnetic moment due to their nuclear spin. If there was an even number of protons, they would compensate each other. In the field of MRI in humans, the magnetic moment of hydrogen atom nuclei has proven to be useful, since living tissue consists of 60-80% water and hydrogen atoms are therefore present in sufficient amounts (4).

If an external magnetic field B_0 with a high constancy is applied, the spin axes and the magnetic moment of the nuclei align relative to this magnetic field and start to circle conically around its longitudinal axis, which is called precession. This precession happens at a certain frequency, called the Larmor frequency, which is dependent on both the strength of the applied magnetic field and the nucleus type. Thereby, the alignment can either be parallel or antiparallel to the magnetic field B_0. As the parallel alignment is slightly more frequent, this results in a longitudinal magnetization M_z (3,4).

When a short radiofrequency pulse (RF pulse), whose frequency corresponds exactly to the Larmor frequency of the spin, is applied perpendicularly, the spins and thus also their cumulative magnetization vector are tilted and in case of a 90° pulse deflected in the xy plane where they create the transverse magnetization M_{xy}. After this RF pulse ends, there are two relaxation processes. First, the excited protons return to their lower-energy parallel state, resulting in a decrease of the transverse magnetization M_{xy} and a corresponding increase of the longitudinal magnetization M_z along the main magnetic field axis which can be measured by the MRI scanner. It is characterized by the time constant T1, which describes the time until the longitudinal magnetization has recovered after the end of the RF pulse. The second process, the transverse magnetization, is based on the dephasing of the spins after the RF pulse due to interactions of the spins with each other. This process is also called spin-spin relaxation and the corresponding time constant is called T2. Overall, longitudinal and transverse magnetization lead to a decrease in the MR signal (2,4,5). To restore the signal decreased by longitudinal and

transverse magnetization, an echo is used. This can be generated, for example, using a 180° pulse which is switched after the 90° pulse after the time τ. After the time 2 τ which is called the echo time (TE) the echo is being measured. The phase order of the spins is thus reversed with the 180° pulse, so the fast and slow spins are again at the same level after the TE and thus precess in phase (rephasing). The repetition time (TR) describes the time between two excitations, in this case between two 90° pulses (2). By combining these processes, an image can finally be generated. To obtain multidimensional images, the origin of the measured signal must be precisely localized in the tissue under investigation along the three spatial dimensions. This is achieved via processes called slice selection, frequency-encoding and phase-encoding (4).

As the relaxation times are dependent on the material, this allows different tissue structures to be distinguished in MRI. In T1-weighted images, the cerebrospinal fluid (CSF) has a decreased signal intensity compared to brain tissue. These images are used in clinical practice primarily to detect anatomical changes, contusions, hemorrhages, or CSF circulation disorders. In contrast, T2-weighted images are characterized by an increased signal intensity of the CSF compared to the brain tissue. This can be used to visualize brain infarcts, inflammatory foci, or tumors. A variant of the T2-weighted images are fluid attenuated inversion recovery (FLAIR)-weighted images, which are also known as "dark fluid" depending on the type of MRI scanner. In contrast to the T2-weighted image, the CSF has a lowered signal intensity here. These images are used for visualization of demyelinating lesions such as multiple sclerosis (4,6).

1.1.2 Functional magnetic resonance imaging

Functional magnetic resonance imaging is a technique that uses MRI to identify neuronal areas and thus also relevant regions in the brain that are associated with the execution of a specific task or the resting state. The physiological principles that enable this technique as well as the experimental design and subsequent analysis of the collected data will be explained in the following chapter.

Physiological principles

When a stimulus elicits activation in a corresponding brain region, energy is expended in the process, leading to local changes in cerebral blood flow (CBF), cerebral blood volume (CBV), and blood oxygenation. This relationship between local activity of neurons and the resulting changes in cerebral blood flow is called neurovascular coupling (4,7). In this process, arteries dilate and increase local blood flow, allowing more oxygenated blood to enter. However, the

increase in CBF is far higher than the increase in oxygen consumption, resulting in an oversupply of oxygenated hemoglobin combined with a concomitant decrease in the concentration of deoxygenated hemoglobin. In this context, such a hemodynamic response can be detected as an indirect measure of electrical activity in the brain using fMRI, since different binding modes of the iron atom lead to different magnetic properties of oxygenated hemoglobin (diamagnetic) or deoxygenated hemoglobin (paramagnetic). Thus, the change in blood oxygenation following cortical activity leads to a decrease in susceptibility and thus to a change in MRI signal, as the decreased concentration of deoxygenated hemoglobin leads to lower local field gradients and thus to less signal loss due to the increase in T2* relaxation time. This results in an increased MRI signal in the active brain area. This process, in which a local hemodynamic response is used to visualize task-specific areas using fMRI, is referred to as the blood oxygen level dependent (BOLD) effect. The blood thus serves as an endogenous contrast agent (4,8,9).

Hemodynamic response

The characteristic BOLD response is overall slower than the underlying electrical stimulus and can be described by a characteristic curve called the hemodynamic response function (HRF). Here, three phases of the response to a stimulus are distinguished. Approximately 1-2s after stimulation, there is a very brief and regional decrease in signal intensity (initial dip), which then transitions to a broad positive signal. The BOLD response does not start until about 2s and takes 5s to reach its maximum. This is followed by a decrease in signal intensity until it returns to baseline after about 10 seconds, followed by a drop below it (post-stimulus undershoot). The initial state is restored after 20-30 seconds (2,4,10).

Study designs

Based on this predictable course of a response to stimulation, experimental investigations using fMRI can be planned and analyzed optimally. In experimental designs, a general distinction is made between two different types of designs. In the event-related design, the hemodynamic response to a single stimulus is measured, with a resting period between the single stimuli, which must be long enough for activation to return to baseline. In most cases, this increases the acquisition time considerably, but it allows conclusions to be drawn about the response to individual stimuli presented if the inter-stimulus interval is long enough. In contrast, a blocked design uses sufficiently long periods of stimulation to measure the brain's response over the entire period. Typically, this alternates between an experimental condition with presentation of a stimulus of interest and a baseline condition without stimulus. The advantage of this

acquisition method is that the hemodynamic responses of the rapidly successive stimuli overlap, resulting in a higher signal that can be detected more reliably. It must be noted that, as the MR signal is being collected during the entire experimental condition, it impossible to determine the response to a single stimulus (10–12).

Analysis of functional MRI data

For the statistical analysis of collected fMRI data, preprocessing is necessary first. Subsequently, a statistical model can be created using the General Linear Model (GLM) and the statistical data analysis can be performed. The individual steps for a statistical analysis of fMRI data will be explained in the following.

The first step mainly concerns analyses that use an event-related paradigm. Since in such paradigms different experimental conditions are measured at very different times by presenting only single stimulus instead of blockwise, this can lead to an increase of the interpolation error, which in turn affects the BOLD signal. Accordingly, this temporal offset should be corrected in the collected data. This is done during slice-timing, where a shift of the temporal signal of all slices to a reference slice is performed. Due to this temporal alignment, all images appear as if they were acquired at the same time (13).

Next, motion correction of the functional data is performed. During data acquisition, the subject spends a long time lying in the MRI scanner, meaning that movements during this period cannot be avoided. In addition, there are short-lasting physiological movements such as those caused by breathing or swallowing. Since even small translational and rotational movements can affect the MRI signal and thus bias activations, these must be corrected by a rigid-body transformation. In this process, all subsequent images are registered to the first image in the series. In addition, the individual movements in each of three translational and three rotational directions can be recorded numerically and stored for later use in statistical analysis, in order to explain unintentional variance (14).

After realignment, the structural and functional data are coregistered. For this, a T1-weighted high-resolution anatomical image and the functional T2*-weighted images are aligned resulting in a spatial correspondence between these images.

In the next step, segmentation of the structural data is performed. Here, the probability with which a voxel belongs to the gray matter, white matter, or cerebrospinal fluid (CSF) is calculated based on the measured signal. Accordingly, the brain is subsequently divided into these segments. In addition, a transformation matrix is calculated, which specifies which transformations are necessary to get the individual brain congruent with the template brain in

the standard space. Probably the best known template is the Montréal Neurological Institute (MNI) template, which is an average image from a large number of spatially normalized brains (4,14,15).

Based on the calculated transformation matrix, both the high-resolution anatomical image and all functional images are normalized. This means that they are brought in line with the reference brain (template) by stretching and compressing. This preprocessing step makes it possible to systematically compare the results of individual subjects both within study groups and between different groups in the later statistical evaluation, despite individual brain anatomy (13).

The last step of the preprocessing is the spatial smoothing of the functional data. This serves to improve the signal-to-noise ratio and thus enables a sharper differentiation of experimentally induced changes from interfering signals. For this purpose, the gray value of each voxel is first offset against those of the neighboring voxels. The three-dimensional Gaussian distribution (kernel filter mask) is used to ensure that the central voxel provides the largest contribution. The full width half maximum (FWHM) value indicates the extent of the smoothing process and the full width of the Gaussian filter mask at maximum height (4).

Following preprocessing, statistical analysis of the data can be performed. It is assumed that the voxels represent measured values during the course of the data acquisition. The aim of the statistical analysis using a General Linear Model (GLM) is to predict to which extent the assumed theoretical time course, which is based on assumptions about the paradigm, corresponds to the actual measured time course of the voxel time series. For this purpose, the data are analyzed using multiple regressors (12).

In theory, the observed value of a voxel Y_{ij} can be explained by the linear combination of weighted independent variables $\beta_j g_i$. In practice, it represents only an estimate of the measured value and can never completely represent the value Y. Reasons for this are measurement biases or a lack of independent variables g. This is accounted for in the analysis by assuming that the measured value Y is composed of the estimated value using the linear combination $\beta_j g_i$ and an error term ε. An estimation algorithm is used to determine the weights β of the independent variable g, causing the error term ε to be minimized (4,14).

These described elements can be represented as vectors and matrices with their dimensions corresponding to the number of volumes and timepoints. The design matrix G, the experimental conditions at the different time points are distinguished, while the parameter matrix β includes all voxels and the regressors of the model. The larger the estimated β parameter, the better the

correlation of the model time series with the actual measured time series, indicating a high stimulation-related BOLD signal within the respective voxel (4).

Using this general linear model, the neuronal response to a stimulus can now be estimated and the hemodynamic response calculated on the basis of the model. For this purpose, a box-car curve is generated based on the predictable course of the neuronal signal, the temporal sequence of which corresponds to the stimulation intervals (stimulation and baseline periods) of the measurement. It is also considered that the hemodynamic response to a stimulus occurs with a time delay, and this is taken into account by modeling the pattern curve using a function. Depending on the research question, contrasts can now be defined that can relate to one or more regressors. This allows the targeted investigation of specific parts of paradigms, while non-interesting parts can be excluded. In this context, certain regressors can also be given a higher or lower influence in the analysis compared to other considered regressors by weighting. The statistical analysis can be performed using a t-test for one or multiple samples. Here, a t-value is calculated for each voxel for the selected contrast. The higher this test statistic is, the more likely it is not a randomly generated but a stimulus-induced activation. These t-values are encoded in a statistical map, a new dataset containing only the test statistics for each voxel in a three-dimensional model, using gray values (4,14).

These described steps for statistical analysis can be applied both to individual subjects (1st level analysis) and to whole groups of subjects (second level analysis). The latter uses the effect sizes (β-weights) of the individual subjects and contrasts from the 1st level analysis to draw conclusions about cortical activation within or between whole subject groups (13).

1.1.3 Diffusion-weighted imaging

In addition to functional MRI, diffusion-weighted imaging has also become established in clinical practice and research. This imaging technique allows conclusions for example about the course or pathological changes of fiber tracts. In the following chapter, the physiological principles as well as the acquisition and evaluation of these data will be addressed.

Physiological principles

Diffusion represents random thermal motion of particles, which is also called Brown molecular motion. For diffusion imaging, as described earlier for magnetic resonance imaging, the hydrogen molecule has been established for in vivo measurements (3,16).

If the propagation of the molecules in all spatial directions is equally possible, then after a certain time the molecules are situated in a sphere with a radius that depends on their mobility.

This uniform spreading in all directions is called isotropic diffusion. However, if the molecules encounter an obstacle during their dispersion, as it is the case, for example, with the axonal cytoskeleton of the human brain, they can no longer propagate freely in all directions, since the movement is now hindered differently by these structures. Accordingly, propagation in all spatial directions is no longer possible equally, which is called anisotropic diffusion (4). In contrast to isotropic diffusion, the particles are not in a sphere after a certain time, but in an ellipsoid. Also, the strength of the diffusion is reduced here compared to isotropic diffusion. This is reflected in a lower diffusion coefficient, which is a measure of the strength of diffusion and indicates the distance covered by a particle in a given time by diffusion. In the case of isotropic diffusion, the diffusion coefficient is a scalar quantity and is determined by the size of the molecules, the temperature and the viscosity of the medium. The process of anisotropic diffusion in three-dimensional space can be described using 3 x 3 tensor matrix D for each voxel, which is also called diffusion tensor. Here, the tensor describes the molecular propagation process in three-dimensional space. Due to its symmetric property, it contains only six independent components (17,18).

After diagonalization of the tensor, three orthogonal eigenvectors v_1, v_2 and v_3 are obtained with the three corresponding eigenvalues λ_1, λ_2 and λ_3. The ellipsoid is defined for all spatial directions by the length of the principal axis sections (eigenvalues) and the direction of the principal axes (eigenvectors). Thus, from the diffusion tensor, the principal diffusion direction can be determined, which corresponds to the direction of the eigenvector with the largest eigenvalue of the tensor matrix D. The largest eigenvalue is indicative of the strength of diffusion in that direction in the voxel under consideration, while the other two eigenvalues describe the diffusion strength across the fiber (in the direction of their corresponding eigenvectors). Accordingly, the largest principal eigenvector is assumed to be the preferred direction of diffusion, as it is most indicative of the structural arrangement of the fiber trajectory. To visualize this preferred direction of diffusion, the Fractional anisotropy (FA) is used. This describes the statistical relationship of the primary axis to the two minor axes and is based only on the eigenvalues, so it is independent of the directions of diffusion measurement as well as the main diffusion direction (18,19).

A clear visualization of the main diffusion direction, i.e. the fiber trajectory, is only given if one of the three calculated eigenvalues is larger than the other two. This is referred to as linear diffusion. When the fiber trajectories cross within a voxel, the main direction of diffusion can no longer be uniquely determined which is called planar diffusion. In the case of isotropic

diffusion, also called spherical diffusion, the diffusion is the same in all directions. Here, the visualization of a main diffusion direction is not possible anymore.

MRI diffusion imaging

In diffusion tensor imaging, the motion of molecules is represented in principle. If a particle's point of origin and its final location do not correspond after a certain time, this difference can be measured. Due to the change in position between excitation and relaxation, the measured signal is attenuated. The amount of signal loss is related to the diffusion coefficient, which in turn depends on the diffusion weighting factor b (b-value), which indicates the degree of diffusion weighting. The b-value is expressed in units of s/mm^2 and can be determined from the duration, strength, and time interval of the diffusion gradients. Since it has the value 0 when the reference image is measured, this is also called the b0 image. The b0 image represents the reference from which the signal decrease is measured. Usually, in addition to the reference image, images with a b-value of 1000 s/mm^2 are measured, which are called b1000 images. Furthermore, images with b-values of more than 1000 can be measured depending on the MRI scanner. Here, the stronger the weighting, the better the diffusion dependence in the tissue is captured. This also affects the measured signal. If the diffusion weighting is too strong, the signal is being attenuated and the noise is being increased which reduces the measurement accuracy. For a complete determination of the three-dimensional molecular motion, six non-collinear directions are needed. If additional directions are added to these six, this results in an over-definition of the tensor, making the calculation of the diffusion parameters more reliable. However, this results in an increase in acquisition time with each added direction. To reduce the acquisition time, diffusion measurements use EPI sequences as in fMRI, measuring the brain in a so-called single shot procedure (17,20).

Analysis of diffusion-weighted MRI data

The acquired data can then be preprocessed, analyzed, and visualized for clinical purposes or for research. For this purpose, a distortion correction should be performed. In this process, different parameters have an influence on the data, which are calculated and considered. One of these factors are artifacts caused by movements of the subjects. The influence of these movements can be reduced by aligning the collected images (see chapter 1.1.2). In addition, artifacts can arise due to eddy currents, which are generated through the switching of gradients. These themselves generate additional inhomogeneous magnetic fields, which affect the quality of the acquired images. Therefore, these eddy currents should be identified and corrected.

Another factor that can affect the quality of the collected diffusion-weighted data is susceptibility artifacts. These can be caused by magnetic properties of objects in the acquisition field and, in addition to distortions, also lead to partial loss of the signal in this area. This is not considered a safety risk but can significantly distort the validity of the acquired images, requiring correction. These influencing factors can be estimated and taken into account during the preprocessing of the data.

After these preprocessing steps, generally two different analyses are distinguished depending on the focus and the research question. When investigating the microstructure of the brain, the data can be visualized as two-dimensional slice images. Here, the gray value of a voxel of the image corresponds to the FA value. This is referred to as a fractional anisotropy map (FA-map). The FA-map provides information about the different lengths of the eigenvectors. In addition, a color value can be assigned to each FA value (color-map or fiber orientation-map). Here the angle of the longest axis of the ellipsoid is represented by the three primary colors red, blue and green, which represent the dominant fiber direction. By mixing the three colors, any fiber direction can be visualized (4,20).

The second type of analysis is tractography, which allows a three-dimensional impression of the fiber trajectory. This can also be tracked over a longer distance and thus over several slices in three-dimensional space. However, the data itself is no longer visualized, but only the structures obtained from the diffusion values of the individual voxels. For this purpose, the tensor field is reduced to a vector field and the resulting main vectors, which indicate the main diffusion direction, are retained for display. Starting from a starting voxel, following the direction of the main eigenvector from one voxel to the next, the orientation of the fiber path is determined. In order to display the fiber trajectories correctly, the calculation must be aborted if it deviates too much from a possible fiber trajectory orientation. This is the case if the FA value is too low, or paths are curved too much (4,17).

1.2 Brain tumors

1.2.1 Definition

A tumor is a cell proliferation in which abnormal cells grow in an unregulated manner. These can be divided into benign tumors (approximately one-third of primary brain tumors) and malignant tumors, which account for about two-thirds of primary brain tumors (21). Based on the tissue of origin, a distinction is therefore made between primary tumors, which originate in brain tissue, the meninges, or cranial nerves, and secondary tumors, which have developed by

metastasis of a primary tumor via blood and lymph pathways or cerebrospinal fluid to the brain (1).

Primary brain tumors can further be subdivided based on the cell type involved. Meningiomas are tumors arising from the cells of the meninges. They represent the most common tumor type within the brain, accounting for more than one-third of all primary brain tumors (21). In 1863, the origin of a tumor arising from glial cells was first identified by Dr. Rudolph Virchow using microscopic and macroscopic methods and was appropriately named a glioma (22). These account for approximately 30% of all tumors of the brain and CNS. CNS lymphomas form from the lymphocytes of the immune system, a Medulloblastoma develops primarily in childhood from embryonic cells of the brain, and Ependymomas develop from cells that form the covering tissue of the nervous system. In addition, mixed forms can also originate from different cell types (23).

Since this work is limited to the study of patients with glioma, only these will be described in the following chapters.

1.2.2 Epidemiology

Among primary gliomas, glioblastoma multiforme accounts for more than half of the cases and is the most malignant brain tumor type. Astrocytic tumors, which include glioblastomas, in total represent more than three-quarters of the cases (21,24). Nearly a quarter of cases are localized in the frontal lobe, with the temporal lobe accounting for another 20%. While the parietal lobe is the third most common localization, accounting for just under 10% of cases, the occipital lobe as well as the cerebellum each account for less than 3% of cases. The remaining third of cases are attributed to the cranial nerves, ventricles, spinal cord, and brainstem or cannot be reliably sorted (21).

The incidence rate of gliomas in the United States in 2014-2018 was 5.95 cases per 100,000 persons. This was less frequently in women with 4.98/100 000 compared to men with 7.05/100 000. The median age of onset for the disease is 62 years. However, this differed according to the diagnosis, with patients with oligodendroglioma generally developing the tumor earlier (median age 43 years) than, for example, glioblastoma patients (median age 65 years) (21,25).

1.2.3 Clinical appearance

The symptoms accompanying a brain tumor can be very diverse and can be roughly divided into the categories of intracranial pressure symptoms, epileptic seizures, neurological deficits

and psychiatric changes. In high-grade tumors, the time between initial manifestation and diagnosis is approximately 3 months while this period can be much longer in low-grade gliomas.

Since there is only limited space in the head due to the surrounding skull, the intracranial pressure may increase, regardless of whether the tumor is benign or malignant. Typical symptoms of this are headache, dizziness, nausea and vomiting. A brain tumor should also be considered as a cause in first-time epileptic seizures in adulthood (23,26). Neurological symptoms are always dependent on the location and extent of the tumor. These include visual impairment, gait abnormalities and paralysis of the extremities, deficits in language comprehension and production, or memory impairment. In addition to neurological deficits, psychiatric changes may also occur. These are manifested, for example, in personality changes, mental health changes such as depression or apathy, or disorientation (27).

Neither of these symptoms are specific to brain tumors only but can occur in a variety of diseases. For this reason, they do not prove the presence of a brain tumor, requiring further diagnostic steps to confirm a reliable diagnosis.

1.2.4 Diagnosis

When cerebral space-occupying lesions in general are suspected, imaging is essential for initial diagnosis. Often, especially in acute cases, cranial computed tomography (CCT) is performed first to visualize potential space-occupying lesions such as a tumor or also an ischemic or hemorrhagic stroke (27).

Using magnetic resonance imaging (MRI), these irregularities can be visualized with a higher resolution and thus in greater detail. Different sequences provide important information about the individual tissues examined, since brain tumors can be distinguished from healthy brain tissue based on differences in density. In addition, mass displacement due to the space-occupying nature of the tumor can be visualized. Pathological changes in the blood vessels as well as the blood-brain barrier can also be visualized by the administration of contrast agents. Furthermore, the pressure of the tumor on the surrounding brain tissue often results in water retention in the form of edema, which is visible in a T2-weighted sequence (28).

In addition, positron emission tomography (PET) can be performed for more detailed diagnostic clarification of a differential diagnosis. A variety metabolic processes in the body can be visualized using slightly radioactive tracers based on glucose or amino acids administered prior to the examination. Since tumor cells have a significantly increased metabolism compared to healthy cells and thus accumulate larger amounts of the tracer substances, this allows especially

for malignant tumors to be distinguished from the surrounding non-neoplastic tissue. In addition, it can be used to plan the ideal site for taking a biopsy in the hotspot area to obtain the most representative tissue sample possible for histological confirmation of the diagnosis. Furthermore, a PET can also be used to plan resection or radiation therapy (26,29).

Neuropsychological testing can also be useful in patients with brain tumor. The objective is to test and assess cognitive functional areas such as attention, memory, language comprehension and production, information processing, number processing or executive functions. Using standardized test procedures with age- and education-corrected norm data for comparison, resources and deficits of the individual patient can thus be quantified, providing good insight into preserved and impaired cognitive functions. In addition, such a standardized examination represents a good starting point for subsequent follow-up (1,29).

1.2.5 Classification

The classification of brain tumors according to the World Health Organization (WHO) distinguishes four malignancy grades from 1-4, which are relevant for both therapy and prognosis. In addition to immunohistochemical characteristics, molecular genetic factors were also considered for the first time in the 2016 version of the classification of brain tumors (30). In the currently valid version of the WHO classification (31), further molecular genetic parameters are included in addition to morphological and immunohistochemical characteristics for the diagnostic classification of brain tumors. The most important molecular markers for the diagnosis of diffuse gliomas include mutations in the isocitrate dehydrogenase (IDH) 1 and 2 genes, loss of nuclear α-thalassemia/mental retardation syndrome X-linked (ATRX) expression, co-deletions of chromosome arms 1p and 19q, homozygous CDKN2A/B deletion, epidermal growth factor receptor (EGFR) gene alteration, telomerase reverse transcriptase (TERT) promoter mutation, the combination of chromosome 7 gain and chromosome 10 loss, and methylation of the O6-methylguanine-DNA methyltransferase (MGMT) promoter (31,32). Using these molecular markers, an integrated diagnosis can be provided based on the presence or absence of gene mutations and expressions. This includes the histological tumor type and its WHO grade as well as information on molecular markers. Table 1 summarizes the integrated diagnosis relevant for this thesis.

Table 1. Overview of integrated diagnoses relevant to this thesis and their CNS-WHO grade as well as molecular markers.

Integrated diagnosis	CNS-WHO grade	Molecular markers
Oligodendroglioma, IDH-mutant and 1p/19q-codeleted	WHO grade 2 or 3	IDH 1 / 2 mutation 1p/19q Co-deletion
Astrocytoma, IDH-mutant	WHO grade 2 or 3	IDH 1 / 2 mutation ATRX mutation TP53, CDKN2A/B
Astrocytoma, IDH-mutant	WHO grade 4	IDH 1/ 2 mutation ATRX mutation CDKN2A/B homozygously deleted
Glioblastoma, IDH wild type	WHO grade 4	IDH-wildtype TERT promoter mutation chromosomes +7/-10 EGFR amplification MGMT promotor methylation

Abbreviations: ATRX: α-thalassemia/mental retardation syndrome Xlinked, CDKN2A/B: Cyclin-dependent kinase inhibitor 2A/B, EGFR: Epidermal growth factor receptor, IDH: Isocitrate dehydrogenase, MGMT: O6-methylguanine-DNA methyltransferase, TERT: Telomerase reverse transcriptase, TP53: Tumor protein P53.

1.2.6 Therapy

In the therapy of brain tumors, the interdisciplinary cooperation of the treating physicians is important, since it is usually a combination of several therapies and therefore representatives of diverse specialties which are involved in the attempt to improve the patient's survival.

The goal of surgical therapy is to resect the tumor as completely as possible. This serves not only to reduce the size of the tumor and at the same time the symptoms it causes, but also to obtain tissue for a histologically confirmed diagnosis. Thus, surgery serves as both a diagnostic and therapeutic intervention which has also a prognostic value. Because of the diffusely infiltrative nature of high-grade gliomas, curative resection cannot be assumed despite radical removal of the tumor. When planning the surgical approach as well as the extent of resection, care must be taken to avoid neurological sequelae, for example, by injuring functionally intact eloquent brain areas. In this context, both the reduction of tumor mass and the preservation of function in the postoperative course have a positive effect on the prognosis and the response to

subsequent therapies (33–37). If surgical resection is not possible due to the location of the tumor or poor general condition of the patient, a biopsy should still be taken, as a histologically confirmed diagnosis is an important basis for further therapeutic decisions (26).
In addition to surgical resection, subsequent treatment with radiation and/or chemotherapy is also performed, especially in the case of malignant tumors. The aim in this case is to eliminate those cell clusters that have infiltrated healthy brain tissue and therefore cannot be resected without risking neurological deficits, or to inhibit their further growth (26). While drug treatment with an agent that blocks cell division is considered a systemic treatment, radiation ttherapy can today be applied locally to the extended tumor area through the use of modern techniques (29).
In addition, therapeutic options have been expanded in recent years to include the use of Tumor Treating Fields (TTFields) for patients with glioblastoma (see chapter 4.1.1 for detailed description).

1.2.7 Prognosis

The course of disease with a brain tumor is dependent on many factors, making it difficult to predict the individual course of the disease. In epidemiological studies, the median survival time across all glioma types and age groups has been found to be 16 months, with a 1-year survival of almost 60%. In particular, the localization of the tumor as well as the type of tumor cells and their growth behavior play an important role. Thus, patients with a low-grade glioma show a higher median survival time for tumors with a lower WHO grade compared to a malignant tumor such as glioblastoma (21,25). In addition, various molecular markers, such as the presence of MGMT promoter methylation, improve the response to therapy and thus contribute positively to the prognosis (32). The age an general condition of the patient as well as the extent of resection status should also be considered (26,27). A neurological deficit acquired after surgery has also shown to have an impact on prognosis and survival (35,36).

1.3 Neuroplasticity

Neuroplasticity is the ability of the brain to adapt to changes at the micro- and macroscopic levels in response to changing environmental conditions. The influence of these has been shown, for example, in studies with rats, which, as a consequence of being kept in a stimulating environment, had heavier cortices than their littermates kept in isolation without a stimulating environment (38,39). Accordingly, brain development is considered to be based on the activity-dependent stabilization of brain functions that results from environmental stimulation.

Depending on whether the microscopic or macroscopic level is regarded, this is referred to as synaptic or cortical plasticity. The term synaptic plasticity was first proposed by the psychologist Donald O. Hebb, who introduced Hebb's learning rule in his book The Organization of behavior, in which it was assumed that increased efficacy of synapses can be achieved by simultaneous activation of pre- and postsynaptic neurons (40). This process is referred to as either short term or long term potentiation, depending on the time period of effect, and forms the basis for numerous complex learning and memory processes (41). Cortical plasticity, on the other hand, accounts for changes in whole structures of the brain, including their location and function. These developments can lead to the reorganization of entire cortical maps (42,43).

While the neuroplasticity of the immature brain had been widely accepted, such processes in the adult brain were critically discussed for a long time and a temporal stability of the developmental state was assumed. In the last decades this hypothesis has been disproved by many research results. Nowadays, according to the current state of research, it is assumed that this is a lifelong process, even if the capacity for neuroplastic changes decreases with aging (44,45).

One of the first research approaches showed neuroplastic changes as a result of amputation of the finger in adult monkeys, which were manifested in a spreading of the cortical receptive fields of the remaining fingers into its representational area (46). Moreover, it has been shown that this reorganization occurs not only at the cortical level but already in upstream structures such as the brainstem, spinal cord, or thalamus (47,48). In addition to animal studies, such changes were later demonstrated in humans who had lost extremities as a result of trauma (49–51). Apart from cortical reorganization as a result of peripheral trauma, such processes can also occur after damage or disease of the brain itself. Here, a distinction is made between acute lesions, which occur, for example, as a result of cerebrovascular infarction, and those that develop slowly but progressively over time. An example of the latter category are brain tumors. These two types of cerebral lesions differ not only in their nature of occurrence, but also in the time available for the brain to adapt to this altered situation. In this context, studies in animals showed that removal of certain brain structures over the course of several operations (progressive lesion) was reflected in better postoperative recovery than removal of the same structures in only one operation in terms of an acute lesion (52).

Regarding neuroplasticity in brain tumors specifically, a distinction is made between preoperative, intraoperative, and postoperative plasticity (53). In this context, preoperative plasticity refers to changes in brain structure and function in response to the growing tumor.

Additionally, different scenarios are distinguished, which have a significant impact on the further course of treatment and thus also on the prognosis. These depend on the proximity of the tumor to eloquent areas and whether these have possibly already shifted compensatorily. The distance between the tumor and the eloquent cortex is crucial for the probability of functional deficits in the postoperative course and whether these will recover in the course of reorganization. The better this likelihood is, the more likely total resection can be pursued, which in turn affects the prognosis (53). Preoperative recruitment of cortex areas is assumed to be based on a three-stage hierarchical model in which local reorganization processes first occur in the immediate vicinity of the tumor before these are extended to other regions of the affected hemisphere and later to the unaffected hemisphere (53).

In addition, neuroplastic changes may occur intraoperatively. In this context, it has already been found in several studies that cortex areas that previously showed no activity responded to stimulation after resection of the tumor (53,54). This is assumed to be an unmasking of redundant intracortical connections and areas.

Furthermore, evidence of neuroplastic processes was also found in the postoperative course. Thus, after removal of the tumor, patients showed improvements in deficits that either existed before surgery or occurred within a short time as a sequela (54).

These described pre-, intra- and postoperative neuroplastic processes should be taken into account during preoperative planning to achieve the best outcome possible for the individual patient.

1.4 MRI as diagnostic tool in patients with brain tumor

When planning the treatment of patients with brain tumors, the benefits of maximum resection must always be contrasted with the costs of possible deficits due to injury of functionally intact eloquent brain areas. Although maximal resection improves the patient's survival and has a positive effect on the further course of therapy and quality of life, these benefits must always be contrasted and weighed against the risks such as damage to functionally still intact areas (55). Despite the extent of resection being an important prognostic marker (56), considerations of treatment and approach should not solely include anatomical factors. It should rather be considered that deficits that occur as a result of damaging intact eloquent areas during surgical resection may have profound consequences for neurologic, cognitive, and social abilities, thus also affect the postoperative quality of life. Therefore, damage to language-critical, motor, or memory-related structures should be avoided as much as possible during surgical removal of abnormal tissue, even if this means that complete resection is not achievable (35,36).

In these considerations, magnetic resonance imaging (MRI) has become an established imaging technique. In addition to the precise detection of the tumor location and extent in the context of anatomical imaging, functional magnetic resonance imaging (fMRI) provides the ability to estimate and visualize cortical activation using the BOLD effect (for detailed information see chapter 1.1.2). In the context of preoperative fMRI, customized tasks can be used to localize various functions such as language, motor, memory, or visual abilities non-invasively and without the administration of contrast agents (57–59). In addition to task-based fMRI paradigms, resting state fMRI (rsfMRI) is also gaining popularity and importance. Here, patients lie in the MRI scanner without an explicit task while cortical activation is measured during the resting state. This offers the advantage that patients who are cognitively incapable of performing certain tasks can also benefit from the advantages of preoperative fMRI. It can also be used in sedated patients and is less dependent on patients' compliance (60–62).

By combining different modalities such as fMRI and diffusion-weighted imaging, the tumor can be visualized in relation to surrounding tissue, eloquent cortex areas, and fiber tracts enabling the optimal planning of the surgical approach. The aim is to minimize damage to intact eloquent cortex areas while maximizing resection of abnormal tissue (28,63,64). The success of this procedure has already been empirically investigated and confirmed (57,65).

However, when evaluating and incorporating preoperative fMRI data, it must be kept in mind that precise mapping of cortical activations can be affected by various reactive changes in the brain. For example, the space-occupying nature of brain tumors can lead to displacement of brain tissue and thus influences the topographic organization of the cortex. This complicates the correct anatomical localization of functionally relevant areas (64). In addition, structural tissue changes can influence the BOLD signal, especially in the immediate vicinity of the tumor. This is not limited to the area of the tumor itself, but still shows effects in more distant areas that exhibit normal vascularization. This can be explained by the fact that glial tumors in particular exhibit infiltrative growth into surrounding tissues, which can affect their structure and function (66). In addition, the BOLD signal can be affected by hemorrhage and the formation of edema (55).

Furthermore, the interpretation of cortical activation in the vicinity of tumors is complicated by tumor-induced disruption of neurovascular coupling, which in turn affects the BOLD signal as this depends on the local increase in the concentration of oxygenated hemoglobin in the blood. Especially tumors with higher malignancy are associated with pathological alteration of the vessels, which may prevent them from responding adequately to an increase in blood volume and oxygenated hemoglobin concentration associated with cortical activation (67,68).

This can result in functional areas showing a lack of cortical activation in the evaluation of the fMRI, which can be erroneously attributed to a decrease in functional activity and not to a pathological physiology resulting in a false-negative BOLD signal. This massively complicates the interpretation of the cortical response to appropriate stimuli. Such a decrease of cortical activations in fMRI in patients with brain tumor has been described several times (69–71), although never a complete absence of the BOLD signal occurred, but only a significant attenuation. This was not only seen in high-grade tumors showing impaired neurovascular coupling or even neurovascular uncoupling (67,69,70), but has also been reported previously in patients with low-grade gliomas (72).

All of these described factors must be taken into account when interpreting a preoperative fMRI in order to derive the maximum benefit for the individual patient from the use of this method while minimizing the risk of postoperative deficits.

1.5 Aim of the thesis

Preoperative imaging allows noninvasive mapping of eloquent brain areas but has to be interpreted cautiously due to the previously described discussion about the integrity of the BOLD signal in the presence of a brain tumor. With regard to this background, it seems even more important to evaluate the influence of the tumor on the acquired MRI signal using patient data and thus to gain a better understanding of this phenomenon. In this context, a constant critical questioning and optimization of techniques are essential. The main goal of this thesis is to contribute to this endeavor. This was achieved by three studies that address different aspects of the investigation of brain tumor behavior in MRI, both in terms of methodology and interpretation.

In these three studies tumor-related neuroplastic processes in patients undergoing preoperative treatment at the University Hospital Regensburg were evaluated and quantified, using different techniques of structural and functional magnetic resonance imaging to further characterize brain tumor behavior. The aim here is to examine this disease of the central nervous system by using multiple methods. The following research questions are addressed in these three studies:

1. Investigation of how the presence of a brain tumor or space-occupying brain lesion in the occipital lobe affects fMRI eccentricity mapping of central, middle, and peripheral visual field areas.

2. Development and evaluation of a preprocessing protocol that allows the three-dimensional reconstruction as well as the analysis of functional MRI data using the FreeSurfer software.
3. Investigation of structural and functional differences between two groups of glioblastoma patients with different morphological tumor growth patterns.

Based on these research questions, three studies will be presented in the following chapters. In addition, the relevant background of each study as well as the resulting specific hypotheses will be discussed in more detail in the respective chapter.

2 ANALYSIS OF CHANGES IN fMRI RETINOTOPIC MAPPING IN PATIENTS WITH BRAIN TUMORS AND SPACE-OCCUPYING BRAIN LESIONS IN THE AREA OF THE OCCIPITAL LOBE

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Directly adopted text are marked as such.

2.1 Introduction

2.1.1 The human visual system

Anatomically, the human eyeball is composed of a dioptric apparatus and an auxiliary system that helps to protect the eye by using eye muscles, eyelids, conjunctiva, and lacrimal glands. Light entering through the pupil first passes through all the layers of the retina inside the eyeball before reaching the photoreceptors on the outer side. Here, the light stimulus is converted into electrochemical impulses before the information is processed and then transmitted. Via the optic nerve, the visual information reaches the lateral geniculate nucleus of the thalamus. This is the origin of the visual radiation, through which the information is transmitted to the primary visual cortex and secondary visual cortex. There, the processing stream of information divides into the dorsal and ventral pathways. The former projects to the parietal lobe and serves to perceive localization and motion of objects while the latter projects to the temporal lobe, processing information about the color and shape of objects (73–75).

Of note in this circuitry is that retinotopic organization is maintained throughout the entire pathway of information transmission. This means that neighboring areas on the retina are also represented neighboring in the thalamus as well as in the visual cortex. Thus, cortically different areas of the visual field can also be distinguished allowing different eccentricities and meridians to be separated from each other. In addition, the distribution of receptors corresponding to the retina is preserved. This is particularly evident when comparing the fovea centralis to the retinal periphery, which shows an overrepresentation of cortical area due to the high density of receptors in the central retina compared to the surface area occupied there (76).

2.1.2 Examination of the human visual system

Research of the (retinotopic) organization of the visual system started already in the 19th century when Munk found the occipital cortex to be relevant for visual abilities in monkeys (77). This hypothesis was supported a later by findings in humans, in which the calcarine sulcus was found to be an important cortex area for vision (78–80).

With the development of imaging techniques in the 1980s and 1990s, the possibilities for studying the visual system widened. These allowed studies to no longer be limited to lesion studies, but enabled the examination of the intact visual system in vivo. Thus, in the late 1980s, the primary visual cortex was studied for the first time using positron emission tomography (PET). In addition, with the development of functional magnetic resonance imaging (fMRI), the cortical response to visual stimuli could be estimated for the first time. This also allowed investigation of retinotopic organization using a phase-encoded paradigm (81).

Increasingly improved acquisition and analysis methods make it nowadays possible to produce a detailed in vivo visualization of retinotopically organized maps of the human visual. For this purpose, different methods are used. In phase-encoded measurement, stimuli in form of rotating wedges and expanding and contracting circles are used to stimulate different parts of the visual field. Cortical activity in response to this stimulation can be estimated using the BOLD effect in fMRI, providing evidence for the representation of different visual field localizations in the cortex. Due to the constant movement of the stimulus, the entire visual field can be scanned within a short period of time. In contrast, meridian mapping or eccentricity mapping uses a block design (see chapter 1.1.2) in which only part of the visual field is exclusively stimulated for a certain stimulation period. These allow the delineation of visual areas based on the stimulated meridians and eccentricities after analysis of the fMRI data. In addition, when an appropriate paradigm is used, the superior and inferior visual fields as well as the central and peripheral visual fields can be distinguished from each other (82–85).

These methods are not only used for the systematic study of the visual system in humans but have also become established in the clinical context. The aim is to characterize and classify pathological changes of congenital or acquired diseases, lesions and traumas. In the case of patients with a brain tumor or a space-occupying brain lesion in the area of the occipital lobe, for example, the brain areas that are still functionally intact despite the tumor can be identified during preoperative imaging. This information can thus be used to plan the surgical intervention. The goal here is to achieve maximum resection of the tumor or lesion while preserving functionally intact areas in order to avoid additional postoperative visual field loss. This would have an additional complicating effect on the postoperative course, with deficits in

the central visual field having more severe consequences (86). Paradigms such as the random dot kinematic program (87), flickering checkerboard patterns (58,88), or light flashes (89) have been used for this purpose in previous studies. These studies also showed that preoperative fMRI techniques provided comparable results to visual field perimetry or intraoperative electrocortical stimulation. Nevertheless, these paradigms as well as their empirical elaboration with regard to their application in patients with brain tumor or lesion are underrepresented in the literature compared to corresponding studies on language and motor abilities. One reason for this underrepresentation may be the rarity of this tumor location. According to a recent epidemiological study, less than 3% of all brain tumors are located in the occipital lobe (21), making it notably difficult for clinical researchers to find an appropriately large sample for representative results.

In addition to task fMRI paradigms, resting state fMRI (rsfMRI) has also become increasingly popular in clinical investigations to identify functional networks in recent years. In this context, it was shown that patients with pituitary adenoma or meningioma, who had visual field defects due to compression of the optic chiasm, showed improvements in the functional connectivity of visual areas as well as visual abilities after surgical resection of the tumor (90). Further studies could also show the influence of such a compressing tumor on brain morphology. Compared to a healthy control group, patients showed a reduced cortical thickness in the occipital lobe and a reduction of gray matter volume, which increased after decompression surgery and correlated with the improvement of visual abilities (91).

2.1.3 Aim of the study and hypotheses

The aim of this study was to investigate how the presence of a brain tumor or space-occupying brain lesion in the occipital lobe affects the BOLD signal during eccentricity mapping of central, middle and peripheral parts of the visual field. In particular, it was focused on whether the retinotopic organization of the visual cortex is still intact in fMRI in these patients.

Previous descriptions of paradigms for functional mapping of visual areas already showed that functionality was indeed still present and could be mapped (58,87,89). Thereby, using reversing checkerboard patterns, correlations could be drawn between the activation pattern in the visual cortex and the results of a perimetric examination (58). In this study, it is assumed that the eccentricity mapping paradigm can be applied analogously to other already used and established paradigms in preoperative fMRI examinations and allows an adequate assessment of the retinotopic organization of remaining intact cortical areas on a whole-brain level.

Hypothesis 1

H0: The eccentricity mapping paradigm is not an adequate method for preoperative visualization of functionally intact visual brain areas and therefore cannot be used in patients with brain tumors. This is evidenced by a high amount of statistically significant differences in the cortical activations elicited by the stimuli compared with those of healthy control subjects.

H1: The eccentricity mapping paradigm represents an adequate method for preoperative visualization of intact visual brain areas and can therefore be used in patients with brain tumors. This is reflected by cortical activations elicited by the stimuli being similar to those of healthy control subjects.

In addition to the investigation on the whole-brain level, the influence of the brain tumor/lesion on the BOLD signal will also be investigated in different regions of interest (ROIs) relevant for processing of visual stimuli. Here, previous studies have already shown structural changes in the occipital cortex as a consequence of suprasellar tumors, even when these did not affect the occipital lobe but the optic chiasm (91,92). These changes should also be reflected at the functional level, as other studies have already shown a correlation between the presence of a brain tumor and a decrease in the BOLD signal in other parts of the brain (68,93,94). Therefore, the presence of a brain tumor/lesion in the occipital lobe region was expected to influence the percent signal change as well as the extent of cortical activation of the primary visual cortex of the affected hemisphere.

Hypothesis 2

H0: There is no statistically significant difference in percent signal change and cluster size of activated voxels in the anatomical region of interest of the primary visual cortex in patients with brain tumor/lesion and healthy controls.

H1: The percent signal change and cluster size of activated voxels in the anatomical region of interest of the primary visual cortex are statistically significantly different between patients with brain tumor/lesion and healthy control subjects.

In addition to the primary visual cortex, regions of interest along the visual processing pathway were also be investigated. ROIs were chosen that are known to be involved in higher visual and attentional processes. Since they are partially located outside the occipital lobe and thus more distant to the tumor/lesion, its direct influence on the BOLD signal is omitted here (67). Although these regions are usually not directly activated by the eccentricity mapping paradigm,

they were assumed to receive less input from areas affected by the tumor/lesion, so a reduction was expected here as well.

Hypothesis 3

H0: There is no statistically significant difference in percent signal change in different anatomical regions of interest involved in visual or attentional processes between patients with brain tumor/lesion and healthy control subjects.

H1: The percent signal change in different anatomical regions of interest involved in visual or attentional processes differ statistically significantly between patients with brain tumor/lesion and healthy control subjects.

In addition to the described ROIs in the affected hemisphere, the corresponding anatomical regions of the contralateral hemisphere not affected by the tumor/lesion were also examined. Here, it was assumed that a higher percent signal change is present in the regions, since these should be far enough away from the tumor and thus are not exposed to its direct influence on the BOLD signal. In this regard, the distance from the tumor plays an important role in terms of percent signal change (67,94). Moreover, this unilateral influence of a tumor on the BOLD signal should be reflected in the lateralization index, as it compares the extent of cortical activations between both hemispheres and computes it into a ratio.

Hypothesis 4

H0: There is no difference in the percent signal change within the anatomical regions of interest between the tumor/lesion affected and unaffected hemispheres within the patient groups. Furthermore, this is reflected in the lateralization index, which has a low value and does not differ from the value of the healthy control subjects.

H1: There are statistically significant differences in the percent signal change within the anatomical regions of interest between the tumor/lesion affected and unaffected hemispheres within the patient groups. The lateralization index also showed statistically significant higher values compared to the healthy control group.

Besides the investigation of cortical activation in a whole-brain evaluation as well as in different relevant local regions of interest, the influence of a tumor / lesion on different cortical networks was also investigated. It was assumed that the network character of the human brain allows interaction between neighboring as well as distant areas even up to the contralateral hemisphere

via anatomical connections (95,96). Damage to one of these interconnected regions or the connection between them can therefore also affect downstream regions, leading to neurocognitive deficits (97).

In addition to these structural connections, a tumor/lesion can also influence the functional connectivity between different areas, meaning that this may be reduced in patients compared to healthy control subjects (98–100). In addition, magnetoencephalography (MEG) studies demonstrated that this not only affected the tumor-affected hemisphere, but also had effects on the contralateral unaffected hemisphere (101,102).

Hypothesis 5

H0: There is no statistically significant difference in functional connectivity within and between different cortical networks between patients with brain tumor/lesion and healthy controls.

H1: There is a statistically significant difference in functional connectivity within and between different cortical networks between patients with brain tumor/lesion and healthy controls.

2.2 Methods

The ethics committee of the University of Regensburg approved this retrospective study (reference number: 19-1337-104).

2.2.1 Sample selection

To investigate the hypotheses, this study examined the preoperative fMRI data of a patient sample with brain tumor or space-occupying brain lesion in the occipital lobe as well as fMRI data of a healthy control sample.

In order to select the patient sample, a database consisting of patients who received fMRI as part of their preoperative treatment at the University Hospital Regensburg was searched. Inclusion criteria were the presence of a brain tumor or lesion in the occipital lobe and a preoperative fMRI using a paradigm for retinotopic mapping.

To demonstrate the applicability of the paradigm in the patient group, their data were compared to those of healthy control subjects without neurological or psychiatric disease. For the selection of the control sample, a pseudonymized list of all subjects examined with MRI in several studies investigating hereditary and age-related macular degeneration at the Department of Psychology I at the University of Regensburg was used (103–105) to find an age- and sex-matched control subject for each patient, as far as possible.

2.2.2 Image Acquisition

Data collection took place at two different MRI scanners at the University Hospital Regensburg (patient sample) and at the District Hospital Regensburg (control sample).

"For patients, magnetic resonance imaging was performed using a Siemens Skyra 3-Tesla full-body scanner (MAGNETOM Skyra; Siemens, Erlangen, Germany) with a 32-channel head coil. The visual stimuli were presented to the patients via a mirror mounted on the head coil, which directed the view to an MR-compatible 32" BOLD screen (Cambridge Research Systems, Rochester, UK) placed at the end of the scanner. A T2*-weighted gradient echo planar imaging (EPI) was used to acquire functional images (TR = 2000 ms, TE = 30 ms, FoV = 192 × 192 mm^2, flip angle = 90° and voxel size = 2 × 2 × 3 mm^3). In each image volume, 31 axial slices were obtained using an interleaved scan sequence. In addition, a T1-weighted structural image (TR = 1980 ms, TE = 3.670 ms, FoV = 256 × 256 mm^2, flip angle = 9° and voxel size = 1 × 1 × 1 mm^3) was obtained.

Magnetic resonance images for control subjects were obtained using a Siemens Allegra 3-Tesla head scanner with a single-channel head coil. The visual stimuli were projected onto a screen by an LCD projector behind the scanner bore and, from there, via a mirror into the visual field of the subjects. T2*-weighted gradient echo planar imaging (EPI) was used to acquire functional BOLD images (TR = 2000 ms, TE = 30 ms, FoV = 192 × 192 mm^2, flip angle = 90° and voxel size = 3 × 3 × 3 mm^3). In each image volume, 34 axial slices were obtained using an interleaved scan sequence. In addition, a T1-weighted structural image (TR = 2300 ms, TE = 2.910 ms, FoV = 256 × 256 mm^2, flip angle = 9° and voxel size = 1 × 1 × 1 mm^3) was obtained." (106)

The stimuli of the eccentricity mapping paradigm used in this study consisted of three circles of different sizes covering the central (0.8 - 9° visual angle), middle (9 - 17° visual angle), and peripheral visual fields (17 - 24.2° visual angle). Thus, the activation pattern could be determined at three eccentric locations along the calcarine sulcus, as previously described in other studies (82,107). These circles consisted of a checkerboard pattern that alternated between black (1 cd/m2) and white (330 cd/m2) at a flicker rate of 8 Hz to prevent adaptation to the stimulus which enhanced cortical activation. The background was gray (165 cd/m2).

The paradigm was designed as a block design (Figure 1). The stimulation blocks lasted 13s and consisted of the presentation of one of the three circles of different sizes. The baseline was the presentation of an empty background for a duration of 18s. Stimuli were presented using Presentation (Neurobehavioral Systems). To avoid active eye movements and thus changes in the stimulated visual field, patients or subjects were instructed to focus a fixation stimulus on

the center of the stimulation field. In this case, patients fixated a blue dot, while control subjects looked at a cross in the center of the screen.

Figure 1. Example of the stimuli used in the retinotopic mapping paradigm. This figure was taken from (106).

2.2.3 fMRI data analysis

The fMRI data analysis was performed using Statistical Parametric Mapping 12 (SPM12; http://www.fil.ion.ucl.ac.uk/spm; accessed on 20.09.2022) with MATLAB version 2019a (The Mathworks Inc., Natick, MA, USA).

During preprocessing, first motion correction was performed and the structural T1-weighted image was coregistered to the mean functional image. Subsequently, the structural image was segmented and the deformation field calculated during this step was used to normalize all functional images as well as the structural image into the MNI standard space. In addition, the functional images were smoothed with a FWHM of 8mm. Statistical analysis was performed using the General Linear Model. The study design was considered in the form of three regressors reflecting the presentation of each of the three eccentricities (one regressor each for the inner, middle, and outer circles). These were then convolved with the hemodynamic response function. The fixation period was not explicitly modeled as a separate regressor and served as an implicit baseline. The six motion parameters (three translational and three rotational motion directions each) estimated during realignment were also included in the model as additional regressors. After individual-level analysis (1st-level analysis), the individual patient groups and the assigned control subjects were additionally compared in various group-

level analyses (2nd-level analyses). The Automated Anatomical Labeling (AAL) toolbox (108–110) was used to assign statistically significant clusters to anatomical regions. For the results of the statistical analysis of the fMRI data, a significance level of $p < .001$ (uncorrected) was set at the voxel level and $p = .05$ (FDR-corrected) at the cluster level.

During the data analysis, increasing difficulties in segmentation and resulting normalization became apparent, especially in older patients and subjects. These appeared to be caused by an age-related change in cerebrospinal fluid (CSF) volume (111). Due to the aging process, morphological changes such as size and shape occur in the brain. These can result in registration and transformation processes not always performing as intended. In this study, this was mainly shown by CSF-filled cavities in frontal areas leading to a miscalculation of the extent of the brain, resulting in an inappropriate transformation matrix being calculated for it. The application of the same led to an incorrect normalization of the functional as well as structural data into the standard MNI space, which was particularly evident in a poor correspondence of occipital regions with the corresponding anatomical areas. The solution to this problem was achieved by applying skull stripping, where all tissue types outside the brain (skull, skin, CSF) were removed, resulting in a better segmentation of the total brain volume. For this purpose, the CAT12 toolbox version 12.7 (http://www.neuro.uni-jena.de/cat/; accessed on 20.09.2022) was used.

To characterize local changes in the BOLD signal, region of interest (ROI) analyses were performed using the Marsbar Toolbox Version 0.44 (112). To create the ROIs, masks of the Regions of interest of the calcarine fissure, area MT+, inferotemporal gyrus, fusiform gyrus, precuneus, intraparietal sulcus, frontal eye fields, and dorsolateral prefrontal cortex (DLPFC) were first exported from the AAL Atlas using the WFU Pick Atlas Toolbox Version 3.0.5 (110,113,114) as well as the Anatomy Toolbox Version 3.0 (115–117). Within these inclusive masks, the t-map of the 1st-level analyses was used to select the voxel that was maximally activated within the anatomical region for each of the eccentricities of each patient and subject. A sphere of diameter 5mm was then placed around this voxel, resulting in a total of 6 ROIs per anatomical area and subject (3 ROIs per hemisphere). For each ROI, the percent signal change (PSC) was calculated using Marsbar. In addition, the cluster size of activated voxels in the anatomical ROI of the calcarine fissure and surrounding cortex was calculated. To capture the hemispheric distribution of cortical activations, the lateralization index within the occipital cortex was also estimated using the LI toolbox (118).

The CONN toolbox (119) implemented in SPM12 was used to evaluate functional connectivity. As with analysis of fMRI data, preprocessing of the data was required here first. Since the

toolbox is based on SPM12, the previously created SPM.mat files were used, meaning that a new preprocessing of the data was not necessary. During denoising, the BOLD time series were bandpass filtered (0.008-0.09 Hz) for noise reduction, and linear detrending was applied (120). After individual-level analysis (1st-level-analysis), group ROI-to-ROI analyses (2nd-level-analysis) were calculated for 23 implemented network ROIs (Default Mode network, Visual network, Salience network, Dorsal Attention network, and Fronto Parietal network) to determine the effect of tumor/lesion on functional connectivity within and between these networks and to compare them between the different groups (Table 2).

Table 2. Overview of all networks analyzed for this study.

Network	Region of interest	Abbreviation
Default Mode	Medial Prefrontal Cortex	MPFC
	Lateral Parietal left hemisphere	LP (L)
	Lateral Parietal right hemisphere	LP (R)
	Precuneus Cortex	PCC
Salience	Anterior Cingulate	ACC
	Anterior Insula left hemisphere	A.INS (L)
	Anterior Insula right hemisphere	A.INS (R)
	Rostral Prefrontal Cortex left hemisphere	RPFC (L)
	Rostral Prefrontal Cortex right hemisphere	RPFC (R)
	Supramarginal Gyrus left hemisphere	SMG (L)
	Supramarginal Gyrus right hemisphere	SMG (R)
Dorsal Attention	Frontal Eye Field left hemisphere	FEF (L)
	Frontal Eye Field right hemisphere	FEF (R)
	Intraparietal Sulcus left hemisphere	IPS (L)
	Intraparietal Sulcus right hemisphere	IPS (R)
Fronto Parietal	Lateral Prefrontal Cortex left hemisphere	LPFC (L)
	Lateral Prefrontal Cortex right hemisphere	LPFC (R)
	Posterior Parietal Cortex left hemisphere	PPC (L)
	Posterior Parietal Cortex right hemisphere	PPC (R)
Visual	Medial Visual Areas	MED
	Occipital Cortex	OCC
	Lateral Visual Areas left hemisphere	LAT (L)
	Lateral Visual Areas right hemisphere	LAT (R)

2.2.4 Statistical data analysis

Numerical data were analyzed using SPSS Version 25 (IBM, Armonk, NY, USA).

Differences in percent signal change between affected and unaffected hemispheres were evaluated in a repeated measures ANOVA for each group (healthy controls, tumor patients, and lesion patients) separately using area (Calcarine fissure, MT+, IT, fusiform, precuneus, IPS, FEF, or DLPFC), hemisphere (affected or unaffected), and stimulated eccentricity (inner circle, middle circle, or outer circle) as within-subject factors. In addition, the calculated tumor/lesion volume of each patient was used as covariates. This was set to $0mm^3$ for the healthy controls. The Mauchly test for sphericity was also performed to evaluate the equality of variances between factors within subjects. In case of violations of this sphericity assumption, the Greenhouse-Geisser adjustment was used.

In addition to the evaluation within the three groups, they were also compared with each other. For this purpose, a repeated measures ANOVA was performed with the same factors as previously described, using diagnosis (control, tumor patients, or lesion patients) additionally as a between-subjects factor. Tumor/lesion volumes were again included as covariates and Greenhouse-Geisser adjustment was used for violations of the sphericity assumption.

Analogous to the comparison of percent signal changes between groups, this was also done for cluster size of activated voxels in the area of the Calcarine fissure.

Lateralization indices were evaluated nonparametrically using Kruskal-Wallis test for independent samples.

Corel version 19 was used for graphical representation of the results. The respective standard error of the mean was used to create the error bars. Statistically significant results were indicated with * for $p < .05$, ** for $p < .01$, and *** for $p < .001$. Figures for the visualization of the functional connectivity were taken from the CONN Toolbox as well as created using the connectivity matrices calculated in the second level analysis.

2.3 Results

2.3.1 Description of the sample

In total, MRI data of 19 patients (P1-P19; 12 females and 7 males) aged 8 to 74 years (M = 45.79 years, SD = 19.632) were included in the sample. This was further subdivided into 12 patients with brain tumor and 7 patients with a space-occupying brain lesion. The fMRI data were collected during routine preoperative treatment at the University Hospital Regensburg between April 2017 and August 2019 and retrospectively analyzed in this study.

Each patient had a diagnosis of a brain tumor (6 glioblastoma multiforme, 2 metastases, 1 glioma, 1 pilocytic astrocytoma, 1 ependymoma, and 1 ganglioglioma) or a space-occupying brain lesion (3 arteriovenous malformations, 3 cavernomas, and 1 inflammatory lesion) in the occipital lobe (see Table 3). As the histological classification of the described tumors did not follow the new WHO classification of 2021 at the time the study was performed, this is expressed as Roman numerals following the convention used at that time.

In addition to the patient sample, 19 healthy control subjects (C1-C19; 9 females and 10 males) aged 13 to 78 years (M = 46.16; SD = 19.021) were retrospectively selected. Whenever possible, each patient was assigned an age- and sex-matched control subject. An unpaired samples t-test showed that the two groups did not differ regarding their age ($t(36) = .059$; $p = .953$).

Table 3. Composition and characteristics of the patient (P1–P19) and control sample (C1–C19) used in this study.

This table was taken from (106).

Subject	Sex	Age	Diagnosis	Hemisphere	Location	Volume (mm^3)	Visual Field Defects
P1	f	52	GBM	left	parieto-occipital	50,597.7	HH on the right side
P2	m	73	GBM	right	temporo-occipital	64,816.4	HH on the left side Improvement after the surgery
P3	f	8	Pilocytic astrocytoma	right	occipital	2233.3	incomplete HVL in the lower left quadrant
P4	m	48	Cavernoma	right	occipital	1506.8	HVL in the upper left quadrant
P5	f	40	Ependymoma	right	parieto-occipital	9688.0	no loss of visual field
P6	m	60	Metastasis	left	occipital	6146.5	Restrictions in the visual field coming from the temporal side
P7	f	48	Metastasis	right	occipital	4684.1	incomplete HVL in the lower right quadrant
P8	f	74	GBM	right	occipital	3589.6	HH on the left side
P9	f	29	Cavernoma	left	occipital	432.5	n.a.
P10	m	43	GBM	left	occipital	3452.0	HVL in the lower right quadrant
P11	f	71	GBM	left	temporo-occipital	12,436.3	HH on the right side
P12	f	31	CNS inflammatory tissue	right	occipital	1236.3	n.a.
P13	f	70	Cavernoma	left	occipital	818.8	n.a.
P14	m	24	AVM	left	occipital	29,976.6	n.a.
P15	f	46	AVM	left	occipital	345.7	no loss of visual field
P16	m	47	GBM	right	temporo-occipital	8361.6	incomplete HVL in the lower left quadrant
P17	f	60	GBM	right	parieto-occipital	5811.4	n.a.

P18	m	12	Ganglioglioma	left	occipital	1761.4	unspecific visual field losses in the inferior area
P19	f	34	AVM	left	parieto-occipital		n.a.
C1	f	52	-	-	-	-	
C2	f	71	-	-	-	-	
C3	f	23	-	-	-	-	
C4	m	45	-	-	-	-	
C5	f	38	-	-	-	-	
C6	m	60	-	-	-	-	
C7	f	51	-	-	-	-	
C8	m	83	-	-	-	-	
C9	m	28	-	-	-	-	
C10	m	40	-	-	-	-	
C11	m	71	-	-	-	-	
C12	f	34	-	-	-	-	
C13	f	68	-	-	-	-	
C14	f	23	-	-	-	-	
C15	m	40	-	-	-	-	
C16	f	51	-	-	-	-	
C17	f	61	-	-	-	-	
C18	m	13	-	-	-	-	
C19	f	34	-	-	-	-	

Abbreviations: GBM: Glioblastoma multiforme, AVM: Arteriovenous malformation, HH: homonymous hemianopsia, HVL: homonymous visual loss, n.a. information not available.

2.3.2. Functional activity clusters

To investigate the influence of a brain tumor/space-occupying brain lesion on the BOLD signal during retinotopic mapping, fMRI data from the patient and control groups described above were analyzed. Here, the cortical activation due to stimulation was calculated three circles covering either the central, middle, or peripheral visual field. The results showed that for each of the three eccentricities examined, similar patterns of cortical activation were found in both patient groups compared with their respective assigned control subjects. At the same time, however, the extent of activated clusters was found to be lower in patients than in control subjects.

To quantify the differences between the groups, group analysis of the fMRI data was performed in SPM12 (Figure 2). Here, the comparison of the tumor patients with the assigned control subjects showed that during stimulation of the central visual field with the inner ring, no

statistically significant differences were found between the two groups. In the conditions of stimulation with the middle and peripheral circles, clusters of statistically significant differences were found in the calcarine fissure and lingual gyrus of both hemispheres as well as in the vermis. For the outer circle, the left cuneus was also included in the cluster. The results of this group comparison between tumor patients and control subjects are summarized in Table 4.

Figure 2. Patterns of cortical activations of the group of patients with brain tumor as well as the according control subjects.

This figure is modified from (106).

Table 4. Results of the group comparisons of healthy control subjects and tumor patients. This table was adapted from (106).

Group	Eccentricity	Cluster		T	MNI Coordinates			Brain Regions
		Size	P_{FDR}		x	y	z	
Controls > Tumor	Inner circle	0	-	-	-	-	-	-
	Middle circle	344	0.006	4.39	2	-76	-4	calcarine fissure (both), lingual gyrus (both), vermis
	Outer circle	323	0.047	5.08	14	-72	-6	calcarine fissure (both), lingual gyrus (both), vermis, cuneus (left)

Abbreviations: MNI: Montreal Neurological Institute

When comparing the lesion patients with the assigned control subjects (Figure 3), there were more pronounced group differences compared with the results of the tumor patients and their respective control subjects. The extent of the clusters, which were statistically significant, was greater than in tumor patients and also spread over more brain areas. These included the superior and middle occipital gyrus, cuneus, precuneus, fusiform gyrus, and lingual gyrus, among others. In addition, it was also found that during stimulation with the middle and peripheral circles, multiple clusters differed statistically significantly between the patient and control groups. These results are summarized in Table 5.

Figure 3. Patterns of cortical activations of the group of patients with brain lesion as well as the according control subjects.

This figure is modified from (106).

Table 5. Results of the group comparisons of healthy control subjects and lesion patients. This table was adapted from (106).

Group	Eccentricity	Cluster		T	MNI Coordinates			Brain Regions
		Size	P_{FDR}		x	y	z	
Controls > Lesion	Inner circle	912	0.004	8.23	-16	-82	26	superior occipital gyrus (left), cuneus (left), middle occipital gyrus (left), calcarine fissure (left), superior parietal gyrus (left)
		614	0.002	8.47	-18	-38	-16	fusiform gyrus (left), parahippocampal gyrus (left), lingual gyrus (left), cerebelum (left)
		1293	<0.001	6.98	22	-60	18	calcarine fissure (both), lingual gyrus (both), right precuneus (right), right cuneus (right), superior occipital gyrus (right)
	Middle circle	991	<0.001	6.67	-14	-94	20	superior occipital gyrus (left), cuneus (left), middle occipital gyrus (left), precuneus (left), superior parietal gyrus (left), calcarine fissure (left), inferior parietal gyrus (left)
		806	0.001	5.67	-42	4	-12	insula (left), superior temporal gyrus (left), postcentral gyrus (left), precentral gyrus (left), rolandic operculum (left), inferior frontal gyrus opercular part (left), temporal pole of superior temporal gyrus (left), Heschl gyrus (left), putamen (left)
	Outer circle	642	0.024	8.61	12	-78	4	calcarine fissure (both), lingual gyrus (both), cuneus (right), precuneus (right)
		570	0.024	6.49	-16	-84	26	superior occipital gyrus (left), cuneus (left), calcarine fissure (left), precuneus (left), superior parietal gyrus (left)

Abbreviations: MNI: Montreal Neurological Institute

2.3.3 Percent signal change

In addition to the investigation of group differences in cortical activation on whole-brain level, different brain areas relevant to visual processing were investigated in specific regions of interest (ROIs) analyses. For this purpose, percent signal change (PSC) in these ROIs was first determined in both affected and unaffected hemispheres and compared between the experimental groups. These were then analyzed separately in a repeated measures ANOVA for each group (healthy controls, tumor patients, and lesion patients).

"Within the control group (Figure 4), there was a significant main effect of the factor area ($F(3.95;67.07) = 44.5$; $p < 0.001$; $d = 3.24$) but not for the hemisphere ($F(1;17) = 2.4$; $p = 0.139$ n.s.; $d = 0.75$), eccentricity ($F(2; 34) = 0.8$; $p = 0.478$ n.s.; $d = 0.42$) or tumor volume ($F(1;17) = 0.3$; $p = 0.569$ n.s.; $d = 0.29$). There was also a significant interaction effect of the factors area x eccentricity ($F(4.26;72.40) = 12.0$; $p < 0.001$; $d = 1.68$). None of the other interaction effects was significant. The post-hoc t-tests showed that, in this group, the only difference between the affected and unaffected hemisphere (allocation was made according to the assigned patient) was found in the DLPFC during the presentation of the inner ring ($t(18) = -2.2$; $p = 0.044$)." (106)

The group of tumor patients showed "a significant main effect of the factor area ($F(7;70) = 3.5$; $p < 0.001$; $d = 3.66$) but no effect of the hemisphere ($F(1;10) = 1.3$; $p = 0.237$ n.s.; $d = 0.74$), eccentricity ($F(2; 20) = 1.3$; $p = 0.302$ n.s.; $d = 0.71$) or tumor volume ($F(1;10) = 0.0$; $p = 1.0$ n.s.; $d = 0.00$). There were also significant interaction effects of the factors area x eccentricity ($F(14;140) = 3.8$; $p < 0.001$; $d = 1.23$) and area x hemisphere x eccentricity $(14;140) = 2.6$; $p = 0.002$; $d = 1.02$), as well as a trend for area x hemisphere x eccentricity x tumor volume ($F(14;140) = 1.6$; $p = 0.077$ n.s.; $d = 0.81$), while the other interaction effects remained not significant. The post-hoc t-tests showed that, in this group, the PSC values differed in the area of the calcarine fissure during the presentation of the middle ring ($t(11) = -3.2$; $p = 0.008$), in the area of the inferotemporal gyrus during presentation of the inner ring ($t(11) = -2.5$; $p = 0.032$) and middle ring ($t(11) = -2.5$; $p = 0.028$) and in the area MT in all three eccentricities (inner ring: $t(11) = -2.8$; $p = 0.016$, middle ring: $t(11) = -2.4$; $p = 0.033$ and outer ring: $t(11) = -2.9$; $p = 0.013$)." (106)

Calcarine fissure
Controls
Tumor
Lesion
% signal change
Inner Circle
Middle Circle
Outer Circle
Affected Hemisphere
Unaffected Hemisphere
Area MT+
Inferotemporal gyrus
Fusiform Gyrus
Precuneus
Intraparietal sulcus
Frontal Eye Fields
DLPFC

Figure 4. Comparison of mean percent signal changes of the three groups studied for both the affected and unaffected hemispheres.
This figure was taken from (106).

The analysis was also carried out for the group of lesion patients which showed "a significant main effect of the factor area ($F(7;35) = 14.0$; $p < 0.001$; $d = 3.3$) but not for the hemisphere ($F(1;5) = 1.8$; $p = 0.243$ n.s.; $d = 1.19$), eccentricity ($F(1.11; 5.54) = 3.0$; $p = 0.136$ n.s.; $d = 1.56$) or tumor volume ($F(1;5) = 0.2$; $p = 0.692$ n.s.; $d = 0.38$). There was also a significant interaction effect of the factors area x eccentricity ($F(14;70) = 4.2$; $p < 0.001$; $d = 1.84$) and a trend for hemisphere x tumor volume ($F(1;5) = 4.6$; $p = 0.087$ n.s.; $d = 1.90$) and area x hemisphere x eccentricity x tumor volume ($F(14;70) = 1.8$; $p = 0.058$ n.s.; $d = 1.19$). No other interactions were significant. The post-hoc t-tests showed that, in this group, the only difference was found in the DLPFC during the presentation of the outer ring ($t(6) = 3.3$; $p = 0.017$)." (106)
In addition to the statistical analyses of PSC within the three study groups, a repeated measures ANOVA with between-subjects factor diagnosis (controls, tumor patients or lesion patients) was also performed. This revealed "a significant main effect of the factor area ($F(4.46;151.46) = 74.4$; $p < 0.001$; $d = 2.96$) but not for the hemisphere ($F(1;34) = 2.7$; $p = 0.112$ n.s.; $d = 0.56$), eccentricity ($F(2; 68) = 2.9$; $p = 0.065$ n.s.; $d = 0.58$), diagnosis ($F(2;34) = 0.9$; $p = 0.398$ n.s.; $d = 0.47$) or tumor volume ($F(1;34) = 0.1$; $p = 0.802$ n.s.; $d = 0.09$). There was also a significant interaction effect of the factors area x tumor volume ($F(7;238) = 2.2$; $p = 0.035$; $d = 0.51$), area x area ($F(5.68;193.11) = 13.3$; $p < 0.001$; $d = 1.25$), area x eccentricity x diagnosis ($F(28;476) = 1.6$; $p = 0.024$; $d = 0.62$), area x hemisphere x eccentricity x tumor volume ($F(14;476) = 1.9$; $p = 0.027$; $d = 0.47$) and area x hemisphere x eccentricity x diagnosis ($F(28;476) = 1.9$; $p = 0.005$; $d = 0.66$), as well as a trend for area x hemisphere x diagnosis ($F(14;238) = 1.6$; $p = 0.079$ n.s.; $d = 0.61$). The other interactions were not significant. The post-hoc t-tests showed a significant difference in the PSC values between the tumor patients and healthy controls in the area of the Calcarine fissure in the affected hemisphere during the presentation of the middle ring ($t(29) = 3.3$; $p = 0.002$)." (106)

2.3.4 Cluster Size of activated voxels

To further characterize the pattern of cortical activation in the previously studied ROI of the calcarine fissure, the cluster size of activated voxels was also collected in addition to the percent signal change. Here, a repeated measures ANOVA was subsequently conducted to compare the

three groups (healthy controls, tumor patients, and lesion patients). This between-group analysis revealed neither a significant main effect nor any interaction effects.

In addition, a repeated measures ANOVA was performed separately for each group (Figure 5). This showed a statistically significant interaction effect hemisphere x eccentricity only ($F(2;34) = 3.5$; $p = 0.040$; $d = 0.991$) for the control group, while all other interactions as well as main effects were not significant. Similarly, in the group of patients with brain tumor, a significant interaction effect eccentricity x tumor volume ($F(2;20) = 5.1$; $p = 0.016$; $d = 1.43$) was found, but no main effect. However, the main effect tumor volume ($F(1;10) = 3.5$; $p = 0.093$ n.s.; $d = 1.18$) showed a trend. In contrast, the lesion group showed a significant main effect of the factor hemisphere ($F(2;10) = 4.8$; $p = 0.034$; $d = 1.96$). In post-hoc t-tests, only a statistically significant difference between the affected and the unaffected hemisphere was found for the group of lesion patients ($t(6) = -3.2$; $p = 0.019$).

Figure 5. Comparison of mean cluster size of activated voxels of the region of interest of the calcarine fissure of the three groups studied for both the affected and unaffected hemispheres. This figure was modified from (106).

2.3.5 Lateralization Indices

To investigate the influence of a tumor/lesion on the hemispheric symmetry of cortical activation, the absolute lateralization index was calculated for each of the three examined

eccentricities in the ROI of the occipital lobe (Figure 6). This revealed a trend for the inner circle (χ^2 = 5.3; p = 0.070 n.s.; d = 0.65) but no significant difference for the middle (χ^2 = 1. 8; p = 0.387 n.s.; d = 0.11) or outer circles (χ^2 = 0.6; p = 0.753 n.s.; d = 0.41) in a Kruskal-Wallis test for independent samples.

Figure 6. Comparison of the lateralization indices in the occipital lobe between the tumor patients, lesion patients and the control group.
This figure was modified from (106).

2.3.6 Functional Connectivity

In addition to the investigation of differences in cortical activation at the whole brain level and in specific regions of interest (ROIs) that are relevant for visual processing, the differences between the groups of brain tumor and brain lesion patients and their matched control subjects were also investigated regarding functional cortical networks. For this purpose, functional connectivity between 23 ROIs of the Default Mode, Visual, Salience, Dorsal Attention, and Fronto Parietal networks implemented in the CONN toolbox was calculated using Fisher-transformed pairwise correlations. To quantify the connectivity present, as in the analyses for whole brain activity, each group was first evaluated individually using one-sample analyses (Figure 7) before comparing the patient and control groups.

This revealed statistically significant intra-network connectivity of all investigated networks across the three stimulated eccentricities in the control subjects. In addition, all three study conditions also showed significant inter-network connectivity between the Default Mode and the Fronto Parietal network, as well as between the two regions of interest of the left and right intraparietal sulcus of the attention network and various ROIs of other networks.

The patients with brain tumor showed statistically significant intra-network connections across all networks and eccentricities, as did the control subjects. In addition, they also showed pronounced inter-network connectivity between parts of the Visual, Salience, and Dorsal Attention networks, as well as between the Default Mode and the Fronto Parietal network. These connections were evident in all three stimulation conditions examined.

The patients with space-occupying brain lesions showed a similar pattern comparable to the control subjects. Again, pronounced connections within the investigated networks were found across all stimulated eccentricities, as well as significant inter-network connectivity between the Default Mode and the Fronto Parietal network, and between the two regions of interest of the left and right intraparietal sulcus of the Dorsal Attention network and various ROIs of other networks. At the same time, in contrast to the other two groups, these patients showed pronounced connections of the medial visual area with other regions of interest across different networks. These connections were also found across all study conditions.

The p-values of the statistical tests of these analyzes of the functional connectivity of each of the three groups can be found in the Appendix as Supplementary tables 1-9.

Figure 7. Patterns of functional connectivity of cortical networks relevant for the processing of visual stimuli of the group of patients with brain tumor, brain lesion as well as the healthy control subjects.

In addition to the evaluations of the functional connectivity of the individual groups, the group of tumor patients and lesion patients were also compared with their respective control groups. When comparing the patients with brain tumor and their assigned control subjects, the patient group showed statistically significantly reduced inter-network connectivity of the individual regions of interest (ROIs) of the Default Mode network with different ROIs of the other investigated networks for all three investigated stimulation conditions. In addition, this group showed more pronounced intra-network connectivity of the Salience and Dorsal Attention networks and significantly stronger connections between the different ROIs of the visual and Dorsal Attention networks with ROIs of other networks (Figure 8).

The p-values of the statistical tests of these comparisons can be found in the Appendix as Supplementary tables 10-15.

Figure 8. Patterns of functional connectivity of cortical networks relevant for the processing of visual stimuli for the group of patients with brain tumor as well as the according control subjects. This figure was taken from (106).

When examining the functional connectivity of the patients with space-occupying brain lesion, they showed a statistically significant reduction in the connections between the occipital cortex and the lateral parts of the Visual network of both hemispheres in the examination condition of the inner circle as well as the outer circle in comparison with the control subjects assigned to them. At the same time, exclusively when stimulated with the inner circle within this network, the connection between the medial ROI and the right lateral ROI was reduced in these subjects. In addition, across all three study conditions, different inter-network connections appeared to be more pronounced in one of the two groups. However, these appeared to occur nonsystematically across all networks (Figure 9).

The p-values of the statistical tests of these comparisons can be found in the Appendix as Supplementary tables 16-21.

Figure 9. Patterns of functional connectivity of cortical networks relevant for the processing of visual stimuli for the group of patients with brain lesion as well as the according control subjects. This figure was from (106).

2.4 Discussion

The aim of this study was to investigate the influence of a brain tumor or space-occupying brain lesion in the occipital lobe on the BOLD signal during fMRI retinotopic mapping. Indications of preserved retinotopic organization of the visual cortex were sought here at the functional level. The selected methods included direct comparison of cortical activation patterns in response to stimulation of central, middle, and peripheral parts of the visual field with circles of three different sizes and functional connectivity within and between relevant cortical networks between patients and healthy control subjects. Here, the patient groups examined separately were those with a brain tumor or a space-occupying brain lesion, as the underlying disease was expected to affect the BOLD signal differently (71). To further characterize the patterns of cortical activations, the percent signal change in different regions of the brain that are relevant for processing of visual stimuli, the cluster size of activated voxels in the region of Interest of the calcarine fissure, and the lateralization index within the occipital lobe were also calculated for all three groups.

As expected, the healthy control subjects showed the representations of the correspondingly stimulated parts of the visual field previously described in various studies (82,107) when the cortical activation patterns on whole-brain levels were evaluated. These activation patterns were also found in both patient groups, although they appeared reduced in their extent. This indicates that the retinotopic organization of the visual cortex appears to be intact despite the presence of a brain tumor or space-occupying brain lesion in the occipital lobe. Moreover, the similarity of the cortical activation patterns suggests that this can be adequately mapped using fMRI eccentricity mapping. It can be assumed that this paradigm is suitable to visualize the functionally intact areas of the visual cortex in preoperative examinations, as it has been reported for other stimuli before (58,87,89). Compared with these, the paradigm evaluated here has the additional advantage of being able to distinguish between central and peripheral visual field components, which provides important supplementary information for preoperative planning and may influence the postoperative outcome and prognosis (35,36).

Furthermore, in addition to the similarity of the cortical activation patterns, some variability was seen in the differences between the two groups of patients with assigned control subjects. These suggest that in this case the patients with brain tumor showed smaller differences when compared with the control subjects than the group of lesion patients. These results were confirmed in a region of interest analysis of the cluster size of activated voxels, where the control subjects had the highest values, although these differences from the two patient groups were not statistically significant. In addition, the hemisphere not affected by the tumor/lesion

showed larger clusters of activated voxels in the patient groups. These findings of decreased activation in the affected hemisphere fits with the findings of previous studies (67,70). In addition, this also corresponds to the results of the examination of the lateralization indices (LI) which, although not statistically significant, showed lower values in control subjects, suggesting a more bilaterally balanced activation within the occipital lobe, whereas both patient groups, as expected, showed rather unilaterally lower cortical activation due to the tumor/lesion and thus higher LI values (67,88).

To further characterize cortical activation following stimulation with circles of three different sizes, the percent signal change was calculated in a total of eight visually relevant brain areas of both hemispheres and compared between the groups. The comparison of the affected and unaffected hemispheres of the tumor patients showed significantly more frequent differences than the group of lesion patients, which showed only a single statistically significant difference (DLPFC during outer circle). This reduction in the BOLD signal of the affected hemisphere has also been reported previously (69,93). In addition to the described interhemispheric differences, comparison of the patient groups with the healthy control subjects showed lower PSC values, although these were statistically significant in only one case (calcarine fissure during middle circle). It was also noticeable that the group of lesion patients often had higher percent signal change values than the tumor patients and that these values were similar to those of the control group. Similar results had been reported previously (71), showing that cortical activation ipsilateral to a tumor was decreased, whereas activation ipsilateral to a space-occupying brain lesion was actually higher. When comparing the results of the examination of cluster size of activated voxels and percent signal change in the calcarine fissure, it was noticeable that patients with a space-occupying brain lesion had higher PSC values here, but at the same time had smaller cluster sizes in some cases.

In addition to differences in cortical activation, functional connectivity within and between relevant cortical networks was examined. Both patient groups as well as the healthy control subjects showed extensive cortical connectivity here in single-sample evaluations. When comparing the patient groups with the control subjects, statistically significant changes in intra-network connectivity were found in the Visual, Salience, and Fronto Parietal networks. In addition, reductions in inter-network connectivity of the Default Mode network were found in the brain tumor patient group, which matches previous findings in other studies (121,122).

With regard to the methodology and analyses used, there are some limitations of this study, which should be discussed in the following. First, it should be mentioned that the data from the patients and control subjects were collected in different settings. While the control subjects

voluntarily participated in a study, the patients' MRI data collection was for the purpose of preoperative treatment and planning of further intervention. Here, the influence of the situation on motivation and willingness to cooperate during data collection cannot be excluded. Moreover, it should be added that both locations used different MRI scanners. Therefore, an additional possible influence of scanner effects cannot be completely excluded. In total, data from both 19 patients and 19 age-matched control subjects were examined in this study. The validity of the results obtained from this small sample size, which is due to the rarity of tumor location (21), should therefore be considered. For this reason, no investigations could be performed based on the division according to specific diagnoses, as this would not have allowed adequate interpretation of the results, resulting in the two patient subsamples having heterogeneous diagnoses. Accordingly, the influence that, for example, tumor grade exerts on the BOLD signal could not be taken into account (67). Furthermore, because this is a cross-sectional design, no statement can be made about the long-term nature of the changes found. Therefore, it should be noted that statements regarding differences before disease as well as development after resection cannot be made in this study. Longitudinal collection of fMRI data both pre- and postoperatively would be desirable in this context and would provide additional interesting insights into neuroplastic changes of the visual system during the course of therapy. In summary, the results indicate that patients with brain tumor/lesion show similar cortical activation patterns in the eccentricity mapping paradigm compared to healthy control subjects. However, these seem to be reduced in their expression due to the present disease, as it has already been shown for other paradigms of preoperative planning (67,70). In this regard, the critical discussion of the integrity and reliability of the BOLD signal when examining patients with brain tumors should also be noted. Thus, it cannot be stated with certainty whether the results of reduction in percent signal change and cluster size of activated voxels may be influenced by changes in neurovascular coupling (55). This phenomenon may extend to neurovascular uncoupling, thus having a profound impact on the interpretation of fMRI results in patients with brain tumors. Therefore, it is possible that even functionally intact brain tissue may show no evidence of brain activity (123). One way to reduce the risk of such false-negative findings approach is cerebrovascular reactivity mapping, in which vasoreactivity can be integrated into the fMRI data model (72,124).

2.5 Conclusion

The results of this study suggest that eccentricity mapping is a suitable paradigm for the preoperative examination of patients with tumors and lesions in the occipital lobe. Decisive for

this conclusion are the similarities found in the cortical activation patterns between the patient groups and healthy control subjects. In addition, it should be emphasized that the lesion patients showed similar values as the healthy control subjects with respect to the percent signal change within the calcarine fissure, whereas they showed lower values than the tumor patients with respect to the cluster size of activated voxels in the same area. These results represent a promising starting point for further research to characterize the changes and limitations in neuroplastic processes and reorganization of retinotopic representation associated with brain tumors and lesions in the occipital lobe.

3 EVALUATION OF A NOVEL PREPROCESSING PROTOCOL FOR THE THREE-DIMENSIONAL RECONSTRUCTION OF BRAIN ANATOMY IN PATIENTS WITH GLIOBLASTOMA MULTIFORME USING FREESURFER

3.1 Introduction

The continuous development of techniques and methods in the field of MRI data analysis has led to a broad variety of software and tools available to researchers, many of which are provided free of charge. Popular choices include Statistical Parametric mapping (SPM) (125), the FMRIB Software Library (FSL) (126), and FreeSurfer (127). Nowadays, the challenge for a researcher in this field is not so much a lack of choices, but rather to find the software that provides the best possible analysis of the data at hand. It must be noted that each method offers both advantages and disadvantages, and there are also limitations that do not always allow unrestricted use for all types of data. In this context, the study presented below will discuss why the FreeSurfer analysis software has not been considered a suitable method to evaluate MRI data from patients with brain tumors and how this obstacle can be circumvented by using a novel preprocessing protocol.

3.1.1 Obstacles in the analysis of MRI data in patients with brain tumors

MRI data from patients with brain tumors present a particular challenge not only in terms of collection under often difficult conditions, but also in terms of analysis. In addition to anatomical changes due to the tumor, in the case of functional MRI (fMRI) data, a limitation in neurovascular coupling up to neurovascular uncoupling also complicates the evaluation and interpretation (55). In these cases, it is of additional importance to choose analysis software that allows the evaluation of such data characterized by pathologic changes. In this context, the FreeSurfer software, which allows volume-based as well as surface-based analysis of fMRI data, has not been considered a suitable software for such data.

The reason for this conviction is that here, for the analysis of MRI data a three-dimensional reconstruction of the brain anatomy is required, which is created using the T1-weighted structural image (127). This process presents little to no problem for examination data from healthy subjects with intact brain anatomy. However, for patient data, as the severity and extent of the lesion or the absence of structures increases, problems arise in the execution of individual steps in the reconstruction process (128). This is particularly evident in the step of brain tissue segmentation as this uses the intensity-normalized gray levels of the input image to divide the brain into gray matter, white matter, and corticospinal fluid (CSF) based on their intensity.

Especially areas that appear as white matter hyperintensities in the FLAIR-weighted images, which appear due to the particular lesion and do not occur in this form in healthy subjects, can be difficult to interpret in the segmentation. These appear as hypointense in the T1-weighted image and can lead to misinterpretation of the gray values, especially in the case of subcortical localization within the white matter. As a result, parts of the tumor are declared as gray matter or CSF or are not even included in the segmentation (127). This erroneous segmentation complicates subsequent anatomical assignment of tissue to individual brain regions (129). Consequences range from faultily segmented areas that could be corrected with some effort to missing of entire brain areas containing the tumor (130). However, since three-dimensional reconstruction is the basis for further analysis in FreeSurfer such as cortical thickness calculation as well as functional MRI and diffusion-weighted data analysis, an error-free reconstruction that adequately represents brain anatomy is of great importance.

3.1.2 Previous approaches addressing these problems

The procedure of previous studies in dealing with data of patients with brain lesions in the context of analyses with FreeSurfer varies and is strongly dependent on the respective sample or its type of lesion as well as the aim of the study (130).

Of course, in such cases, there is the possibility to initially decide not to use FreeSurfer and to use an analysis tool that does not require a three-dimensional reconstruction of the brain anatomy. In such cases, SPM or FSL are often used as they use a volume-based approach and thus do not require reconstruction of gyri and sulci, which are used for surface-based analyses as in FreeSurfer.

Some studies already used FreeSurfer to examine MRI data from patients with brain tumor or lesion but limited their region of interest to areas away from the tumor. For example, Karunamuni et al. (2017) examined hippocampal volume in patients with gliomas. Here, patients whose tumor protruded into the hippocampal region based on the T1-weighted image after contrast administration, and the FLAIR-weighted image based on the extent of lesion-induced hyperintensities (131). Thus, error-free reconstruction of the cortex surface was not necessary, meaning that the presence of a brain tumor did not affect the analysis.

If the lesion is located in the area of interest, the further procedure should be planned depending on its size and extent. In the case of smaller local lesions, there is a realistic chance that their influence on the reconstruction is so small that they can be compensated for by FreeSurfer. In cases of other lesions, such as inflammatory lesions in multiple sclerosis, where it is necessary to compensate for them before reconstruction, a lesion filling approach, in which the affected

voxels are replaced by intensity values of neighboring unaffected voxels, can be used to reduce their influence (132).

For larger lesions that may also involve different cortical structures, more complex solution strategies are needed to compensate for them. For example, areas affected by the tumor can be excluded from further analysis by cost function masking (133). This may improve the performance of the study, but can equally lead to a deterioration in the quality of the data, especially those from patients with large lesions (134). As an alternative, Solodkin (2010) introduced a "virtual brain transplantation" approach when examining data from stroke patients, by which tissue from the healthy hemisphere is mirrored onto the affected areas within an anatomical image to create a modified, pseudo-healthy T1-weighted image (128). This idea is based on the so-called enantiomorphic normalization (134).

3.1.3 Aim of the study and hypotheses

The aim of this study was to develop and evaluate a standardized protocol with processing steps that enable three-dimensional reconstruction in FreeSurfer. It was important that these steps should contain as little subjective influence as possible and should be as automated as possible. Overall, previous studies showed that it seems to be possible in principle to use FreeSurfer even in patients with larger lesions such as stroke (128). These also showed that anatomical parcellation was comparable to manually created segmentations (130). Accordingly, it can also be assumed in the case of this study that a complete reconstruction of MRI data from patients with glioblastoma is feasible, as long as these data are appropriately preprocessed beforehand.

Hypothesis 1

H0: FreeSurfer cannot be used for MRI data from glioblastoma patients as a three-dimensional reconstruction of brain anatomy is not possible without error.

H1: Three-dimensional reconstruction of brain anatomy using MRI data collected from patients with glioblastoma is possible in FreeSurfer by using preprocessing steps.

Previous studies have already shown that the results of structural analyses such as gray matter volume or cortical thickness (135,136) are highly correlated between FreeSurfer and SPM12 or the CAT12 toolbox implemented therein. Although, in most cases, systematic over- or underestimations of one of the toolboxes studied were also found. These studies, however, involved solely morphological comparisons, whereas functional MRI data were disregarded. In this study, based on the results of structural analyses, it was assumed that only minor differences

should be found even when comparing the results of functional MRI data. To evaluate this, a healthy control sample was to show that there is no difference between the results of the two analysis softwares, before this is also evaluated for patient data.

Hypothesis 2

H0: The results calculated and compared for a healthy control sample in FreeSurfer and SPM12 are significantly different.

H1: The calculated results of functional MRI analyses obtained on a healthy control sample are not different from those obtained in SPM12.

Hypothesis 3

H0: The results of the fMRI analyses of the patient sample differ significantly between FreeSurfer and SPM12.

H1: The calculated results of functional MRI analyses collected on the patient sample are not statistically significantly different between FreeSurfer and SPM12.

For the patient sample, a protocol with preprocessing steps was developed to modify a high-resolution T1-weighted image so that it can be used in FreeSurfer for three-dimensional reconstruction. This reconstruction is subsequently the basis on which the functional MRI data were analyzed. It is uncertain how much this modification affects the results of the fMRI analyses. Therefore, the results from FreeSurfer were compared with those from SPM12 using both the modified and unmodified T1-weighted images.

Hypothesis 4

H0: When comparing the results from FreeSurfer and SPM12, there are significant differences between the analyses using the modified and unmodified T1-weighted image.

H1: The influence of the modification of the T1-weighted image is neglectable as there are no statistically significant differences between the results of FreeSurfer and those of SPM12 using both the modified and unmodified T1-weighted image.

3.2 Methods

The ethics committee of the University of Regensburg approved the conduction of this retrospective study (reference number: 19-1635-104).

3.2.1 Sample selection

To investigate the hypotheses stated in the last chapter, this study examined preoperative fMRI data from patients with glioblastoma and fMRI data from healthy control subjects.

To select the patient sample, a database, including all patients with preoperative fMRI examinations acquired during routine treatment of patients at the University Hospital Regensburg was searched.

The inclusion criteria for a data set into the study was the availability of 4 different structural images (T1, T1C, T2, FLAIR) in the medical record of the respective patient, whereby the T1-weighted image had to be a 3D-MPRage image, as well as fMRI data of the language paradigm used in this hospital for preoperative fMRI.

In addition, retrospectively selected data of healthy control subjects were included in this study. This data was acquired for another study which evaluated the same language paradigm as was used for the patients.

3.2.2 Image Acquisition

For patients, the examination setup was the same as already described in chapter 2.2.2.

A T2*-weighted gradient echo planar imaging (EPI) was used to acquire functional images (TR = 2000 ms, TE = 30 ms, FoV = 192 × 192 mm^2, flip angle = 90°, voxel size = 2 × 2 × 3 mm^3). In each image volume, 31 axial slices were obtained using an interleaved scan sequence. In addition, a T1-weighted structural image (TR = 1980 ms, TE = 3,670 ms, FoV = 256 × 256 mm^2, flip angle = 9°, voxel size = 1 × 1 × 1 mm^3) was obtained.

Data from healthy control subjects were collected at the District Hospital Regensburg as part of a study on a Siemens Allegra 3T head scanner (MAGNETOM Allegra; Siemens, Erlangen, Germany) using a 1-channel phased-array head coil. Visual stimuli for each task were projected onto a projection screen at the end of the scanner and visualized to the subjects via a mirror on the head coil. Functional images were acquired using a T2*-weighted EPI sequence (TR = 2000 ms, TE = 30 ms, FoV = 192 × 192 mm^2, flip angle = 90°, voxel size = 3 × 3 × 3 mm^3). A total of 34 slices were acquired here. In addition, a high-resolution T1-weighted structural image with 160 slices was acquired in each subject (TR = 2300 ms, TE = 2.91 ms, FoV = 256 × 256 mm^2, flip angle = 9°, voxel size = 1 × 1 × 1 mm^3).

All stimuli were created and presented with the stimulus delivery and experimental control program Neurobehavioral Systems Presentation (www.neurobs.com). Stimuli were presented in written form and were centrally arranged and presented in black font on a light gray background.

Figure 10. Example of the stimuli used in the verb generation paradigm.

For this study, a semantic paradigm for verb generation (Figure 10) was used because it had the largest patient sample available. During the language task patients and controls were instructed to generate a semantically associated verb corresponding to a presented noun (e.g., milk - drink). During the acquisition, blocks of stimulation (20s) and rest period (fixation of a cross; 10s) alternated. Here, during the stimulation period, a new stimulus was presented every 2s, to which the patients were asked to respond by forming the corresponding verb in their mind without speaking. This was to avoid movement artifacts as well as sensorimotor language-supportive but not language-critical brain activation.

3.2.3 Preprocessing protocol and three-dimensional reconstruction

The relevance and necessity for creating a preprocessing protocol that allows for complete and accurate cortical reconstruction in FreeSurfer becomes clear when dealing with the T1-weighted image of a patient with a brain tumor. In this case, the reconstruction runs properly up to the creation of the white matter segmentation and the filling in of the white matter mask. Since the tumor cannot be clearly assigned to gray or white matter due to its out-of-range gray shades in the T1-weighted image, this often results in either a misinterpretation (segmentation of a subcortical tumor as gray matter) or a hole (tumor missing) in the mask.

This caused large defects to be found in the subsequent steps, especially in the automatic topology fixer, with a number of faulty vertices of 20000-60000 not uncommon. Considering that the processing time to repair a defect in this step is equal to the square of the number of vertices involved, defects in this size range can be expected to take several days to weeks or even months to process. For studies involving not only a single but multiple patients, such reconstruction times are unacceptable given that the cost of processing bears no relation to its benefit. Moreover, these repair processes were not infrequently aborted without results after

prolonged reconstruction times, since this step was very detrimental to working memory and often exceeds its capacity. Therefore, during this study, different ways of preprocessing the T1-weighted image were evaluated in order to generate the most suitable support for reconstruction for further data analysis of MRI data (Figure 11).

Figure 11. Three-dimensional reconstruction of a patient with temporal glioblastoma using a native T1-weighted image (left) and the same patient using a contrast enhanced T1 image (middle). For comparative purposes, the successful reconstruction of a healthy control subject is also illustrated (right).

The preprocessing protocol to be evaluated in this study is based on segmentation of the patient's tumor using multimodal MRI images. For this purpose, T1-weighted images with and without contrast agent as well as T2- and FLAIR-weighted images were used as input for the Bratumia software (137). Using the accurate algorithm option, the individual tumor of each patient was segmented into the three compartments necrosis, contrast enhancing part and edema. Taken together, these resulted in a binary mask that covered the entire tumor including all changes in gray values in the MR images (Figure 12).

Figure 12. Illustration of the in Bratumia inserted T1, T1C, T2 and FLAIR images and the resulting binary lesion map.

In a second step, this mask was used to replace all voxels thus defined as brain tumor with healthy tissue of the contralateral hemisphere using enantiomorphic normalization of the Clinical Toolbox (134,138). This step utilizes the symmetrical properties of the brain, in which the two hemispheres resemble each other except for a few differences. Consequently, this step limits the efficacy of this approach only to unilaterally confined tumors without midline shift. In this case, the portion of the tumor protruding into the unaffected hemisphere would be transferred as well, forming, for example, a small tumor remnant in the middle of the brain. It is also possible that structures that are normally located medially may now appear in duplicate. These factors must be kept in mind when using the protocol. The modified T1-weighted image, which now no longer contained a tumor due to the preprocessing steps, was then used for three-dimensional reconstruction in FreeSurfer. For this, the recon-all command with default settings was used (Figure 13).

Figure 13. The binary lesion map (boundaries indicated in red) obtained from the first step was used to replace the tumor in the native T1-weighted image (left) with healthy tissue from the opposite hemisphere (middle). The resulting modified T1-weighted image was then used for three-dimensional reconstruction in FreeSurfer (right).

In order to quantitatively capture the time and resource savings that preprocessing of the T1-weighted images provides, the T1-weighted images that were not modified were also reconstructed in addition to the three-dimensional reconstruction described above. In each case, both reconstruction time and abortion rate were determined. Since for patients with brain tumor a native MPRage is rarely available, but usually contrast-enhanced T1-weighted images are acquired, these were also reconstructed both modified and unmodified. Here, reconstruction time and abortion rate were also determined. For comparison purposes, this was additionally collected for unmodified T1-weighted images of healthy control subjects.

3.2.4 fMRI data analysis in FreeSurfer

Analysis of the functional MRI data was performed using FreeSurfer Functional Analysis Stream (FsFast). During preprocessing, the collected fMRI data were first prepared for statistical analysis. For this purpose, a template was created using the first image of the functional image series. This was then used to coregister the functional images and the structural image. In addition, a binary brain mask was created based on the template to limit the analysis to the brain only and to save resources. For this purpose, FreeSurfer uses the Brain extraction tool (BET) implemented in FSL (139). In the next step, motion correction is performed. The deviation of each frame of the whole examination is compared with the first frame of the series. The calculated head movements in three translational and three rotational directions are compensated for and this information is also stored so that it can serve as a

regressor in the statistical analysis. The last step of preprocessing is resampling to the standard space together with spatial smoothing. Here, the images were smoothed using a FWHM kernel of 8 x 8 x 8 mm^3. The template brain in standard space is referred to as fsaverage in FreeSurfer and was created from the average of the brains of 40 healthy subjects.

Statistical analysis of the preprocessed data is performed using general linear model (GLM). For this, the stimulation periods used in the paradigm are used as regressors and convoluted with the hemodynamic response. The fixation period was not explicitly modeled as a separate regressor and served as an implicit baseline. Motion parameters previously calculated in the motion correction step were also considered to be included in the model to minimize motion-associated activations.

To investigate the clinical utility of FreeSurfer, data from patients and control subjects were analyzed in native individual space. The analyzing steps were the same here, only resampling to the standard space was omitted.

3.2.5 fMRI data analysis in SPM12

The analysis of the functional MRI data using SPM12 included analogously the same steps as the evaluation using FsFast. During motion correction, the individual functional volumes were matched to the first image of the run and the six motion parameters were stored. Subsequently, coregistration of the structural to the functional images was performed. After segmentation of the anatomical image, the deformation field computed there was used to normalize the functional data to the standard MNI space. Subsequently, the functional images were smoothed with a FWHM kernel of 8 x 8 x 8 mm^3 to increase the signal-to-noise ratio. Based on the general linear model (GLM), the individual design matrices were composed of a regressor reflecting the verb generation condition convolved with the hemodynamic response function. As in the evaluation with FreeSurfer, the fixation period served here as an implicit baseline. Motion parameters derived from realignment were also included to reduce intraindividual variance.

To compare the extent of the influence of the modification of the T1-weighted image carried out using the preprocessing protocol on the results, all patient data were analyzed once each with modified and unmodified T1-weighted image. This allowed the evaluation of the effect of this modification and should also prevent systematic differences in the comparison of the two analysis methods.

For fMRI analysis in native individual space in SPM12, the functional images were preprocessed and analyzed with the same parameters without normalization to the standard space.

3.2.6 Comparison of functional MRI results between FreeSurfer and SPM12

In order to compare the fMRI data in both standard MNI space and native subject space after preprocessing and statistical analysis, the generated t-maps were used. In these, the calculated t-statistics for each voxel of the brain are presented as a three-dimensional map. Based on the intensity value of the gray value, the individual t-value was thus recorded for each voxel. To compare these t-maps, the Sørensen-Dice coefficient (SDC) was used (Figure 14), which provides a measure of the similarity between two samples (140,141).

Since the SDC can only compare binary MRI data, the calculated t-maps were first binarized at a fixed value of t = 3. This means that all t-values ≥3 are encoded with a 1 and values <3 with a 0. For the binarized t-maps, the similarity between the t-maps from FreeSurfer and SPM12 were then calculated in Matlab version 2020b.

Figure 14. The results of the 1st level analyses, calculated with FreeSurfer (left) and with SPM12 (right). After binarization of the t-maps at t= 3, these maps are compared using the Sørensen-Dice coefficient.

In addition, to evaluate the influence that the modified T1-weighted image might have on the segmentation and normalization of the functional data, the SDC between the results of these two SPM12 analyses and the results of FreeSurfer were also calculated.

3.2.7 Statistical data analysis

Acquired numerical data such as the reconstruction time of reconstructions of different variants of T1-weighted images and their abortion rate were analyzed using SPSS version 28 (IBM, Armonk, NY, USA).

Reconstruction times of the different versions of the patient data were compared within this group using paired-sample t-tests. To adjust for multiple testing, the Benjamini-Hochberg correction (false discovery rate; FDR) was used (142). The comparison of these data to the healthy control group was performed in a one-way ANOVA, where FDR-corrected post-hoc t-tests were used to describe the significant results in more detail.

The abortion rate during reconstruction was determined for each of the four variants of the patient data and compared in a Cochran Q test and specified by FDR-corrected post-hoc tests.

Comparison of SDCs between the patient and control groups was performed using Mann Whitney U tests (FDR-corrected) and within the patient group using a Wilcoxon test.

Statistically significant results are marked with * for $p < .05$, ** for $p < .01$, and *** for $p < .001$. The standard error (SEM) was used to create the error bars. Corel Draw version 19 was used to graphically present the results.

3.3 Results

3.3.1 Description of the sample

The patient sample included N = 27 retrospectively selected datasets that were collected during routine preoperative fMRI examinations at the University Hospital Regensburg as part of medical patient care. At the time of examination, the patients (11 female, 16 male) were aged between 47 and 79 years (M = 60.48, SD = 8.781) and were diagnosed with a glioblastoma multiforme after surgery.

In addition to the analysis of MRI data from patients with brain tumor, data from 33 healthy control subjects were also collected as part of a study. These completed the same fMRI language paradigm as the patients. This control group serves primarily as a comparison sample to investigate the functioning of all analyses described below also on the healthy brain.

3.3.2 Comparison of reduced reconstruction time and abortion rate

For all 27 patients, the described preprocessing protocol consisting of segmentation of the individual tumor using four MRI modalities and filling affected areas with tissue from the unaffected hemisphere was applied for both T1-weighted image (T1) and contrast-enhanced T1-weighted (T1C). A total of four reconstruction runs were performed for each patient (Figure 15)), using the modified and unmodified version of the T1 and T1C images, respectively. Here, the processing time required for the reconstruction process and the abortion rate due to excessively large defects were measured. For comparison purposes, these parameters were also collected from the group of healthy control subjects.

Figure 15. Three-dimensional reconstruction of a patient with temporal glioblastoma using a native T1-weighted image (left), a contrast enhanced T1 image (middle) and the modified T1-weighted image after application of the preprocessing protocol (right).

This showed that all patient data that had been preprocessed with the described protocol could be reconstructed without any issue (abortion rate 0%) with a mean reconstruction time of 4.56 hours. Comparing this mean reconstruction time with those of the other three patient conditions, paired samples t-tests with FDR correction (Figure 16) revealed statistically significant differences from the reconstruction time of T1 without modification ($t(22) = -2.846$;

$p_{adj.}$ = .014) and T1C with modification (t(18) = -3.095; $p_{adj.}$ = .012) and without modification (t(12) = -5.091; $p_{adj.}$ = .002). In addition, the other conditions also differed from each other, which were T1 unmodified from T1C modified (t(15) = -2.427; $p_{adj.}$ = .028) and T1C unmodified (t(11) = -4.481; $p_{adj.}$ = .003), as well as T1C modified from T1C unmodified (t(10) = -2.853; $p_{adj.}$ = .020). Comparing each condition with the reconstruction time of data from healthy control subjects, a one-way ANOVA showed a significant difference (F(4,110) = 11.164; p < .001). FDR-corrected post-hoc tests showed that the mean reconstruction time of control subjects was statistically different from those of the T1C modified ($p_{adj.}$ < .001) and T1C unmodified ($p_{adj.}$ = .001) conditions, but not from the T1 modified ($p_{adj.}$ = .733) and T1 unmodified ($p_{adj.}$ = .124).

Figure 16. Comparison of the reconstruction times (left) and abortion rates (right) of the native T1-weighted image (T1) and T1-weighted data after administration of contrast agent (T1C). A total of four reconstruction runs were performed for each patient, one using the modified and unmodified T1 and T1C images, respectively.

Moreover, when the abortion rates of the four different patient group reconstruction conditions were compared, a Cochran Q test showed a statistically significant difference in connected samples (χ^2 (3) = 21.787; p < .001). Post-hoc tests showed that the discontinuation rates of both unmodified T1-weighted images with and without contrast medium ($p_{adj.}$ = .010) and the

modified T1-weighted image differed from the modified T1C ($p_{adj.}$ = .029) as well as unmodified T1C image ($p_{adj.}$ < .001).

3.3.3 Comparison of the analyses of functional MRI data between FreeSurfer and SPM12

To investigate the level of similarity of results between FreeSurfer and SPM12, the same functional MRI data were analyzed in both analysis tools and the results were compared. For this purpose, the calculated t-maps, which present the calculated t-statistics for each voxel using intensity coding of the gray values in three-dimensional form, were compared using the Sørensen-Dice coefficient (SDC). The control group showed values between .41-.89 (median .81) for the results in native space and .43-.86 (median .80) for evaluations in standard MNI space. For the patient group, this showed values of .60-.88 (median .80) and .57-.86 (median .75). The results of both groups were compared with each other for the evaluation in the native as well as in the standard MNI space (Figure 17A) using the Mann-Whitney-U test (FDR-corrected). There were no statistically significant differences for evaluations in either native space (U = 380,000; Z = -.973; $p_{adj.}$ = .330) or MNI space (U = 321,000; Z = -1.850; $p_{adj.}$ = .129).

Figure 17. (A) Comparison of the SDC between the patients and the healthy controls for data in native as well as the MNI standard space. (B) The results were also compared in MNI space with those of SPM12 using the modified and the unmodified T1-weighted image.

3.3.4 Analysis of the influence of the modification of the T1-weighted image

In order to investigate the influence of the modification of the T1-weighted image on the analysis of fMRI data, the results were compared with those from SPM12. For the segmentation step in SPM12, the modified T1-weighted image as well as the unmodified T1-weighted image were used once to calculate the deformation field in independent analysis streams. The results of the two analyses were then compared with those from FreeSurfer, whose basis for normalization into standard space was the modified T1-weighted image. The Wilcoxon test for paired samples showed no statistically significant difference when comparing the two SDCs ($z = 240.500$; $p = .216$; Figure 17B).

3.4 Discussion

The aim of this study was to create and evaluate a standardized protocol with processing steps that allows the three-dimensional reconstruction in FreeSurfer. Here, a mask is obtained by segmenting the tumor to define its boundaries. This area is then replaced with tissue from the corresponding site in the unaffected hemisphere, producing a modified T1-weighted image without tumor. This was used for reconstruction in FreeSurfer afterwards (127).

Comparisons of reconstruction times showed no statistically significant differences from those of a healthy control group but from those of the unmodified T1-weighted image of the same patients and from those obtained during reconstruction using contrast-enhanced modified and unmodified T1-weighted images. In addition, comparison of the abortion rate during reconstruction showed that the rate using the modified T1-weighted image (0% abortion rate) was statistically significantly different from those using the modified as well as unmodified T1-weighted image after contrast agent administration. These results suggest that modification of the T1-weighted image according to the protocol presented here not only enables three-dimensional reconstruction in FreeSurfer, but also is comparable to those of a healthy control sample in terms of reconstruction time and abortion rate. This is also consistent with the results of a previous study in which the lesion-affected portion of the brain was also replaced with healthy donor tissue (130). Here, it was also shown that this procedure allows cortical parcellation. Showing this was also the aim of previous other studies (128,134,143). However, it was noticeable that all these studies were limited to the investigation of structural properties such as cortical parcellation, whereas the analysis of functional MRI data could not be found in the literature, neither for patient data nor for healthy subjects.

To evaluate the quality of the results of such fMRI analyses calculated on the basis of this three-dimensional reconstruction, the same data were analyzed both in the individual subject/patient

space as well as in the standardized MNI space and the calculated t-maps were compared. The sample of healthy control subjects showed a median Sørensen-Dice coefficient of .81 in the individual space and .80 in the MNI space. The patients showed comparable values of .80 and .75, respectively. This shows a high degree of agreement in the results between FreeSurfer and SPM12, which did not perfectly coincide. These results are comparable to those found in structural comparisons between FreeSurfer and SPM12 (144) Nevertheless, since these discrepancies occurred in both groups, with SDC not statistically different between patient and control groups, it can be ruled out that this is due to the patients' tumor or modification of the T1-weighted image of this group. Rather, systematic differences involving areas from a binary mask, which is intended to restrict the analysis to the brain tissue area only to save resources, seem to be the reason for these differences. For example, SPM12 includes the region of the eyeballs in the mask because they are fluid-filled and have similar MR properties to corticospinal fluid (CSF). In FreeSurfer this area is not included in the mask, resulting in a systematic difference in the presence of activation artifacts. Furthermore, closer inspection showed that differences between the two methods were mainly noticeable at the margins of the clusters of cortical activations. Slight differences in t-values were shown in these areas, which were noticeable due to the binarization of the masks. For example, the marginal difference between two voxels with t= 2.99 and t = 3.00 could cause the former not to be included in the binary mask because its value was smaller than 3, whereas the t-value of the second voxel was just large enough to be considered. This leads to systematic differences in these areas, which resulted in the failure to find a perfect correspondence between the binary t-masks of both evaluation methods. Furthermore, since the SDC values are similar both in native and after normalization to the MNI standard space, a systematic error due to different normalization approaches can be ruled out. While SPM12 first segments the native T1-weighted image into gray matter, white matter, and CSF and warps these individual tissue classes individually into MNI space, in FreeSurfer the gyri and sulci are transformed into a sphere based on the white matter surface, which is subsequently fitted to a standard brain (125). Accordingly, normalization in FreeSurfer is based on fitting gyri and sulci, rather than normalizing entire tissue classes (145). This makes FreeSurfer insensitive to pathological changes in gray matter such as atrophy resulting from aging. The results of this study suggest that these differences in the normalization process do not affect the results of the fMRI analyses.

Furthermore, it was investigated whether, due to the modification of the T1-weighted image, systematic bias would confound the results of the analysis of functional MRI data. It was assumed that in case of a systematic bias, the Sørensen-Dice coefficient should be higher when

comparing the results from FreeSurfer with those from SPM12, where the modified T1-weighted image was used to calculate the deformation field. Here, both comparisons showed similar SDC, which were not statistically significantly different from each other. This is consistent with a previous study which found that modification of the T1-weighted image by filling multiple sclerosis lesions had no effect on the calculation of the volumes of the different brain tissues in FreeSurfer, whereas it was found to differ significantly in SPM12 (132). Given the described susceptibility of SPM to such modifications and the only minor differences found in this study, it can be concluded that the influence of the modification of the anatomical image on the results of functional MRI evaluations is marginal.

Accordingly, compared to SPM12, the results of fMRI evaluations show comparable results in volume-based analyses. These are provided by both softwares. In a direct comparison, however, it must be stated that the evaluation with FreeSurfer has a worse cost-benefit ratio than SPM12 due to increased time and resource requirements. For purely volume-based evaluations, the latter is more likely to be the tool of choice due to these considerations. Nevertheless, FreeSurfer offers a number of additional analysis and evaluation methods that SPM12 does not provide. The most important method to be mentioned here is the surface-based analysis (127).

Regarding the methods and the study designs, some limitations have to be considered. For example, the application of the preprocessing protocol implies a modification of the T1-weighted image. The influence on the results of the fMRI analysis was considered and analyzed in this study, but cannot be excluded despite a statistically non-significant difference in the Sørensen-Dice coefficient. Due to this aspect as well as the modification of the image itself, it is questionable whether this approach would be suitable for use in preoperative planning, even though there would certainly be advantages due to the availability of new analysis methods. However, this approach is certainly applicable for use in the field of research. Furthermore, by modifying the T1-weighted image, the brain structure was altered in the area of the brain tumor/lesion by replacing this area with healthy tissue from the contralateral unaffected hemisphere. Although this allows three-dimensional reconstruction in FreeSurfer, conclusions about morphological changes in these areas as a result of the disease are no longer possible. In addition, it should be mentioned that the patient and control groups were collected using the same paradigm but on different MRI scanners. However, since cortical activation was not directly compared in this study, but only the calculated SDC of the results between SPM12 and FreeSurfer was considered between both groups, the influence of the different MRI scanner can be considered marginal.

The steps of the preprocessing protocol shown here as well as the evaluation of the fMRI results were limited to patients with glioblastoma in this study. It should be mentioned at this point that this modification of the T1-weighted image can be extended to other brain tumor entities as well as other types of space-occupying brain lesions. This requires accurate segmentation of the underlying lesion which is not provided by the Bratumia software (137), which is limited to the segmentation of glioblastomas. In addition to the manual creation of a lesion map, it is also possible to approximate the extent of the tumor/lesion based on the hyperintensities in the FLAIR-weighted image and use these for masking.

3.5 Conclusion

In summary, modifying a T1-weighted image by replacing the tumor with tissue from the corresponding site in the unaffected hemisphere allows three-dimensional reconstruction in FreeSurfer. Reconstruction times did not differ from those of healthy control subjects. In addition, there was a high degree of similarity in the results of functional MRI evaluations between FreeSurfer and SPM12, suggesting that both are suitable for this use. Comparison of the results using the modified and unmodified T1-weighted image did not show differences in the results. This suggests that the effect of modification on the results of the fMRI analyses is marginal. Overall, this approach thus provides the opportunity for new investigations that are not possible with other methods.

4 ANALYSIS OF STRUCTURAL AND FUNCTIONAL NEUROPLASTIC CHANGES IN PATIENTS WITH DIFFERENT GLIOBLASTOMA TUMOR GROWTH PATTERNS

4.1 Introduction

4.1.1 Glioblastoma multiforme

This study refers to the analysis of glioblastomas, a subtype of gliomas. Since these have already been described in more detail in chapter 1.2, only the specific characteristics of glioblastomas will be discussed in this chapter. For aspects that apply to both gliomas and glioblastomas, reference is made to the corresponding chapter.

Definition and epidemiology

The glioblastoma multiforme (GBM) represents an undifferentiated, fast growing brain-derived and exclusively malignant tumor of the highest WHO grade 4. Histologically, it belongs to the astrocytic tumors that arise from neuroepithelial tissue (146).

GBM is a brain tumor that manifests mainly in elderly patients with a median age of onset of 65 years. In this context, the incidence is 3.23/100 000 persons, with men being more frequently affected with 4.04/100 000 than women with 2.53/100 000 (21,25). In most cases (95%), the diagnosis is a de novo primary GBM, while in 5% of cases, there is a secondary GBM manifesting from a WHO grade 2 or 3 tumor. It has been noted that patients with secondary GBM are on average 10-15 years younger than patients with primary GBM (146,147).

Most commonly, glioblastoma occurs subcortically in the hemispheres of the cerebrum. They can occur in all lobes of the brain, but some localizations are more common than others. Among these, localization in the frontal or temporal lobes, as well as combined fronto-temporal localization, occurs most frequently. Localization in the occipital lobe is least common (21).

Along with diffuse growth preferentially along myelinated fibers, glioblastoma exhibits marked infiltrative growth, which was described as early as in 1940 (148). Due to its infiltrative nature, rapid extension into adjacent brain structures up to the contralateral hemisphere via corpus callosum is not uncommon, resulting in the observation of new formation of tumor mass at secondary sites as well (66).

Clinical appearance

Due to the rapid growth of glioblastomas, symptoms usually appear within a few weeks or months. They are usually progressive over longer periods of time, but may also occur suddenly,

for example, when there is hemorrhage inside the tumor. The symptoms are comparable to those of brain tumors in general (see 1.2.3). At the macroscopic level, hemorrhages, cystic changes, and necrosis can often be seen in addition to tumor tissue (28).

Diagnosis

As with brain tumors in general, magnetic resonance imaging is considered the gold standard in the initial diagnosis of glioblastoma. The T1-weighted image initially shows the relationship of the tumor to normal brain anatomy. Here, the glioblastoma appears iso- to hypointense. The T1-weighted image with contrast agent administration is particularly relevant for diagnostic clarification in the case of glioblastoma. Since the blood-brain barrier is usually disturbed in this tumor, the contrast agent also accumulates inside it. The contrast agent margin thereby demarcates the actual tumor from perifocal concomitant reactions. In the T2-weighted or FLAIR sequence, the extent of the entire tumor can be visualized showing an hyperintense area around the accumulation of contrast agent of the T1-weighted image. Accompanied by edema and infiltrating tumor cells are heterogeneously hyperintense (28).

However, imaging techniques are not sufficient to confirm the final diagnosis. Histological examination of a tissue sample obtained by biopsy or surgical resection is required. Microscopic examination reveals a variable and diverse appearance. An important characteristic of GBM is a high cell density. In addition, necrosis and / or microvascular proliferation may occur .

Furthermore, various molecular markers play an important role. These are also used to determine a diagnosis according to the currently valid WHO classification (31). With regard to isocitrate dehydrogenase (IDH) 1 / 2, there is no mutation, but the presence of the wild type. The same applies to histone H.3-G34. In addition, mutation of the promoter of telomerase reverse transcriptase (TERT) and / or amplification of the epidermal growth factor receptor (EGFR) gene and / or a +7/-10 copy number change may be present. Methylation of the MGMT promoter will also be determined as this is an important prognostic factor (31,32).

Therapy

An untreated glioblastoma usually leads to the patient's death within a few weeks to months. Like brain tumors in general, surgical resection, radiation and chemotherapy are the treatment methods of choice depending on the age and general condition of the patient as well as the localization of the tumor.

The goal of surgery, as it is for brain tumors in general, is to reduce mass and symptoms and to confirm the diagnosis by tissue biopsy. The objective is to remove the portions of the

glioblastoma that show contrast on MRI in order to achieve a high degree of local tumor control. In this regard, complete resection has a positive effect on survival time compared to purely conventional therapy (Stupp, 2009). However, complete resection of all tumor cells is difficult to achieve in most cases due to extensive infiltrative growth of the tumor (56,66).

The combination of radiation and chemotherapy with temozolomide has become the gold standard in the treatment of glioblastoma. In this regard, the published EORTC-NCIC trial, which included over 500 patients, showed this combination to be significantly superior to radiation therapy alone (149). The group of patients continued to be followed after the publication of the initial results, so that results on 5-year survival rates are also available. This was almost 5 times higher than in the study group that received radiation therapy alone (150).

The current standard is a combination of surgical resection, radiation therapy and chemotherapy to achieve the best possible outcome through a combination effect.

In recent years, the use of Tumor Treating Fields (TTFields) has also become established in the treatment of newly diagnosed glioblastomas. The concept of this therapy is based on the effect of rapidly changing electric fields on frequently dividing cells such as tumor cells. The tumor therapy fields are generated via electrodes located, for example, in a cap that the patient can wear directly on the scalp. The electric fields generated in this way interfere with cell mitosis by restricting the formation of microtubules and thus spindle formation, and they lead to the destruction of cells undergoing cell division. The result is an increased apoptosis rate, so that the growth of the malignant tissue can be slowed down and this can even lead to a reduction in the size of the tumor. This procedure, which complements classical therapy, leads to a significant prolongation of both progression-free and overall survival of glioblastoma patients without a significant increase in side effects (151,152).

Prognosis

Glioblastoma is considered a malignant tumor and is associated with an extremely unfavorable prognosis even with the best possible therapeutic treatment. The 1-year survival is about 40%, meaning that more than half of the cases die within the first year after diagnosis. This is also reflected in the median survival of 8 months across all age groups. It is also noticeable that the median survival of patients is also related to age, with younger patients often showing a higher median survival time (25,153).

4.1.2 Cellular and molecular heterogeneity and subclassification approaches

The addition of "multiforme" to the term glioblastoma is intended to illustrate the variable appearance of this brain tumor. Microscopically, this is reflected in a diversity in the size and shape of the tumor cells. In addition to increased invasiveness, glioblastomas are characterized by heterogeneity at both the inter-tumor and intra-tumor levels (154). This not only affects the diagnosis, but also the selection of an optimal treatment for the individual patient.

Recent studies have addressed inter-tumor heterogeneity and propose a subdivision of this heterogeneous disease based on different gene expressions. In this context, Phillips et al. (2006) distinguished between three different subtypes (proneural, proliferative, and mesenchymal) in high-grade gliomas, which also proved to be prognostically relevant (155). In contrast, further studies assume four subtypes, which were furthermore demonstrated in cell culture (156,157). Here, knowledge of the inter-tumor heterogeneity of glioblastomas, as well as their genetic and molecular basis, offers the possibility of choosing a treatment better tailored to the individual subtype. However, intra-tumor heterogeneity must also be considered in this context. This is characterized by the fact that individual areas or cells of the same tumor can be assigned to different subtypes based on the evaluations. This has an additional impact on prognosis, with increasing intra-tumor heterogeneity being associated with poorer prognosis (158).

4.1.3 MRI heterogeneity and subclassification approaches

Glioblastoma shows an inhomogeneous appearance not only at the microscopic level, but also macroscopically in the MRI. In this context, examination using imaging techniques not only offers the advantage of non-invasiveness, but also allows the tumor to be recorded in its entirety. This reveals a usually substantial accumulation of contrast agent surrounding the necrotic part of the tumor. In addition, this accumulation of contrast agent is surrounded by peritumoral edema. Furthermore, any hemorrhage that may have occurred into the glioblastoma as well as vessels within the tumor can be visualized. The shape of the tumor itself and that of the accumulation of contrast agent, which results from disease-related disruption of the blood-brain barrier, may vary (6,159).

Although the heterogeneous appearance of glioblastoma in magnetic resonance imaging has been known for a long time (see, e.g., Johnson, 1989), this heterogeneity was evaluated as a prognostic criterion only a few years ago. For this purpose, Visually AcceSAble Rembrandt Images (VASARI) features were developed to describe qualitative differences (160), which attempts to categorize the heterogeneous group of gliomas based on features such as tumor size and localization or proximity to eloquent cortex. These were also shown to be prognostically

relevant along with other factors such as age and general condition (160). In addition to these qualitative features, quantitative analyses of medical images of different modalities using radiomics features have also been established. This is based on the assumption that data from imaging modalities can be used to make predictions about tissue characteristics, diagnoses, and disease progression, which usually require molecular examinations following biopsy collection. This has also demonstrated relevant insights for brain tumors, including predictions of tumor grade or survival (161–164). The features have also been used to predict the molecular subtypes of the heterogeneous group of glioblastomas and the formation of recurrence (165,166).
In addition, this approach also allowed subclassifications of glioblastomas based on morphological rather than molecular features. In this context, cluster analysis was used to identify three morphological subtypes based on shape, texture, and marginal sharpness. These also appeared to be prognostically relevant (167). The reproducibility of these results was shown by further publications shortly afterwards. This showed the prognostic relevance of the shape of the tumor, which was independent of age, general condition, and tumor volume (168). In addition, a low geometric heterogeneity and / or a spherical margin seem to have a positive impact on prognosis (169). These results suggest that morphological heterogeneity of glioblastomas is not a matter of coincidence, as its relevance is supported by empirical data.

4.1.4 Aim of the study and hypotheses

The aim of this study was to further examine the previously described heterogeneity of glioblastomas using structural and functional magnetic resonance imaging. The focus was to characterize the heterogeneous group of glioblastomas based on the previously described subtyping using the morphological parameters with regard to neuroplasticity.
As previous studies have shown, the presence of a glioblastoma leads to pathological changes in the microstructure of the white matter. This can be quantified via the fractional anisotropy (FA) using diffusion-weighted imaging (DWI). Here, previous studies have found reduced FA values compared to healthy brain tissue (170,171). Due to the diffuse growth and infiltration of tumor cells into healthy brain tissue, it is assumed that structural neuroplastic changes are not limited to the area of the tumor defined by the contrast agent, but rather are also found in the surrounding tissue (172). This was also reflected in a reduction of fractional anisotropy not only in the area of edema, but also necrosis and contrast enhancing tumor (173,174). Considering previous research results, it can also be assumed in this study that this intra-tumor heterogeneity between different proportions of the tumor can also be shown in this study. For this purpose, within the two patient groups with uniform and diffuse tumor growth patterns, the individual

tumor compartments of necrosis, contrast-enhancing tumor, and edema were examined and compared with respect to their mean fractional anisotropy (FA) values. As previously shown in other studies, it can be assumed that the necrosis part of the tumor should have a lower FA value, whereas higher values should be found in the edema compartments (174).

Hypothesis 1

H0: There is no evidence for intra-tumor heterogeneity in the two patient groups with uniform and diffuse tumor growth patterns as these show no statistically significant differences in the values of fractional anisotropy between the individual tumor components.

H1: Intra-tumor heterogeneity can be demonstrated in both patient groups with uniform and diffuse tumor growth patterns via statistically significant differences in the values of fractional anisotropy between the individual tumor components.

Furthermore, fractional anisotropy was used not only to further characterize glioblastoma, but also for diagnostic purposes. In this context, FA was shown to be a reliable factor for differentiating between glioblastoma and brain metastases as GBM patients showed increased FA values in the tumor areas (173,175,176). In addition, fractional anisotropy was shown to have predictive value and to allow inferences about the prognosis of patients with glioblastoma (177,178). Considering previous research findings in which the glioblastoma subtypes examined in this study have also been shown to have prognostic value (167,169), it is hypothesized that these differences between the two groups of patients studied here should also be reflected in the values of fractional anisotropy.

Hypothesis 2

H0: There is no statistically significant difference between the tumor growth patterns observed in the two patient groups with uniform and diffuse tumor growth pattern with respect to the fractional anisotropy of different compartments of the tumor.

H1: The two patient groups with uniform and diffuse tumor growth pattern show statistically significant difference in fractional anisotropy. It is assumed that the prognostically less favorable group of patients with diffuse tumor growth pattern has lower FA values than the group of patients with uniform tumor growth pattern.

In addition to pathological changes at the microstructural level, those at the functional level were also investigated in order to quantify differences between the two patient groups with

uniform and diffuse tumor growth patterns. It has already been shown in previous studies that a tumor significantly affects the level of BOLD signal (68,94) as well as the extent of cortical activation (69) in the motor and somatosensory cortex. It was also shown that the malignancy of a tumor is also an important influencing factor (67), which can have a significant effect on the level of the BOLD signal. Given the prognostic value of subdividing the heterogeneous group of glioblastoma patients (167,169), in this study it is assumed that this is also reflected at the functional level and can be quantified using the percent signal change as well as the lateralization index (LI).

Hypothesis 3

H0: There is no difference in percent signal change within the language-relevant regions of interest between the two patient groups with uniform and diffuse tumor growth patterns. This is further demonstrated by similar lateralization indices of both groups, which has a high value due to a high language lateralization.

H1: There are statistically significant differences between both patient groups in the percent signal change within the language-relevant regions of interest, with the patients with uniform tumor growth pattern showing higher PSC values than the patients with diffuse tumor growth pattern. The lateralization index also shows statistically significant higher values in the group of patients with uniform tumor growth pattern.

Hypothesis 4

H0: There is no difference in the percent signal change and lateralization indices within the motor-relevant regions of interest between the two groups of patients with uniform and diffuse tumor growth patterns.

H1: There are statistically significant differences between both patient groups in the percentage signal change within the motor-relevant regions of interest, with the patients with uniform tumor growth pattern showing higher PSC values than the patients with diffuse tumor growth pattern. The lateralization index also shows statistically significant higher values in the group of patients with diffuse tumor growth pattern.

Due to the bilateral nature of cortical activations following motor actions, the usage of a motor paradigm allows, in addition to the direct comparison between groups, the comparison of the BOLD signal between the tumor-affected and the unaffected hemisphere. In this regard, a

difference has already been shown in previous studies resulting in a lower BOLD signal (68,69,93,94) and activation pattern (70,72) in the affected hemisphere.

Hypothesis 5

H0: There is no difference in the percent signal change between the motor-relevant regions of interest between the tumor-affected and unaffected hemispheres within the two groups of patients with uniform and diffuse tumor growth patterns. This is further reflected in the lateralization index, which has a low value in both groups and is not statistically different between the two groups.

H1: Statistically significant differences in the percent signal change can be found between the motor-relevant regions of interest of the tumor-affected and the non-affected hemispheres within the two patient groups with uniform and diffuse tumor growth patterns. Here, the tumor-affected hemisphere shows a reduction in PSC compared with the unaffected hemisphere, with this difference being more pronounced in patients with a diffuse tumor growth pattern. In the lateralization index, the patients with diffuse tumor growth pattern also showed statistically significant higher values.

In addition to the investigation of local differences in percent signal change between both patient groups, changes at the level of cortical networks were investigated. Here, studies with magnetoencephalography already showed that the influence of the tumor was not only locally limited to the affected hemisphere, but had global effects up to the contralateral hemisphere (101,102). In addition, malignancy was shown to be an important influencing factor on the functional connectivity of cortical networks in fMRI (122). Moreover, connectivity of tumor-affected areas was previously shown to have prognostic value for patients with glioblastoma (98). Based on these previous research findings and taking the previously described hypotheses 3-5 regarding the influence of morphological tumor growth pattern on the BOLD signal into account, it is assumed that differences can also be found at the level of cortical networks between the two groups of patients examined here.

Hypothesis 6

H0: The two patient groups with uniform and diffuse tumor growth patterns do not differ in functional connectivity within and between language- and motor-relevant cortical networks.

H1: There are statistically significant differences in functional connectivity within and between language- and motor-relevant cortical networks between the two patient groups, assuming that

patients with uniform tumor growth patterns have stronger intra- and inter-network connectivity than patients with diffuse tumor growth patterns.

4.2 Methods

The ethics committee of the University of Regensburg approved the conduct of this retrospective study (reference number: 21-2564-104).

4.2.1 Sample selection

To investigate the hypotheses proposed in the previous chapter, fMRI data of patients with glioblastoma as well as fMRI data of healthy control subjects were examined in this study.

To select the patient sample, a database was searched that included all patients with preoperative fMRI examinations acquired as part of the routine treatment at the University Hospital Regensburg. Inclusion criteria for this study were a histologically confirmed diagnosis of glioblastoma multiforme and preoperative fMRI with at least one of the language and or motor paradigms. Due to the unilaterality of language abilities, only patients with left hemispheric glioblastoma were included in the sample in the case of the language paradigm. For fMRI studies on the motor system, tumor location was not relevant, so both patients with left- and right-hemispheric tumors were included in the sample. To investigate microstructural changes in the white matter, patients were also determined from those previously selected who had diffusion-weighted imaging and structural MRI data from four different modalities (T1, T1C, T2, and FLAIR) to segment the tumor.

To better interpret the results calculated with the patient group later, their data were compared with those of healthy control subjects without neurological and psychiatric history. In the case of the language paradigms, the subjects already described in chapter 2.2.2 were used again for this study as the three examined fMRI paradigms were the same as used for patients. Since such data were not available for the motor paradigms, the Human Connectome Project (HCP) database was searched for matching subjects. Here, the fMRI data of 1200 healthy subjects are stored and can be used for research purposes after registration. Data on different paradigms, including similar motor tasks comparable to those patients complete in preoperative fMRI, were used for this study (179–183). In order to match subjects based on age, a request to access the Restricted Data was made and granted. As the HCP database contained only subjects up to the age of 37 years, matching to the age of the patients could not be ensured. Therefore, those sex-matched subjects who had the highest age were selected for the sample.

4.2.2 Image Acquisition

The setup for the patient data acquisitions was as already described in chapter 2.2.2 and 3.2.2, as all data were acquired on the same MRI scanner at the University Hospital Regensburg.

Diffusion-weighted MRI data were acquired (TR = 5200 ms, TE = 95 ms, FoV = 230 × 230 mm^2, flip angle = 90°, voxel size = 0.89 × 0.89 × 3 mm^3) and had 39 axial slices.

MRI data of the three language paradigms were acquired for patients corresponding to sequences as described in chapter 3.2.2. In addition to the verb generation paradigm described there, paradigms for generating antonyms and sentences were also used. These did not differ from the verb generation paradigm in the structure of the study design but used different stimuli, whereby the opposite was to be formed to presented words or individual words were to be combined to form a grammatically correct sentence. Furthermore, a high-resolution T1-weighted image was collected according to chapter 2.2.2.

The fMRI images of each motor paradigm were collected using a T2*-weighted EPI sequence (TR = 3000 ms, TE = 35 ms, FoV = 1151 × 1151 mm^2, flip angle = 90°, voxel size = 2 × 2 × 3 mm^3) with 28 axial slices. Here, a separate run was performed for each examined body part (left hand, right hand, left foot, right foot, and tongue), in which only the examined body part was moved by the patient. This also means that they could be run individually. Therefore, depending on the localization of the tumor, only those paradigms were used which were relevant for the individual patient. The motor tasks were, for the hands, touching the other four fingers consecutively with the thumb of the respective hand, for the feet, repeated grasping movements with the toes, and for the tongue, repeated touching of the palate. Via the monitor at the end of the MRI bore, patients received cue stimuli that indicated whether they were currently in the stimulation period (green monitor) or baseline period (red monitor). In total, a run lasted 3.2 minutes divided into 8 blocks of 24s duration (4x baseline period, 4x stimulation period), with each measurement starting with a baseline period (Figure 18).

Figure 18. Example of the stimuli used in the motor paradigm used for patients.

For the control subjects, the fMRI data acquisition of the language paradigms as well as the high-resolution anatomical T1-weighted image has already been described in chapter 2.2.2.
The MRI data of the motor paradigms were collected as part of the Human Connetome Project. For this study, only the unprocessed fMRI data examining motor function (TR = 720 ms, TE = 33.1 ms, FoV = 208 × 180 mm^2, flip angle = 52°, voxel size = 2 × 2 × 2 mm^3, 72 slices) and a high-resolution T1-weighted image (TR = 2400 ms, TE = 3.14 ms, FoV = 224 × 224 mm^2, flip angle = 8°, voxel size = 0.7 × 0.7 × 0.7 mm^3) were used. The motor fMRI studies here were performed in two runs (Figure 19), one with left-to-right phase encoding and the other with right-to-left phase encoding. Each of the two runs lasted 3:34 minutes and consisted of 13 blocks (10 task blocks of 12s each and 3 rest blocks of 15s each). The 10 task blocks consisted of two blocks per investigated body part (left hand, right hand, left foot, right foot, and tongue), which were announced using a preceding 3-second cue stimulus. The tasks were to move the fingers of the corresponding hand, to squeeze the toes of the foot or moving the tongue (184).

Figure 19. Example of the stimuli used in the motor paradigm used for healthy controls. Abbreviations: C: cue, F: fixation, LF: left foot, LH: left hand, RF: right foot, RH: right hand, T: tongue.

4.2.3 Subdivision of the patient sample based on the morphological tumor growth pattern

The patient group was subdivided based on the morphological appearance of the tumor in the T1-weighted MRI image after contrast agent administration (Figure 20). A distinction was made between a uniform contrast margin no thicker than 4mm and a diffuse contrast pattern whose thickness was >4mm. This subdivision was made by an experienced neuroradiologist.

Figure 20. Exemplary T1-weighted MRI images with contrast agent administration in patients with (A) uniform annulus-shaped contrast agent uptake and (B) diffuse contrast agent uptake. Contrast enhancement was highlighted from the MR image for better visualization.

4.2.4 DWI data analysis

The diffusion-weighted data were first preprocessed using the FMRIB Software Library (FSL) (126). This included correction for motion of the patient during acquisition and distortions induced by eddy currents (185). Since a b0 image with opposite phase encoding direction was not available for all patients, correction for susceptibility-induced distortions was not performed to improve sample size, otherwise the power of the results would have suffered due to an inadequately small sample. The b0 image was then undergone skull stripping, which removed all non-brain tissue from this image using the Brain Extraction Tool (BET) from FSL (139). Subsequently, the dtifit command was used to fit the tensor model for each voxel. In this step, the eigenvalues and eigenvectors were calculated and three-dimensional maps in which the fractional anisotropy (FA) are encoded using gray values were obtained. These were used in this study to quantify microstructural differences between the two patient groups.

Individual masks of individual tumor compartments of each patient were created as regions of interest. For this purpose, anatomical images (T1, T1C, T2, FLAIR) were used to segment the respective tumor using Bratumia software (137). This was divided into the necrosis, contrast-enhancing tumor, and edema. Each of the three compartments were used to calculate the mean FA value for this part of the tumor (Figure 21).

Figure 21. The segmentation of the tumor, created using the Bratumia software, was used to quantify microstructural changes during the fractional anisotropy evaluation. Here, an FA value was calculated for each of the compartments necrosis, contrast enhancement, and edema.

4.2.5 fMRI data analysis

The functional MRI data for both the language and motor paradigms were analyzed in SPM12. For this purpose, the data were preprocessed initially. This involved first matching the functional images to the first image in the series to correct for motion-related artifacts, followed by coregistration of the functional and structural images. After segmentation of the high-resolution anatomical T1-weighted image, normalization of the structural and functional data into standard MNI space was performed. Subsequently, the functional images were smoothed with a kernel of FWHM 8 x 8 x 8 mm^3 to increase the signal-to-noise ratio.

Based on the general linear model, the individual design matrices are composed of a regressor that reflects each examination condition and was convolved with the hemodynamic response function. The fixation periods were not explicitly modeled as a separate regressor and served as an implicit baseline. The motion correction parameters calculated during realignment were also included as six additional regressors to reduce intraindividual variance. The corresponding language or motor paradigm was chosen as contrasts to calculate the respective t-statistics.

For regions of interest (ROI) definition, anatomical masks of language- or motor-relevant regions and two control regions were created. For this purpose, the angular gyrus, supramarginal gyrus, the middle and superior temporal gyrus as well as the inferior frontal gyrus opercular and triangular part were chosen as language-relevant regions of interest as they represent important parts of the language network. In addition, two control ROIs in the left and right occipital lobe were chosen, as these were reliably activated by the paradigms. These ROIs were extracted from the AAL atlas using WFU Pickatlas Toolbox Version 3.0.5 (110,113,114). The language paradigm contained an additional visual component by presenting the stimuli in written form, which allowed using both occipital lobes of the affected as well as unaffected

hemisphere as control regions, since these areas were not affected by the tumor in any patient and at the same time were reliably activated by the chosen paradigms. Regions of interest relevant for motor abilities were also chosen for examination of the MRI data of the motor paradigms. These were the motor cortex, premotor cortex and the supplementary motor area. As motor processing occurs bilaterally in the cortex, use of this paradigm offered the additional advantage of comparing affected and unaffected hemispheres in these areas and evaluating the direct influence of the tumor. ROIs relevant to this paradigm were extracted using the SPM Anatomy Toolbox Version 3.0 (115–117).

The Marsbar Toolbox Version 0.44 (112) was used to investigate the percent signal change (PSC) in the regions of interest. The previously extracted anatomical ROIs were used as a mask to identify the voxel with the maximum activation within each region of interest based on the t-map previously generated in the statistical analysis. The coordinates of this voxel were subsequently used in Marsbar to generate a spherical ROI with a diameter of 5mm around this voxel, which was then used for the analysis of the PSC. This approach should on the one hand objectify the ROI generation, since it was performed according to strict predefined rules. On the other hand, the calculation of the percent signal changes was not systematically biased by the size of the anatomical ROIs, since they all had the same size.

After the ROIs were generated, they were checked for overlap with the tumor (contrast-enhancing tumor and / or necrosis). Since these are not functional brain tissues, a region of interest within the tumor would lead to a bias of the calculated results. Therefore, such ROIs that overlapped with the respective individual tumor were excluded from the analysis.

In addition to the percent signal change, the lateralization index (LI) in areas of the frontal, parietal and temporal lobe for language paradigms as well as the frontal and parietal lobe for motor paradigms were calculated using the LI toolbox (118) to quantify the symmetry or asymmetry of cortical activation. Here, the activated voxels of both hemispheres are contrasted and put into relation, so that the LI can be used as a hint to the uni- or bilaterality of cortical activation.

The CONN toolbox implemented in SPM12 (119) was used to evaluate the functional connectivity of the six fMRI paradigms used in this study. The basis for this analysis is provided by the SPM.mat files created with SPM12, which were created for analyzing the PSC and contain information on the underlying fMRI images including all previously described preprocessing steps as well as the GLM calculated for this purpose. Thus, no new preprocessing of the data was necessary. During denoising, the BOLD time series were bandpass filtered (0.008-0.09Hz) for noise reduction purposes. In addition, the motion parameters in three

translation and three rotation directions computed in SPM12 in realignment were included, as well as their first order temporal derivatives. Furthermore, linear detrending was performed (120). After first level evaluation of the data at single subject level, ROI-to-ROI analyses were computed at group level. In the case of the language paradigms, 23 implemented regions of interest of different cortical networks (Default Mode network, Salience network, Dorsal Attention network, Fronto Parietal network, and language network) were used; for the analysis of the motor paradigms, 22 ROIs were used (Default Mode network, Salience network, Dorsal Attention network, Fronto Parietal network, and Sensorimotor network). The cerebellar network was not included here as the cerebellum was not acquired completely during MRI data collection in most patients and this would bias the results.

Table 6. Overview of all networks analyzed for this study as well as the regions of interest contained therein and their abbreviations.

Network	Region of interest	Abbreviation
Default Mode	Medial Prefrontal Cortex	MPFC
	Lateral Parietal left hemiphere	LP (L)
	Lateral Parietal right hemiphere	LP (R)
	Precuneus Cortex	PCC
Salience	Anterior Cingulate	ACC
	Anterior Insula left hemisphere	A.INS (L)
	Anterior Insula right hemisphere	A.INS (R)
	Rostral Prefrontal Cortex left hemisphere	RPFC (L)
	Rostral Prefrontal Cortex right hemisphere	RPFC (R)
	Supramarginal Gyrus left hemisphere	SMG (L)
	Supramarginal Gyrus right hemisphere	SMG (R)
Dorsal Attention	Frontal Eye Field left hemisphere	FEF (L)
	Frontal Eye Field right hemisphere	FEF (R)
	Intraparietal Sulcus left hemisphere	IPS (L)
	Intraparietal Sulcus right hemisphere	IPS (R)
Fronto Parietal	Lateral Prefrontal Cortex left hemisphere	LPFC (L)
	Lateral Prefrontal Cortex right hemisphere	LPFC (R)
	Posterior Parietal Cortex left hemisphere	PPC (L)
	Posterior Parietal Cortex right hemisphere	PPC (R)
Language	Inferior Frontal Gyrus left hemisphere	IFG (L)
	Inferior Frontal Gyrus right hemisphere	IFG (R)

	Posterior Superior Temporal Gyrus left hemisphere	PSTG (L)
	Posterior Superior Temporal Gyrus right hemisphere	PSTG (R)
Sensorimotor	Lateral Sensorimotor Cortex left hemisphere	LAT (L)
	Lateral Sensorimotor Cortex right hemisphere	LAT (R)
	Superior Sensorimotor Cortex	SUP

4.2.6 Statistical data analysis

Numerical data were analyzed using SPSS version 28 (IBM, Armonk, NY, USA).

Investigations of structural differences, which were quantified by fractional anisotropy (FA) values, were performed between the two groups of patients using the Mann-Whitney U test. To examine differences in FA values within the two groups, Wilcoxon tests for paired samples were used. For multiple testing purposes, the results of each analysis were then adjusted using Benjamini-Hochberg (False Discovery Rate; FDR) correction (142).

The calculated percent signal changes were compared between the three groups (uniform tumor growth pattern, diffuse tumor growth pattern, and healthy control subjects) using a one-way ANOVA. In this case, a repeated measures ANOVA was considered unsuitable as those spherical ROIs that showed direct contact with the tumor were excluded from the analysis. As missing data even in only one of the ROIs results in an exclusion of the whole data set in a repeated measures design, almost half of the sample would have to be excluded and the results would not be representative. The percent signal changes (PSC) were therefore evaluated using one-way ANOVAs (FDR-corrected), which does not exclude the entire patient in case of missing data.

Lateralization indices were evaluated nonparametrically using Kruskal-Wallis test for independent samples, which were adjusted using False Discovery (FDR) correction as previously done for the evaluation of PSCs.

Corel version 19 was used for the graphical representation of the results. The respective standard error of the mean was used to create the error bar. Statistically significant results were indicated with * for $p < .05$, ** for $p < .01$, and *** for $p < .001$. Figures for functional connectivity were created using the connectivity matrices calculated in the second level analysis.

4.3 Results

4.3.1 Description of the sample

The sample included a total of 97 patients and consisted of 41 female and 56 male patients aged 24 - 80 years (mean: 60.02 years). For detailed information see Table X.

To investigate structural changes in the white matter, those patients who received diffusion-weighted imaging during preoperative examinations were selected from the patient population. Only those patients who also had structural images of the four modalities T1, T1C, T2, and FLAIR were considered for the sample, as these were needed to create an individual tumor segmentation. Thus, 29 patients (11 female and 18 male; mean age 61.69 years) were included into this part of the study. A two-sample t-tests showed that the age did not differ between patients with uniform and diffuse tumor growth pattern ($t(27) = .751$; $p = .459$).

Of the 97 patients in the total sample, 64 received language fMRI (64 verb generation, 47 antonym generation, and 57 syntax generation). Two-sample t-tests showed that the age of both patient groups did not differ statistically significantly from each other in the verb generation ($t(62) = 1.604$; $p = .114$), antonym generation ($t(45) = 1.107$; $p = .274$), or syntax generation ($t(55) = 1.699$; $p = .095$) paradigms.

In addition, 37 patients of the sample received a motor fMRI (36 hand movement, 16 foot movement, and 28 tongue movement). Of these, 16 patients were female and 21 were male. The mean age was 59.46 years. Again, two-sample t-tests showed no differences regarding the age of both patient groups for the hand ($t(34) = .077$; $p = .939$), feet ($t(14) = -.497$; $p = .627$), or tongue ($t(26) = -.707$; $p = .486$) paradigms.

Table 7. Demographic data of the patient sample as well es the subsamples of patients with uniform and diffuse tumor growth pattern.

			Total	Uniform tumor growth pattern	Diffuse tumor growth pattern
Structural MRI	DTI	N	29	13	16
		Age	61.69	63.46	60.25
		Sex	18 male 11 female	8 male 5 female	10 male 6 female
Language fMRI	Verb generation	N	64	23	41
		Age	59.84	62.87	58.15
		Sex	37 male 27 female	13 male 10 female	24 male 17 female
	Antonym generation	N	47	16	31
		Age	59.66	62.31	58.29
		Sex	26 male 21 female	9 male 7 female	17 male 14 female
	Syntax generation	N	57	22	35
		Age	59.86	63.90	57.83
		Sex	33 male 24 female	13 male 9 female	20 male 15 female
Motor fMRI	Hand movement	N	36	13	23
		Age	59.36	59.54	59.26
		Sex	20 male 16 female	7 male 6 female	13 male 10 female
	Foot movement	N	16	6	10
		Age	57.25	55.33	58.4
		Sex	8 male 8 female	3 male 3 female	5 male 5 female
	Tongue movement	N	28	11	17
		Age	58.75	57.00	59.88
		Sex	17 male 11 female	6 male 5 female	11 male 6 female

For comparison purposes, in addition to the patient group, fMRI data from healthy control subjects were analyzed. The control subjects for the language paradigms were the same as described in chapter 3.3.1 for the second study of this thesis. Data from the Human Connectome Project (HCP) were used as the motor control group, which had healthy subjects complete tasks

similar to the patients on MRI. In total, 37 healthy subjects (21 male and 16 female) aged 34 – 37 years (mean age: 35.00 years) were included.

4.3.2 Fractional anisotropy

In order to investigate structural differences between the two patient groups, diffusion-weighted MRI data were used to calculate the fractional anisotropy (FA) for the three tumor compartments of necrosis, contrast enhancement, and edema. Comparing the two patient groups (Figure 22A), a Mann-Whitney-U test for independent samples in each case showed no group differences in necrosis (U = 147,000; Z = .902; $p_{adj.}$ = .910), contrast enhancement (U = 120,500; Z = -.115; $p_{adj.}$ = .910), and edema (U = 127,000; Z = .134; $p_{adj.}$ = .910). In addition, the volumes of each compartment were also compared between the two groups to exclude systematic variations that could potentially affect the mean FA values. In this regard, independent-samples t-tests adjusted for multiple testing using Benjamini-Hochberg correction showed no differences in all three compartments necrosis (t(26,149) = -.668; $p_{adj.}$ = .603), contrast enhancement (t(27) = -1.036; $p_{adj.}$ = .603), and edema (t(24,667) = -.526; $p_{adj.}$ = .603).

Figure 22. Mean values of the fractional anisotropy for both patient groups with uniform and diffuse tumor growth pattern. While there was no evidence for inter-tumor heterogeneity (A), both groups showed differences between the compartments in terms of intra-tumor heterogeneity (B).

In addition to examining inter-tumor heterogeneity, the intra-tumor heterogeneity within the two groups of patients with uniform tumor growth pattern (U-TGP) and diffuse tumor growth pattern (D-TGP) was also analyzed (Figure 22B). For this purpose, the FA values of the individual compartments were compared separately for both groups using the Wilcoxon test for paired samples (FDR-corrected). This revealed statistically significant differences between the necrosis compartment and the contrast-enhancing portion of the tumor ($z = 3.110$; $p_{adj.} = .003$) and edema ($z = 3.180$; $p_{adj.} = .003$) in the U-TGP group. Furthermore, the FA values of the contrast-enhancing portion of the tumor differed from those of the edema ($z = -2.341$; $p_{adj.} = .023$). The group of patients with D-TGP showed a similar picture, as the FA values of all three compartments also differed from each other ($z = 3.206$; $p_{adj.} = .003$; $z = 3.258$; $p_{adj.} = .003$; $z = -2.068$; $p_{adj.} = .039$).

4.3.3 Percent signal change

In order to investigate the influence of the glioblastoma tumor growth pattern on the BOLD signal, all six fMRI paradigms (three language paradigms and three motor paradigms) were evaluated and percent signal change was calculated in regions of interest (ROIs) relevant to these functions (Figure 23). As several ROIs had direct contact with the tumor and were therefore not included in the analysis, instead of a repeated measures ANOVA a one-way ANOVA was calculated for each ROI. The individual tests were adjusted using a Benjamini-Hochberg correction for multiple comparisons.

Figure 23. Comparison of mean percent signal changes of the three groups of patients with uniform and diffuse tumor growth pattern as well as healthy control subjects for the (A) verb generation, (B) antonym generation, and (C) syntax generation paradigms.

Verb generation

The analysis of the verb generation paradigm (Figure 22A) showed statistically significant differences between groups in the angular gyrus ($F(2,87) = 5.583$; $p_{adj.} = .025$), inferior frontal gyrus opercular part ($F(2,90) = 3.922$; $p_{adj.} = .048$), inferior frontal gyrus triangular part ($F(2,90) = 3.879$; $p_{adj.} = .048$), and in the left occipital lobe ($F(2,93) = 8.641$; $p_{adj.} = .002$). Furthermore, there was a trend in the right occipital lobe ($F(2,93) = 3.042$; $p_{adj.} = .090$). In contrast, no statistically significant differences were found in the middle temporal gyrus ($F(2,88) = 2.334$; $p_{adj.} = .154$) and superior temporal gyrus ($F(2,88) = 2.187$; $p_{adj.} = .167$) and in the supramarginal gyrus ($F(2,86) = .677$; $p_{adj.} = .533$). Post-hoc t-tests showed statistically significant differences between patients with diffuse tumor growth pattern (D-TGP) and healthy control subjects in the angular gyrus ($p_{adj.} = .011$) and the inferior frontal gyrus opercular part ($p_{adj.} = .032$) after FDR correction. In the control region of the occipital lobe of the affected left hemisphere, control subjects differed from both patients with D-TGP ($p_{adj.} = .006$) and patients with uniform tumor growth pattern (U-TGP, $p_{adj.} = .006$). In the right unaffected occipital lobe, there was a trend for a difference between control subjects and D-TGP patients ($p_{adj.} = .062$). A statistically significant difference between the two groups of patients was not found in any of the regions of interest.

Antonym generation

The antonym generation paradigm (Figure 22B) also showed a significant group difference in the area of the angular gyrus ($F(2,71) = 5.146$; $p_{adj.} = .033$) and the left occipital lobe ($F(2,76) = 10.279$; $p_{adj.} = .001$). In addition, the groups differed in the area of the superior temporal gyrus ($F(2,74) = 4.408$; $p_{adj.} = .040$) and there was a trend in the middle temporal gyrus ($F(2,72) = 2.986$; $p_{adj.} = .090$). In contrast to the verb generation paradigm, no differences were found in the inferior frontal gyrus opercular part ($F(2,76) = 2.057$; $p_{adj.} = .180$) and triangular part ($F(2,75) = 1.210$; $p_{adj.} = .365$) as well as in the right occipital lobe ($F(2,76) = 2.057$; $p_{adj.} = .180$). Post-hoc t-tests showed that in the angular gyrus, the D-TGP group differed significantly from the control group ($p_{adj.} = .016$). In addition, differences were found in the left affected occipital lobe between the control subjects and the D-TGP group ($p_{adj.} = .006$) and the U-TGP group ($p_{adj.} = .005$). The two patient groups differed statistically significantly in the superior temporal gyrus ($p_{adj.} = .032$).

Syntax generation

In the syntax generation paradigm (Figure 23C), a one-factor ANOVA (FDR-corrected for multiple testing) revealed statistically significant group differences in the area of the angular gyrus

($F(2,82) = 4.669$; $p_{adj.} = .035$), middle temporal gyrus ($F(2,82) = 4.713$; $p_{adj.} = .035$), and in the occipital lobe of the affected left hemisphere ($F(2,86) = 9.133$; $p_{adj.} = .002$) as well as the unaffected right hemisphere ($F(2,86) = 11.331$; $p_{adj.} = .001$). Furthermore, there were significant differences in the inferior frontal gyrus triangular part ($F(2,84) = 4.308$; $p_{adj.} = .040$) and a trend in the opercular part ($F(2,85) = 2.980$; $p_{adj.} = .090$). No statistically significant differences were found in the superior temporal gyrus ($F(2,83) = .512$; $p_{adj.} = .601$) and supramarginal gyrus ($F(2,81) = 1.396$; $p_{adj.} = .320$). In this analysis, FDR-corrected post-hoc t-tests showed a statistically significant difference between control subjects and D-TGP patients in the angular gyrus ($p_{adj.} = .006$) and in the inferior frontal gyrus part triangularis ($p_{adj.} = .032$). Furthermore, statistically significant differences were shown in both the occipital lobe of the affected and unaffected hemisphere between control subjects and U-TGP patients ($p_{adj.} = .006$ in each case) and between control subjects and D-TGP patients ($p_{adj.} = .006$ and $p_{adj.} = .003$).

For the three motor paradigms, ROIs were assigned to the affected or unaffected hemisphere allowing a comparison of both hemispheres (Figure 24). Each of the healthy control subjects was uniquely assigned to a patient enabling information about which hemisphere was considered affected to be transferred.

A
B
C
Percent signal change
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
Diffuse TGP
Uniform TGP
Healthy controls
Motor cortex BA 4
Premotor cortex BA 6
Supplementary motor cortex
Motor cortex BA 4
Premotor cortex BA 6
Supplementary motor cortex
Affected hemisphere
Unaffected hemisphere
*

Figure 24. Comparison of mean percent signal changes of the three groups of patients with uniform and diffuse tumor growth pattern as well as healthy control subjects for the (A) hand movement, (B) feet movement, and (C) tongue movement tasks.

Hand movement

For the movement of the hand (Figure 24A), the analysis showed a trend in the area of the supplementary motor cortex of the hemisphere affected by the tumor ($F(2,60) = 9.164$; $p_{adj.} = .006$) as well as the motor cortex ($F(2,69) = 7.055$; $p_{adj.} = .015$) and the supplementary motor cortex ($F(2,69) = 5.778$; $p_{adj.} = .029$) of the unaffected hemisphere. Furthermore, there was a trend in the Motor Cortex area of the affected hemisphere ($F(2,61) = 4.420$; $p_{adj.} = .058$). No statistically significant differences were found in the premotor cortex of the affected hemisphere ($F(2,58) = .720$; $p_{adj.} = .659$) or the unaffected hemisphere ($F(2,69) = 2.195$; $p_{adj.} = .268$). FDR-corrected post-hoc t-tests showed statistically significant differences here in the SMA of the affected hemisphere between the control subjects and the U-TGP group ($p_{adj.} = .020$) and the D-TGP group ($p_{adj.} = .033$). In the motor cortex of the unaffected hemisphere, there was a significant difference between D-TGP patients and the control subjects ($p_{adj.} = .020$) and in the supplementary motor cortex of the same hemisphere between U-TGP patients and control subjects ($p_{adj.} = .020$).

When comparing the affected and unaffected hemispheres, no statistically significant differences were found in the group of U-TGP patients for the motor cortex ($t(10) = -.179$; $p_{adj.} = .861$), premotor cortex($t(10) = -1.519$; $p_{adj.} = .288$), and supplementary motor area ($t(11) = -1.320$; $p_{adj.} = .321$). The same result was shown in the D-TGP patients ($t(20) = -1.229$; $p_{adj.} = .420$; $t(18) = -.074$; $p_{adj.} = .942$; $t(19) = .920$; $p_{adj.} = .551$).

Foot movement

There was no statistically significant difference during foot movement (Figure 24B) between any group. This was found for the motor cortex ($F(2,26) = .437$; $p_{adj.} = .732$), premotor cortex ($F(2,25) = .687$; $p_{adj.} = .659$), and supplementary motor cortex ($F(2,23) = .931$; $p_{adj.} = .659$) of the affected hemisphere and for the same ROIs of the unaffected hemisphere ($F(2,27) = .202$; $p_{adj.} = .842$; $F(2,27) = .172$; $p_{adj.} = .842$; $F(2,27) = .466$; $p_{adj.} = .732$).

Analogous to the movement of the hands, neither patients with uniform ($t(3) = -2.574$; $p_{adj.} = .247$; $t(3) = -1.211$; $p_{adj.} = .402$; $t(3) = -2.760$; $p_{adj.} = .247$) nor diffuse tumor growth patterns ($t(9) = -.720$; $p_{adj.} = .551$; $t(9) = -2.047$; $p_{adj.} = .159$; $t(8) = -2.726$; $p_{adj.} = .083$) showed

differences between the motor cortex, premotor cortex, and supplementary motor area of the affected and unaffected hemispheres in FDR-adjusted paired-samples t-tests.

Tongue movement

Evaluation of percent signal changes measured in response to tongue movement (Figure 24C) showed only a statistically significant difference in the motor cortex area of the unaffected hemisphere ($F(2,53) = 4.992$; $p_{adj.} = .046$) and a trend for the motor cortex of the affected hemisphere ($F(2,42) = 4.253$; $p_{adj.} = .062$). The premotor cortex ($F(2,49) = 2.436$; $p_{adj.} = .252$) and supplementary motor cortex ($F(2,52) = 1.455$; $p_{adj.} = .437$) were not statistically significant in either the affected hemisphere or the unaffected hemisphere ($F(2,53) = .810$; $p_{adj.} = .657$; $F(2,53) = 1.752$; $p_{adj.} = .367$). Post-hoc t-tests showed no statistically significant differences between groups for the motor cortices of both hemispheres after FDR correction.

When comparing affected and unaffected hemispheres, neither U-TGP ($t(9) = -1.620$; $p_{adj.} = .288$; $t(9) = .461$; $p_{adj.} = .738$; $t(9) = 2.258$; $p_{adj.} = .247$) nor D-TGP patients ($t(12) = -2.537$; $p_{adj.} = .083$; $t(15) = -.756$; $p_{adj.} = .551$; $t(16) = -2.421$; $p_{adj.} = .083$) showed differences in the three regions of interest examined in this study.

4.3.4 Lateralization Indices

To investigate the hemispheric distribution of cortical activations, the lateralization index (LI) was calculated for all six paradigms in relevant brain lobes using the LI toolbox (Figure 25).

For the language examinations, the LI was calculated for each of the three paradigms in the frontal, parietal, and temporal lobes and compared between the three examination groups. For this purpose, the Kruskal-Wallis test was used with independent samples and adjusted for multiple testing using FDR correction.

In this analysis, for the verb generation paradigm, there was a statistically significant difference in LIs in the frontal lobe ($\chi^2 = 10.161$; $p_{adj.} = .014$) and in the parietal lobe ($\chi^2 = 11.421$; $p_{adj.} = .010$), but not in the temporal lobe ($\chi^2 = .027$; $p_{adj.} = .987$). Post-hoc tests showed significant differences in the frontal lobe between the control group and both the U-TGP group ($p_{adj.} = .014$) and the D-TGP group ($p_{adj.} = .024$). A similar result was found when comparing in the parietal lobe, where both patient groups also differed from the control group ($p_{adj.} = .007$ and $p_{adj.} = .017$).

When the antonym paradigm was examined, statistically significant differences were found in the frontal lobe ($\chi^2 = 23.044$; $p_{adj.} < .001$) and parietal lobe ($\chi^2 = 20.244$; $p_{adj.} < .001$) but not

in the temporal lobe (χ^2 = 4.477; $p_{adj.}$ = .160). Post-hoc tests showed here that in the frontal as well as parietal lobes, the control group differed from both patient groups ($p_{adj.}$ < .001 each). Evaluation of the LIs for the sentence generation paradigm revealed no statistically significant differences in any of the frontal lobe (χ^2 = 4.506; $p_{adj.}$ = .160), parietal lobe (χ^2 = 2.771; $p_{adj.}$ = .322), and temporal lobe (χ^2 = 1.637; $p_{adj.}$ = .469) areas examined.

Figure 25. Comparison of the lateralization indices of the language paradigms in the fontal, parietal and temporal lobe between both patient groups with uniform and diffuse tumor growth pattern and the control group.

To examine the lateralization of cortical activity in the three motor paradigms (Figure 26), lateralization indices were calculated in the frontal as well as parietal lobe areas and compared among the three study groups. Here, no statistically significant differences were found for all three paradigms during movement of the hands (frontal: χ^2 = 5.042; $p_{adj.}$ = .241; parietal: χ^2 = 2.112; $p_{adj.}$ = .492), the feet (frontal: χ^2 = 1.418; $p_{adj.}$ = .492; parietal: χ^2 = 8.657; $p_{adj.}$ = .079), and the tongue (frontal: χ^2 = 1.451; $p_{adj.}$ = .492; parietal: χ^2 = 2.068; $p_{adj.}$ = .492).

Figure 26. Comparison of the lateralization indices of the motor paradigms in the fontal and parietal lobe between both patient groups with uniform and diffuse tumor growth pattern and the control group.

4.3.5 Functional connectivity

In addition to percent signal change and lateralization indices of language- and motor-relevant regions of interest, the functional connectivity of relevant cortical networks was analyzed.

For language fMRI, five different networks (Default Mode, Salience, Dorsal Attention, Fronto Parietal and Language network) were used with a total of 23 regions of interest (ROIs) implemented in the CONN-toolbox to evaluate intra- as well as inter-network connectivity (Figure 27). Here, the two patient groups with uniform tumor growth pattern (U-TGP) and diffuse tumor growth pattern (D-TGP) were compared with a healthy control group.

Figure 27. Comparisons of functional connectivity of cortical networks relevant for the processing of language between the control group and each patient group as well as between both patient groups with uniform and diffuse tumor growth pattern.

Verb generation

When comparing the D-TGP patients with the matched control subjects, a significantly decreased intra-network connectivity was found within all networks. However, at the same time, these patients exhibited extensive inter-network connectivity between the ROIs of the different networks, which was statistically significantly more pronounced than in the assigned control subjects. This pattern was also evident when comparing the U-TGP patients with their matched control subjects, although less connections were involved. When comparing the two patient samples, the intra-network connections of the U-TGP patients within the Salience and Dorsal Attention networks as well as connections between the ROIs of the Salience, Dorsal Attention and Fronto Parietal networks were significantly stronger. In addition, a significant reduction in inter-network connectivity of several ROIs of the Default Mode network was found

in this group. The p-28values of the statistical tests of these comparisons can be found in the Appendix as Supplementary tables 22-27.

Antonym generation

Similar to the comparison of functional connectivity of the verb generation paradigm, both patient groups showed significantly reduced intra-network connectivity within all networks during antonym generation compared to their respective assigned control subjects. In addition, both patient groups also exhibited extensive inter-network connectivity between the ROIs of the different networks, which was statistically significantly stronger than in the assigned control subjects. When comparing the two patient groups, there were some significantly more pronounced connections in the D-TGP group, which were spread across all networks examined. At the same time, only one connection (right posterior superior temporal gyrus - right rostral prefrontal cortex) was significantly reduced in this comparison. The p-values of the statistical tests of these comparisons can be found in the Appendix as Supplementary tables 28-33.

Syntax generation

In addition, the functional connectivity of the syntax generation paradigm was also evaluated. Here, both control groups showed significantly stronger intra-network connectivity within all networks compared with their respective assigned patients. In addition, significant reductions in inter-network connectivity between the saliency and language networks were evident when comparing the U-TGP patients and control subjects. Furthermore, extended inter-network connectivity between the ROIs of the different networks was found here in both patient groups and was statistically significantly stronger than in the assigned control subjects. Comparison of the two patient groups also revealed statistically significant differences within and between networks, which were unsystematically distributed across all networks examined. The p-values of the statistical tests of these comparisons can be found in the Appendix as Supplementary tables 34-39.

Regarding motor functions, the five previously investigated paradigms (left hand, right hand, left foot, right foot, tongue) were also examined with regard to the functional connectivity of relevant areas. For this purpose, five cortical networks (Default Mode, Salience, Dorsal Attention, Fronto Parietal and Sensorimotor network) with a total of 22 implemented regions of interest (ROIs) were investigated with respect to intra- and internetwork connectivity. To better evaluate the influence of the tumor on the affected hemisphere, the sample was not only

divided by group into patients with uniform tumor growth pattern (U-TGP) and diffuse tumor growth pattern (D-TGP) as well as healthy control subjects, but within this group additionally differentiated by affected hemisphere. The results described below are first reported for the patients whose tumor was located in the left hemisphere before those for the right hemisphere are described (Figure 28).

Figure 28. Comparisons of functional connectivity of cortical networks relevant for the processing of motor actions between the control group and each patient group as well as between both patient groups with uniform and diffuse tumor growth pattern with tumor in the left hemisphere.

Left hand

When evaluating differences in functional connectivity in patients with left hemispheric tumor as well as their matched control subjects, movement of the left hand showed some significant differences both within and between networks. Compared to their matched control subjects, D-TGP patients showed significantly lower functional connectivity in the Sensorimotor network, the Salience network, and the Dorsal Attention network. In addition, significant differences in inter-network connectivity were observed, including stronger connectivity of control subjects between the regions of interest (ROIs) of the Dorsal Attention network and the ROIs of the Salience and Sensorimotor networks. In addition, the control subjects showed significantly weaker connections between the Default Mode network as well as the Fronto Parietal network and several ROIs of the other networks.

When comparing the U-TGP patients with their control group, fewer differences were evident. There were isolated differences in intra-network connectivity in the Default Mode network, Sensorimotor network, Salience network, Dorsal Attention network, and Fronto Parietal network. In all these connections, control subjects showed stronger connectivity. At the same time, there were also intra-network connections that were significantly increased in the patients. Between-network connections were found to be statistically significantly higher in the control subjects, which were found to be stronger in the control subjects across all networks. At the same time, there were also connections that were more pronounced in the patient group. These were predominantly between the fronto-parietal network and the other networks.

When comparing the two patient groups, there were no statistically significantly stronger connections in intra-network connectivity for either group. At the same time, U-TGP patients showed significantly increased connectivities between the Fronto Parietal Network and other networks, while D-TGP patients showed significantly stronger connections between Default Mode network and several other networks.

Right hand

Furthermore, the functional connectivity of cortical networks in response to the movement of the right hand, which has the cortical representation in the left hemisphere affected by the tumor, was compared between the groups. This revealed numerous intra-network connectivities when comparing the patients with diffuse tumor growth patterns and their matched control subjects, which were stronger in the control group. These included the entire Sensorimotor network as well as large portions of all other networks evaluated in this study. In addition, there were several significantly stronger connections between the Sensorimotor network, the Salience

network, and the Dorsal Attention network. Significantly higher connections of the patient group, on the other hand, were predominantly found between the Default Mode network and the ROIs of different other networks.

When comparing patients with uniform tumor growth patterns with control subjects, there were isolated significant differences in the Default Mode network, Sensorimotor network, and Salience network, all of which predominated in control subjects. They also showed significantly stronger inter-network connections of the Sensorimotor network with the Salience network and Dorsal Attention network. At the same time, the patients showed significantly increased connections of the Default Mode network with regions of interest of the Sensorimotor, Salience, and Dorsal Attention networks.

Comparing the two groups of patients, the main differences were in inter-network connectivity, with few exceptions of the Salience network. Here, U-TGP patients showed enhanced connections of the Default Mode network with ROIs from Sensorimotor, Salience, and Dorsal Attention networks, whereas in the D-TGP group connections between the Fronto Parietal network and ROIs from Dorsal Attention network and Salience network were significantly more pronounced.

Left foot

In addition to evaluating the functional connectivity of cortical networks during movement of the hands, they were also analyzed for the movement of each of the two feet. When comparing the D-TGP patients with the healthy control subjects, it was found for movements of the left foot that the intra-network connections within the Sensorimotor network for all regions of interest were stronger in the control subjects. This was also the case for parts of the Salience as well as Fronto Parietal network. None of the connections within networks were increased for the patient group. Inter-network connectivity also showed widely higher connectivities for the control group between the Sensorimotor network and the Salience and Dorsal Attention, and between the Salience network and the Dorsal Attention network. In contrast, the D-TGP patients group showed numerous stronger connections of the MPFC to the regions of interest of other networks.

When comparing the U-TGP patients with the healthy control subjects, the control subjects showed increased intra-network connectivity in parts of the Salience network as well as the fronto-parietal network, and isolated significantly stronger connections between the networks. At the same time, the patients showed significantly stronger inter-network connections between individual ROIs the Default Mode network and Salience network as well as Fronto Parietal

Network and between the Fronto Parietal Network and the Sensorimotor, Salience, and Dorsal Attention networks.

When comparing the two groups of patients, only four statistically significant connections were found, which were stronger in the group of U-TGP patients. All other comparisons between groups remained statistically not significant.

Right foot

Likewise, functional connectivity was quantified during movement of the right foot, which projects to the left hemisphere affected by the tumor. Here, compared to the D-TGP patients, the control subjects showed sporadically more pronounced connections within networks as well as between networks, which was particularly evident in the connectivity of the Fronto Parietal network and the Salience network. In patients, only two connections overall were stronger between the MPFC and the right RPFC and between the PPC and SMG of the right hemisphere. When analyzing the U-TGP patient group, it showed increased functional connectivity between the Default Mode network as well as the Fronto Parietal network and several ROIs of other networks compared to the healthy control subjects, while in this group only four connections were more pronounced.

Comparison of the two groups of patients showed that in the group of U-TGP patients, connections within the Fronto Parietal network and between the Fronto Parietal network as well as Dorsal Attention network and different ROIs of other networks were more pronounced. In the group of D-TGP patients, only isolated connections were significantly stronger. These occurred between individual ROIs of the Salience network and those from the Default Mode network as well as Fronto Parietal network.

Tongue

In addition to the extremities, activation elicited by movement of the tongue was also examined. Here, control subjects showed significantly stronger intra-network connectivity in the Sensorimotor, Salience, Dorsal Attention, and Fronto Parietal networks compared with D-TGP patients. Furthermore, increased connections between the Dorsal Attention network and individual ROIs of other networks were evident. In addition, significantly decreased connections of the MPFC (Default Mode network) and multiple other regions of interest as well as between the Fronto Parietal network and several ROIs of other networks were found.

Statistical comparison of the U-TGP patient group with the control subjects was not possible because of an insufficient sample size. The correlations were included in Figure 28 for clarity

reasons. Here, various connections appeared that seem to be more pronounced in patients, such as within the Salience network or between the Default Mode network and the ROIs of other networks.
When comparing the two patient groups, the U-TGP patients showed significantly stronger connections within the Fronto Parietal network and individual other ROIs. In addition, however, they showed statistically significantly reduced connections of the Fronto Parietal and Dorsal Attention networks with the ROIs of other networks.

The p-values of the statistical tests of these comparisons described before can be found in the Appendix as Supplementary tables 40-69.

Analogous to the patients with glioblastoma in the left hemisphere, the patients with right hemispheric tumor were also investigated with respect to the functional connectivity (Figure 29) of relevant areas based on the previously studied five paradigms (left hand, right hand, left foot, right foot, tongue).

Figure 29. Comparisons of functional connectivity of cortical networks relevant for the processing of motor actions between the control group and each patient group as well as between both patient groups with uniform and diffuse tumor growth pattern with tumor in the right hemisphere.

Left hand

The cortical activations during movement of the left hand projecting to the affected right hemisphere will be described first. Here, control subjects showed significantly stronger intra-network connectivity within the Sensorimotor, Salience, and Dorsal Attention networks compared to the group of D-TGP patients, as well as significant connections between the Salience network and the regions of interest (ROIs) of other networks. At the same time, there were significantly weaker connections between the Fronto Parietal network and several ROIs of the other networks.

The comparison of the U-TGP patients with the matched healthy control subjects showed reduced intra-network connectivity in parts of the Salience and Dorsal Attention networks as well as in individual inter-network connections. At the same time, this group showed statistically significantly stronger connections between some regions of interest of the Default Mode as well as Fronto Parietal network and several ROIs of other networks.

When comparing the two patient groups, the U-TGP group showed an increase in inter-network connectivity between the Default Mode and Sensorimotor network. In addition, isolated statistically significantly stronger connections between the ROIs of different networks were shown in one as well as the other group.

Right hand

The evaluation of functional connectivity during movement of the right hand showed significantly stronger intra-network connectivity in the healthy control group compared to the D-TGP patient group, involving the entire Dorsal Attention network, but also parts of the other networks. In addition, there were significantly stronger inter-network connections between the Sensorimotor network as well as the Salience network and the ROIs of other networks. At the same time, connections between the Default Mode network as well as the Fronto Parietal network and several other networks were significantly reduced.

Compared with the control group, the U-TGP patients showed a reduction in the intra-network connectivity of parts of the Sensorimotor, Salience, and Dorsal Attention networks. In addition, inter-network connectivity showed reductions between the ROIs of the Sensorimotor, Salience, and Dorsal Attention networks and increases between the ROIs of the Dorsal Attention and Fronto Parietal networks.

Similar to left hand movement, a comparison of the two patient groups revealed mainly isolated nonsystematic increases and decreases in functional connectivity. The p-values of the statistical tests of these comparisons can be found in the Appendix as Supplementary tables 76-81.

Left foot

The analysis of functional connectivity following movement of the left foot revealed that all intra-network connections of the Dorsal Attention network were stronger in the control group. In addition, there were more pronounced connections between the regions of interest of this network and the ROIs of the Salience network, as well as between Sensorimotor network and some ROIs of all other networks. In contrast, the patient group showed a total of only four connections that were more pronounced. These mainly involved the left posterior parietal cortex.

Comparing the assigned control subjects with the patients in the U-TGP group, there were significantly stronger intra-network connections in the Salience and Dorsal Attention networks, as well as significant connections between the Salience and Sensorimotor and between Salience and Dorsal Attention networks. At the same time, there was a reduction in the strength of connections between portions of the Default Mode network as well as Fronto Parietal network and several ROIs of other networks.

When comparing the two groups of patients, the U-TGP group showed stronger intra-network connectivity within the Sensorimotor network. In addition, these patients showed increased connectivity between the Sensorimotor, Salience, and Dorsal Attention networks compared with the D-TGP group, whereas connections between the left PPC of the Fronto Parietal network and various ROIs of the Salience network were reduced.

Right foot

When analyzing connectivity following right foot movement, the comparison of control subjects with D-TGP patients showed a significant increase in connectivity involving large portions of the Dorsal Attention network as well as portions of the other networks. In addition, there were also significant reductions in inter-network connectivity distributed across all networks. In this between-group comparison, the patient group showed only one statistically significant stronger connection.

When comparing the assigned control subjects with the patients in the U-TGP group, there were significantly stronger intra-network connections in the Default Mode, Sensorimotor, and Salience networks, as well as significant connections between the Salience and Dorsal Attention networks. At the same time, there was a reduction in connection strength between portions of the Default Mode network as well as Fronto Parietal network and several ROIs of other networks.

Comparing the two patient groups, patients with U-TGP showed significantly stronger intra-network connectivity within parts of the Sensorimotor, Dorsal Attention, and Fronto Parietal networks, as well as significantly stronger connections between the fronto-parietal network and ROIs of other networks. At the same time, however, this group also showed a significant reduction within the Salience network. The p-values of the statistical tests of these comparisons can be found in the Appendix as Supplementary tables 88-93.

Tongue

In addition to functional connectivity during movements of the hands and feet, this was also evaluated for the tongue. Here, there was a statistically significant reduction in intra-network connectivity in the control group compared to D-TGP patients, which was evident in parts of the Default Mode, Sensorimotor, Salience, and Dorsal Attention networks. In addition, inter-network connectivity was reduced between several regions of interest of the Salience network and those of the Dorsal Attention network. At the same time, however, there were stronger expressions of connectivity between the ROIs of the Default Mode network and those of other networks and between the Salience network and the Fronto Parietal network.

When comparing the assigned control subjects with the patients in the U-TGP group, significantly stronger intra-network connections were evident in the Sensorimotor and Salience network regions. In addition, isolated significantly stronger connections were found between the ROIs of the different networks. At the same time, there was a reduction in the strength of connections between portions of the Fronto Parietal network and several ROIs of other networks and between the Default Mode network and the Salience network.

There were mainly isolated nonsystematic increases and decreases in functional connectivity when comparing the two patient groups.

The p-values of the statistical tests of these comparisons described before can be found in the Appendix as Supplementary tables 70-99.

4.4 Discussion

The aim of this study was to investigate the influence of the morphological tumor growth pattern in patients with glioblastoma on the structural and functional neuroplastic changes. For this purpose, a group of patients was subdivided into two groups based on the morphological appearance of the tumor using the pattern of contrast enhancement in MRI. In addition, fMRI

data from healthy subjects were evaluated and compared with the two patient groups for control purposes.

To investigate structural differences between the group of patients with uniform tumor growth pattern (U-TGP) and diffuse tumor growth pattern (D-TGP), diffusion-weighted images were evaluated and the mean fractional anisotropy (FA) values from different tumor compartments were extracted. When these mean FA values were compared in the compartments necrosis, contrast enhancment, and edema, there were no statistically significant differences between the two groups of patients with respect to inter-tumor heterogeneity. This result was unexpected, as fractional anisotropy had already been shown to successfully discriminate between glioblastomas and metastases (173,175), and it was therefore assumed that this principle could also be applied to GBM subtypes. However, when intra-tumor heterogeneity was examined within each patient group, statistically significant differences were found between all three tumor compartments in both U-TGP patients and D-TGP patients. Similar results have been reported previously and are consistent with the findings reported in this study (174). The results suggest that different tumor compartments have different influences on pathological changes in brain microstructure, but this effect seems to be equally expressed in both tumor growth pattern subtypes.

In addition to investigating microstructural changes, the two patient groups were also examined for differences in the BOLD signal. For this purpose, the percent signal change (PSC) in relevant regions of interest (ROIs) was investigated for three language paradigms (verb, antonym, and syntax generation) as well as for three motor paradigms (hand, foot, and tongue movement). In addition to the two patient groups with uniform and diffuse tumor growth patterns, healthy control subjects were examined. When evaluating the three language paradigms, only one ROI, namely the superior temporal gyrus during antonym generation, showed a statistically significant difference in the form of a higher PSC of the D-TGP patients. Even though in most regions of interest the U-TGP patients showed higher PSC values, further comparisons between the two groups did not reveal statistically significant differences. When the healthy control subjects were compared with the two patient groups, the majority showed differences with the group of patients with diffuse tumor growth pattern. This is a further indication that differences exist on a functional level between the two patient groups with uniform and diffuse tumor growth patterns, although these were not statistically significant. A very similar result was additionally found when examining motor paradigms, as here too D-TGP patients had lower PSC values in most ROIs examined. This suggests that although minor differences seem to exist, they are either not substantial enough to be statistically

significant or are masked by a mediator variable. This means that there is another influencing factor that exerts an influence on the measured BOLD signal, but was not considered in this study. One possible factor that could be addressed in this case is the distance between the region of interest and the tumor. Although all ROIs that were in direct contact with the tumor were excluded from the analysis, this spatial factor was not considered for the remaining ROIs and could provide additional relevant information. This has already been described in previous studies (67,94).

In addition, it was found that the control ROIs in the occipital lobes in the control group showed higher PSC values than both patient groups in most cases. It was noticeable that this concerned not only the control region in the affected hemisphere, but in the case of syntax generation also the contralateral unaffected hemisphere. This result suggests that the tumor not only locally affects the brain and its function, but also exerts global effects on the entire brain, including the unaffected hemisphere, as described in previous studies (66).

Regarding the comparison of the affected and unaffected hemispheres of the two groups of patients in the three motor paradigms, minor reductions in percent signal change in the tumor-affected hemisphere were found in both groups. However, these were too marginal to be statistically significant. This result is consistent with other previous studies that have already found a reduction in BOLD signal in the motor cortex of the tumor-affected hemisphere (55,93), although the results here did not show significance at the statistical level.

In addition, differences in lateralization indices between the patients and control subjects and between both groups of patients with uniform and diffuse tumor growth patterns were examined. Here, statistically significant differences were found in the verb and antonym generation paradigms, but not during syntax generation or in the motor paradigms. It was also noticeable in the significant differences that these were limited exclusively between control subjects and patients, whereas comparisons between the two patient groups showed no statistically significant differences.

In the analysis of changes in functional connectivity, comparisons with healthy control subjects showed that especially intra-network connectivity was significantly reduced in glioblastoma patients. These were here not only found in the affected hemisphere, but also showed in interhemispheric connections. These results are in line with previous studies reporting global changes in functional connectivity accompanying a brain tumor (98,101,102). Comparison between the two groups of tumor patients with uniform and diffuse tumor growth patterns showed only marginal differences, as was already the case for percent signal change and lateralization indices. Therefore, it can be concluded that all three evaluations indicate minor

differences between the groups, which, however, were not pronounced enough to be statistically significant.

Regarding the methodology of these analyses, some limitations should be noted. First, the fact that patients and control subjects were collected on different MRI scanners should be mentioned. While the same paradigms were used for the language fMRI and only the location of the data collection differed, it should be noted that although the same MRI scanner model (Siemens Skyra) was used for the motor fMRI, the sequences and tasks differed during the data collection. Therefore, it is uncertain what influence this has on the results of the percent signal changes, especially in the motor examinations, since they may vary depending on the scanner and protocol. On the examination of the lateralization indices as well as the functional connectivity, this influence is estimated to be lower, as here either normalized quotients or the temporal correlations are considered. In addition to the differences in the collection of data, it should also be noted that the age of both control groups was statistically significantly lower than that of the patients. This means that the influence of age-related changes in brain function cannot be completely excluded in the patient group compared to the healthy control subjects. However, the influences of the MRI scanner, examination protocol, and age can all be considered minor when examining the two patient groups with each other, since the data of these two groups, whose comparison was the focus of this study, were collected in the same examination setting and, moreover, both groups did not differ statistically significantly with respect to age.

4.5 Conclusion

In conclusion, no differences were found in this study regarding microstructural changes between both groups of patients with uniform and diffuse tumor growth pattern. However, on a functional level, there is an indication for a reduction of the BOLD signal in patients with diffuse tumor growth pattern, although these were not statistically significant. Moreover, when control regions were examined, it was shown that the influence of the tumor on the BOLD signal is not only locally limited to the area of the tumor, but has global effects up to the contralateral unaffected hemisphere.

5 GENERAL DISCUSSION

5.1 Summary of the research questions of the thesis

Up to the present state of research, brain tumors represent a special challenge for modern medicine and science. Therefore, systematic studies of this disease are an important for a comprehensive understanding of the development, behavior and treatment of brain. In this field, especially in the last decades, research has contributed significantly to the improvement of diagnostics and treatment of patients. In addition to the discovery of molecular markers, which affect the prognosis of a patient and are the starting point for targeted and tailored forms of therapy, the establishment of preoperative fMRI for visualizing eloquent brain areas in the vicinity of the tumor has also been shown to have a positive impact on the treatment of patients (65). In this context, however, the integrity of the BOLD signal in patients with brain tumors has often been critically questioned in the literature (55). In light of this background, it seems all the more important to investigate the influence of the tumor on the acquired MRI signal on the basis of patient data and thus gain a better understanding of this. The studies performed within the scope of this dissertation contribute a part to this overall goal. The following research questions were addressed and investigated:

1. Investigation of how the presence of a brain tumor or space-occupying brain lesion in the occipital lobe affects fMRI eccentricity mapping of central, middle, and peripheral visual field areas.
2. Development and evaluation of a preprocessing protocol that allows the three-dimensional reconstruction as well as the analysis of functional MRI data using the FreeSurfer software.
3. Investigation of structural and functional differences between two groups of glioblastoma patients with different morphological tumor growth patterns.

To address the first research question of how the presence of a brain tumor or space-occupying brain lesion in the occipital lobe affects fMRI eccentricity mapping of the central, middle, and peripheral visual fields, the feasibility of retinotopic mapping of central and peripheral visual fields in patients with brain tumor was investigated for the first time. The results of the study suggest that patients with brain tumor as well as with space-occupying brain lesion still show intact retinotopic organization of the visual cortex despite their disease, although cortical activations appear reduced compared to a healthy control group. In addition, local region of

interest analyses showed that the patients with space-occupying brain lesions had higher values of percent signal change in the calcarine fissure than the tumor patients and were comparable to those of the control subjects, but showed a significantly reduced pattern in terms of cluster size of activated voxels compared to patients with brain tumor. Overall, the results of this study indicate that a space-occupying brain lesion seems to have less effect on the level of the BOLD signal and more on the volume of cortical activation, whereas the opposite was observed in patients with brain tumor.

The second study aimed to create and evaluate a preprocessing protocol that allows three-dimensional reconstruction of the T1-weighted anatomical image in FreeSurfer, which has previously led to erroneous results due to poor detection and handling of pathological changes. Results have shown that modification of the T1-weighted image, in which tumor-affected areas were replaced with healthy tissue from the contralateral hemisphere, allows reconstruction. Here, the time required for reconstruction and the abortion rate did not differ from those of a healthy control group. In addition, comparisons of the analyses of functional MRI data with the results from the established SPM12 software showed that the results of the volume-based analysis of both methods yielded comparable results. Therefore, it is concluded that modification of the T1-weighted image with the preprocessing protocol presented here is an appropriate way to use FreeSurfer in data of patients with brain tumor, while providing new ways to analyze patient data.

The third study focused on investigating structural and functional differences between two groups of glioblastoma patients with different morphological tumor growth patterns. Here, the results indicated structural differences within the tumor between different tumor components (intra-tumor heterogeneity), but not between the two groups of patients with uniform and diffuse tumor growth patterns (inter-tumor heterogeneity). Examination of differences in BOLD signal showed that the patients with a prognostically more favorable uniform tumor growth pattern had higher percent signal change values in most regions of interest on both language fMRI and motor fMRI, but these differences were not statistically significant. In the lateralization of cortical activation, the language paradigms showed little difference between the two groups of patients, whereas the motor paradigms showed higher values of the lateralization indices in the prognostically less favorable group of patients with diffuse tumor growth pattern. Although these differences were statistically not significant, they indicate a more pronounced shift of the otherwise bilateral activation in motor-relevant areas in this group toward a more unilateral activation pattern. This may represent evidence for the stronger influence of the prognostically less favorable tumor growth pattern on cortical activation.

Regarding the additionally investigated functional connectivity, only minor and mostly balanced and unsystematically distributed differences between the two patient groups with uniform and diffuse tumor growth pattern were shown. Overall, it can be concluded from the results that minor differences between both patient groups seem to be present on a functional level, but do not appear significant on a statistical level.

5.2 Conclusions for future research projects

The three studies presented in this thesis were able to generate results that not only contribute relevantly to the current state of research, but may also be relevant for future research projects. Here, the presented results and limitations can be used as a starting point for planning and conducting further studies on the characterization of neuroplastic processes in patients with brain tumors.

Potential future studies using fMRI retinotopic mapping

In the first study presented here, retinotopic mapping in patients with brain tumors was described using the eccentricity mapping paradigm using three circles of different sizes. Visualization of the cortical representations of the horizontal as well as vertical visual field meridian would suitably complement these results and provide valuable additional information about possible neuroplastic changes in the visual cortex that were not detected by eccentricity mapping. In addition, for both paradigms, eccentricity mapping as well as meridian mapping, a more graduated stimulation of smaller areas of the visual field would be desirable. This would allow more detailed maps of cortical representations of individual visual field areas (186). Combining wedge stimuli that rotate both clockwise and counterclockwise and circles that both expand and contract can additionally increase the accuracy of meridian mapping and eccentricity mapping. Here, phase-encoded retinotopic mapping would be a possible method for acquiring and evaluating such paradigms (187).

In addition to the advantages mentioned above, phase-encoded retinotopic mapping also offers the advantage that, due to the stimuli used, a comparison with potential visual field defects of the patients may be possible in addition to the more detailed retinotopic maps. This comparison of fMRI data with those of perimetry is based on the assumption that it is possible to calculate the stimulus to which each individual voxel's reaction is maximal (123,188). The combination of the different stimuli enables this to be calculated for all meridians and eccentricities in the entire visual field, and thus allows conclusions about any visual field defects can be drawn on

the basis of the combined results. These can also be compared and evaluated using additionally performed perimetric examinations of the visual field.

Another research question, whose investigation would provide additional valuable insight into the behavior of brain tumors, would be to compare the results of fMRI retinotopic mapping in the presence of brain tumors along the processing pathway of visual information. Here, it could be examined whether retinotopic organization is also preserved in these tumors and how different tumor localizations affect the BOLD signal. Conceivable tumor localizations here include pituitary adenomas that compress the optic chiasm before these fibers reach the thalamus, or tumors that infiltrate the optic radiation and thus affect fiber connections of information that have already been preprocessed in the thalamus. Initial evidence for neuroplastic changes was already provided here by studies that found morphological changes in the visual cortex as a result of tumors along the visual pathway (92).

In addition to these suggestions for research questions related to the preoperative state of patients, it would also be desirable to follow the postoperative course of visual abilities using fMRI. Here, it would be conceivable to additionally perform retinotopic mapping on patients in routine follow-up examinations using MRI. Such investigations would provide valuable insights into postoperative neuroplastic changes. Initial evidence for changes in morphometry as well as resting state functional connectivity associated with improvements in visual abilities in the postoperative course has already been found (90,91), but longitudinal investigation of changes in cortical activations in response to specific stimulation of the visual field would also be desirable.

Potential future studies using FreeSurfer on data from patients with brain tumors

The second study of this dissertation dealt with the creation and evaluation of a preprocessing protocol that allows three-dimensional reconstruction in FreeSurfer. Since this study also showed that functional MRI data can be analyzed with this and these results are similar to those from SPM12, this approach can also be used for further future studies. An example of this would be the analysis of phase-encoded retinotopic mapping, which was described in the previous chapter. For this type of analysis, FreeSurfer provides a separate analysis stream.

Since the three-dimensional reconstruction forms this basis for all evaluations and they are thus mapped to the same template, better comparisons can also be made between different types of analysis. Thus, functional neuroplastic changes can be directly related to the corresponding structural changes in fiber connections or fractional anisotropy without being subject to bias due to additional normalization and registration steps.

Potential future studies

The third study conducted within this thesis investigated structural and functional neuroplastic changes in patients with glioblastoma multiforme (GBM). Here, the patient sample was divided into two subgroups based on the morphological appearance of the accumulation of contrast agent in MRI and compared with each other. Minor differences were shown here, which, however, were statistically not significant. Based on the results, it seems reasonable to conclude that an existing difference between the groups could be masked by another mediator variable, which has not been considered so far. The aim of a further study could be to identify this variable.

Another interesting approach for future research would be the correlation of the investigated structural and functional parameters on the survival of the patients. In this regard, previous studies have already shown that, for example, the expression of fractional anisotropy in different portions of the tumor has been shown to be a prognostic predictor. Similarly, this has been shown for functional connectivity (98). In addition to survival, an investigation of the molecular markers and their correlation with the structural and functional parameters found here would be a worthwhile approach for further research.

6 CONCLUSIONS

Considering the results of all three studies as well as the findings of other previously published studies, the relevance of investigating the behavior and influence of brain tumors in relation to structural and functional magnetic resonance imaging is clearly evident. The continuous development of techniques and methods of data collection and analysis is an important aim here. At the same time, in consideration of the fact that the influence of the tumor on the MRI signal cannot be quantified unambiguously until today, the investigation of this effect represents an important starting point for the improvement of the interpretation of the data of these imaging techniques.

In this thesis, three studies examining different aspects of preoperative imaging have demonstrated that the presence of a brain tumor has profound implications for the structure and function of the brain, which are not only localized to the area affected by the tumor, but are global to the contralateral unaffected hemisphere.

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8 APPENDIX

Supplementary Table 1.

Summary of p-values of one-tailed t-tests of the healthy control group during stimulation with the inner circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		<.001	<.001	<.001	.194	.153	.991	.954	.738	.961	.999	.456	.810	.996	.998	.982	.805	>.999	>.999	.040	.048	.129	.156
	LP (L)	<.001		<.001	<.001	.167	.887	.861	.832	.867	.962	.992	.915	.956	.894	.988	.527	.731	.978	.998	<.001	<.001	<.001	.001
	LP (R)	<.001	<.001		<.001	.666	.757	.875	.848	.932	.969	.996	.795	.678	.996	.885	.303	.628	.836	.916	<.001	<.001	<.001	<.001
	PCC	<.001	<.001	<.001		<.001	.813	.998	.991	.168	.933	.974	.033	.089	.876	.818	.911	.939	.939	.980	<.001	<.001	<.001	<.001
VN	MED	.194	.167	.666	<.001		.975	.018	.022	.012	.092	.039	.366	.161	.011	.037	.562	.402	.466	.472	.640	.616	.454	.545
	OCC	.153	.887	.757	.813	.975		<.001	<.001	.538	.556	.294	.055	.131	.121	.599	.962	.961	.503	.687	.004	.273	.088	.316
	LAT (L)	.991	.861	.875	.998	.018	<.001		<.001	.565	.220	.007	.980	.108	.010	.034	.494	.406	<.001	<.001	.033	.106	.033	.305
	LAT (R)	.954	.832	.848	.991	.022	<.001	<.001		.665	.615	.046	.976	.174	.053	.116	.713	.330	<.001	<.001	.057	.077	.307	.435
SN	ACC	.738	.867	.932	.168	.012	.538	.565	.665		<.001	<.001	<.001	<.001	<.001	<.001	.280	.209	.001	<.001	.742	.919	.313	.247
	AINS (L)	.961	.962	.969	.933	.092	.556	.220	.615	<.001		<.001	.001	.002	<.001	.001	.473	.069	.001	.001	.754	.900	.618	.907
	AINS (R)	.999	.992	.996	.974	.039	.294	.007	.046	<.001	<.001		.005	<.001	<.001	<.001	.368	.288	<.001	<.001	.818	.861	.315	.298
	RPFC (L)	.456	.915	.795	.033	.366	.055	.980	.976	<.001	.001	.005		<.001	.022	.018	.494	.332	.021	.037	.270	.825	.206	.287
	RPFC (R)	.810	.956	.678	.089	.161	.131	.108	.174	<.001	.002	<.001	<.001		<.001	<.001	.498	.204	.002	<.001	.829	.732	.003	.015
	SMG (L)	.996	.894	.996	.876	.011	.121	.010	.053	<.001	<.001	<.001	.022	<.001		<.001	.393	.599	<.001	<.001	.632	.487	.345	.725
	SMG (R)	.998	.988	.885	.818	.037	.599	.034	.116	<.001	.001	<.001	.018	<.001	<.001		.134	.344	<.001	<.001	.994	.799	.491	.225
DAN	FEF (L)	.982	.527	.303	.911	.562	.962	.494	.713	.280	.473	.368	.494	.498	.393	.134		.003	.002	.001	.849	.691	.779	.814
	FEF (R)	.805	.731	.628	.939	.402	.961	.406	.330	.209	.069	.288	.332	.204	.599	.344	.003		.022	.001	.990	.834	.771	.827
	IPS (L)	>.999	.978	.836	.939	.466	.503	<.001	<.001	.001	.001	<.001	.021	.002	<.001	<.001	.002	.022		<.001	.948	.464	.576	.439
	IPS (R)	>.999	.998	.916	.980	.472	.687	<.001	<.001	<.001	.001	<.001	.037	<.001	<.001	<.001	.001	.001	<.001		.989	.856	.786	.717
FPN	LPFC (L)	.040	<.001	<.001	<.001	.640	.004	.033	.057	.742	.754	.818	.270	.829	.632	.994	.849	.990	.948	.989		<.001	<.001	<.001
	PPC (L)	.048	<.001	<.001	<.001	.616	.273	.106	.077	.919	.900	.861	.825	.732	.487	.799	.691	.834	.464	.856	<.001		<.001	<.001
	LPFC (R)	.129	<.001	<.001	<.001	.454	.088	.033	.307	.313	.618	.315	.206	.003	.345	.491	.779	.771	.576	.786	<.001	<.001		<.001
	PPC (R)	.156	.001	<.001	<.001	.545	.316	.305	.435	.247	.907	.298	.287	.015	.725	.225	.814	.827	.439	.717	<.001	.001	<.001	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 2.

Summary of p-values of one-tailed t-tests of the healthy control group during stimulation with the middle circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		<.001	<.001	<.001	.276	.004	.997	.998	.307	.995	.998	.069	.441	.999	>.999	.974	.886	>.999	>.999	.471	.230	.017	.030
	LP (L)	<.001		<.001	<.001	.164	.214	.992	.988	.994	>.999	>.999	.827	.987	.996	>.999	.728	.945	.992	>.999	<.001	<.001	.002	.003
	LP (R)	<.001	<.001		<.001	.144	.381	.976	.963	.991	.999	>.999	.852	.900	.978	.999	.513	.887	.996	>.999	<.001	<.001	<.001	.001
	PCC	<.001	<.001	<.001		.005	.551	.998	.998	.832	.997	>.999	.009	.242	.907	.996	.353	.932	.993	>.999	.001	<.001	.001	<.001
VN	MED	.276	.164	.144	.005		.119	.006	.009	.541	.117	.521	.122	.232	.373	.249	.862	.029	.518	.520	.747	.881	.499	.864
	OCC	.004	.214	.381	.551	.119		<.001	.001	.496	.227	.014	.295	.104	.409	.259	.965	.628	.736	.467	.925	.930	.116	.658
	LAT (L)	.997	.992	.976	.998	.006	<.001		<.001	.679	.043	.008	.754	.568	.009	.006	.092	.005	<.001	<.001	.678	.710	.192	.944
	LAT (R)	.998	.988	.963	.998	.009	.001	<.001		.787	.067	.009	.653	.460	.038	.004	.236	.006	<.001	<.001	.462	.457	.316	.808
SN	ACC	.307	.994	.991	.832	.541	.496	.679	.787		<.001	<.001	<.001	<.001	.009	.005	.226	.317	.030	.073	.919	.927	.113	.083
	AINS (L)	.995	>.999	.999	.997	.117	.227	.043	.067	<.001		<.001	.015	.001	<.001	<.001	.467	.164	.009	.028	.966	.982	.716	.694
	AINS (R)	.998	>.999	>.999	>.999	.521	.014	.008	.009	<.001	<.001		.055	<.001	<.001	<.001	.309	.108	<.001	<.001	.993	.989	.169	.113
	RPFC (L)	.069	.827	.852	.009	.122	.295	.754	.653	<.001	.015	.055		<.001	.200	.067	.541	.251	.325	.137	.034	.191	.020	.169
	RPFC (R)	.441	.987	.900	.242	.232	.104	.568	.460	<.001	.001	<.001	<.001		.006	<.001	.104	.190	.049	.126	.930	.553	<.001	.001
	SMG (L)	.999	.996	.978	.907	.373	.409	.009	.038	.009	<.001	<.001	.200	.006		<.001	.217	.556	<.001	<.001	.147	.038	.431	.282
	SMG (R)	>.999	>.999	.999	.996	.249	.259	.006	.004	.005	<.001	<.001	.067	<.001	<.001		.116	.100	<.001	<.001	.878	.806	.241	.041
DAN	FEF (L)	.974	.728	.513	.353	.862	.965	.092	.236	.226	.467	.309	.541	.104	.217	.116		.116	.002	<.001	.501	.092	.324	.709
	FEF (R)	.886	.945	.887	.932	.029	.628	.005	.006	.317	.164	.108	.251	.190	.556	.100	.116		.008	.009	.893	.774	.831	.966
	IPS (L)	>.999	.992	.996	.993	.518	.736	<.001	<.001	.030	.009	<.001	.325	.049	<.001	<.001	.002	.008		<.001	.387	.009	.879	.602
	IPS (R)	>.999	>.999	>.999	>.999	.520	.467	<.001	<.001	.073	.028	<.001	.137	.126	<.001	<.001	<.001	.009	<.001		.916	.821	.851	.871
FPN	LPFC (L)	.471	<.001	<.001	.001	.747	.925	.678	.462	.919	.966	.993	.034	.930	.147	.878	.501	.893	.387	.916		<.001	<.001	<.001
	PPC (L)	.230	<.001	<.001	<.001	.881	.930	.710	.457	.927	.982	.989	.191	.553	.038	.806	.092	.774	.009	.821	<.001		<.001	<.001
	LPFC (R)	.017	.002	<.001	.001	.499	.116	.192	.316	.113	.716	.169	.020	<.001	.431	.241	.324	.831	.879	.851	<.001	<.001		<.001
	PPC (R)	.030	.003	.001	<.001	.864	.658	.944	.808	.083	.694	.113	.169	.001	.282	.041	.709	.966	.602	.871	<.001	<.001	<.001	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 3.

Summary of p-values of one-tailed t-tests of the healthy control group during stimulation with the outer circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		<.001	<.001	<.001	.386	.267	.980	.972	.362	.986	.998	.020	.400	>.999	.998	.986	.853	>.999	>.999	.499	.116	.311	.126
	LP (L)	<.001		<.001	<.001	.049	.993	.774	.794	.989	.997	>.999	.808	.990	.993	.994	.790	.722	.993	.996	<.001	<.001	.021	.054
	LP (R)	<.001	<.001		<.001	.522	.230	.477	.707	.936	.987	>.999	.537	.483	.987	.987	.860	.771	.986	.971	.106	.002	.002	<.001
	PCC	<.001	<.001	<.001		<.001	.983	.963	.962	.159	.924	.998	.004	.178	.693	.859	.987	.691	.938	.939	.257	.014	.128	.005
VN	MED	.386	.049	.522	<.001		>.999	.008	.020	.052	.049	.335	.033	.174	.098	.189	.934	.471	.048	.114	.428	.562	.825	.902
	OCC	.267	.993	.230	.983	>.999		<.001	<.001	.639	.882	.423	.261	.249	.889	.881	.983	.296	.797	.812	.085	.363	.011	.029
	LAT (L)	.980	.774	.477	.963	.008	<.001		<.001	.838	.397	.020	.915	.758	.165	.037	.833	.459	<.001	<.001	.157	.290	.052	.371
	LAT (R)	.972	.794	.707	.962	.020	<.001	<.001		.940	.756	.019	.870	.807	.246	.087	.754	.091	<.001	<.001	.113	.268	.159	.462
SN	ACC	.362	.989	.936	.159	.052	.639	.838	.940		<.001	<.001	<.001	<.001	.001	<.001	.181	.018	.031	.400	.940	.845	.294	.128
	AINS (L)	.986	.997	.987	.924	.049	.882	.397	.756	<.001		<.001	<.001	<.001	<.001	<.001	.645	.009	.007	.299	.338	.882	.457	.341
	AINS (R)	.998	>.999	>.999	.998	.335	.423	.020	.019	<.001	<.001		.007	<.001	<.001	<.001	.481	.001	<.001	.003	.739	.839	.053	.019
	RPFC (L)	.020	.808	.537	.004	.033	.261	.915	.870	<.001	<.001	.007		<.001	.054	.028	.776	.183	.105	.594	.110	.386	.300	.096
	RPFC (R)	.400	.990	.483	.178	.174	.249	.758	.807	<.001	<.001	<.001	<.001		.002	<.001	.193	.073	.017	.274	.591	.783	.005	.004
	SMG (L)	>.999	.993	.987	.693	.098	.889	.165	.246	.001	<.001	<.001	.054	.002		<.001	.135	.086	<.001	.001	.606	.685	.233	.261
	SMG (R)	.998	.994	.987	.859	.189	.881	.037	.087	<.001	<.001	<.001	.028	<.001	<.001		.095	.010	<.001	<.001	.906	.876	.191	.058
DAN	FEF (L)	.986	.790	.860	.987	.934	.983	.833	.754	.181	.645	.481	.776	.193	.135	.095		.059	<.001	<.001	.518	.310	.846	.691
	FEF (R)	.853	.722	.771	.691	.471	.296	.459	.091	.018	.009	.001	.183	.073	.086	.010	.059		.011	.017	.633	.431	.637	.397
	IPS (L)	>.999	.993	.986	.938	.048	.797	<.001	<.001	.031	.007	<.001	.105	.017	<.001	<.001	<.001	.011		<.001	.336	.258	.772	.353
	IPS (R)	>.999	.996	.971	.939	.114	.812	<.001	<.001	.400	.299	.003	.594	.274	.001	<.001	<.001	.017	<.001		.712	.754	.773	.453
FPN	LPFC (L)	.499	<.001	.106	.257	.428	.085	.157	.113	.940	.338	.739	.110	.591	.606	.906	.518	.633	.336	.712		<.001	<.001	<.001
	PPC (L)	.116	<.001	.002	.014	.562	.363	.290	.268	.845	.882	.839	.386	.783	.685	.876	.310	.431	.258	.754	<.001		<.001	<.001
	LPFC (R)	.311	.021	.002	.128	.825	.011	.052	.159	.294	.457	.053	.300	.005	.233	.191	.846	.637	.772	.773	<.001	<.001		<.001
	PPC (R)	.126	.054	<.001	.005	.902	.029	.371	.462	.128	.341	.019	.096	.004	.261	.058	.691	.397	.353	.453	<.001	<.001	<.001	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 4.

Summary of p-values of one-tailed t-tests of the tumor patients group during stimulation with the inner circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.034	.005	<.001	.418	.672	.993	.996	.185	.753	.890	.821	.989	.730	.973	.287	.943	.963	.997	.187	.234	.281	.283
	LP (L)	.034		.001	.001	.049	.980	.207	.312	.965	.932	.811	.819	.879	.271	.214	.056	.372	.062	.400	.010	.009	.038	.014
	LP (R)	.005	.001		<.001	.044	.995	.504	.097	.730	.976	.981	.710	.946	.254	.252	.296	.905	.058	.641	.049	.066	.109	.028
	PCC	<.001	.001	<.001		.002	.790	.168	.113	.422	.960	.982	.909	.970	.594	.583	.118	.685	.017	.688	.048	.020	.057	.113
VN	MED	.418	.049	.044	.002		.991	.001	.001	.130	.050	.052	.131	.525	.026	.028	.244	.190	.041	.022	.572	.784	.966	.912
	OCC	.672	.980	.995	.790	.991		.002	.267	.132	.333	.180	.125	.038	.834	.788	.156	.045	.924	.248	.751	.922	.118	.710
	LAT (L)	.993	.207	.504	.168	.001	.002		<.001	.066	.036	.018	.008	<.001	.004	.001	.021	.021	<.001	<.001	.213	.731	.018	.855
	LAT (R)	.996	.312	.097	.113	.001	.267	<.001		.712	.721	.162	.404	.377	.319	.002	.013	.004	.005	<.001	.618	.797	.664	.908
SN	ACC	.185	.965	.730	.422	.130	.132	.066	.712		<.001	<.001	<.001	<.001	<.001	<.001	.036	.011	.004	<.001	.344	.790	.082	.286
	AINS (L)	.753	.932	.976	.960	.050	.333	.036	.721	<.001		<.001	.001	<.001	.001	<.001	.223	.023	.011	.001	.525	.788	.203	.625
	AINS (R)	.890	.811	.981	.982	.052	.180	.018	.162	<.001	<.001		<.001	<.001	.001	<.001	.217	.016	.008	.001	.770	.908	.424	.775
	RPFC (L)	.821	.819	.710	.909	.131	.125	.008	.404	<.001	.001	<.001		<.001	<.001	<.001	.102	.002	.001	<.001	.350	.974	.125	.510
	RPFC (R)	.989	.879	.946	.970	.525	.038	.000	.377	<.001	<.001	<.001	<.001		<.001	<.001	.319	.003	.001	<.001	.546	.764	.018	.379
	SMG (L)	.730	.271	.254	.594	.026	.834	.004	.319	<.001	.001	.001	<.001	<.001		<.001	.105	.089	.001	.011	.744	.544	.158	.426
	SMG (R)	.973	.214	.252	.583	.028	.788	.001	.002	<.001	<.001	<.001	<.001	<.001	<.001		.016	.002	.001	<.001	.377	.550	.054	.073
DAN	FEF (L)	.287	.056	.296	.118	.244	.156	.021	.013	.036	.223	.217	.102	.319	.105	.016		.010	.002	.012	.996	.598	.795	.229
	FEF (R)	.943	.372	.905	.685	.190	.045	.021	.004	.011	.023	.016	.002	.003	.089	.002	.010		.009	<.001	.817	.998	.158	.699
	IPS (L)	.963	.062	.058	.017	.041	.924	<.001	.005	.004	.011	.008	.001	.001	.001	.001	.002	.009		<.001	.039	.008	.015	.178
	IPS (R)	.997	.400	.641	.688	.022	.248	<.001	<.001	<.001	.001	.001	<.001	<.001	.011	<.001	.012	<.001	<.001		.301	.439	.038	.358
FPN	LPFC (L)	.187	.010	.049	.048	.572	.751	.213	.618	.344	.525	.770	.350	.546	.744	.377	.996	.817	.039	.301		<.001	<.001	.003
	PPC (L)	.234	.009	.066	.020	.784	.922	.731	.797	.790	.788	.908	.974	.764	.544	.550	.598	.998	.008	.439	<.001		.001	.002
	LPFC (R)	.281	.038	.109	.057	.966	.118	.018	.664	.082	.203	.424	.125	.018	.158	.054	.795	.158	.015	.038	<.001	.001		.004
	PPC (R)	.283	.014	.028	.113	.912	.710	.855	.908	.286	.625	.775	.510	.379	.426	.073	.229	.699	.178	.358	.003	.002	.004	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 5.

Summary of p-values of one-tailed t-tests of the tumor patients group during stimulation with the middle circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.003	<.001	<.001	.015	.068	.656	.851	.073	.982	.964	.850	.986	.977	.982	.422	.980	.992	.996	.381	.186	.432	.136
	LP (L)	.003		<.001	<.001	.164	.380	.063	.241	.575	.978	.997	.857	.573	.906	.438	.528	.300	.251	.259	.128	.053	.053	.232
	LP (R)	<.001	<.001		<.001	.026	.690	.112	.102	.479	.911	.978	.760	.977	.556	.622	.092	.808	.207	.522	.117	.099	.211	.036
	PCC	<.001	<.001	<.001		.007	.012	.023	.114	.535	.981	.978	.797	.930	.835	.714	.277	.644	.257	.323	.046	.009	.032	.169
VN	MED	.015	.164	.026	.007		.086	.028	.003	.162	.084	.067	.116	.512	.080	.109	.235	.263	.037	.060	.487	.782	.314	.773
	OCC	.068	.380	.690	.012	.086		<.001	.001	.103	.040	.151	.078	.157	.189	.191	.223	.009	.125	.010	.077	.228	.029	.545
	LAT (L)	.656	.063	.112	.023	.028	<.001		<.001	.689	.304	.085	.306	.076	.055	.054	.062	.032	.001	<.001	.611	.529	.091	.968
	LAT (R)	.851	.241	.102	.114	.003	.001	<.001		.727	.278	.172	.559	.478	.354	.368	.127	.012	.012	.001	.519	.529	.440	.872
SN	ACC	.073	.575	.479	.535	.162	.103	.689	.727		.001	.001	<.001	<.001	.009	<.001	.098	.017	.016	.009	.076	.433	.329	.182
	AINS (L)	.982	.978	.911	.981	.084	.040	.304	.278	.001		<.001	.001	.002	.001	<.001	.104	.005	.053	.009	.148	.702	.224	.439
	AINS (R)	.964	.997	.978	.978	.067	.151	.085	.172	.001	<.001		.006	.001	.006	<.001	.102	.010	.009	.002	.861	.925	.669	.836
	RPFC (L)	.850	.857	.760	.797	.116	.078	.306	.559	<.001	.001	.006		<.001	<.001	<.001	.247	.088	<.001	.017	<.001	.135	.002	.054
	RPFC (R)	.986	.573	.977	.930	.512	.157	.076	.478	<.001	.002	.001	<.001		<.001	<.001	.617	.010	<.001	.002	.009	.163	.002	.130
	SMG (L)	.977	.906	.556	.835	.080	.189	.055	.354	.009	.001	.006	<.001	<.001		<.001	.547	.178	<.001	.038	.114	.188	.016	.167
	SMG (R)	.982	.438	.622	.714	.109	.191	.054	.368	<.001	<.001	<.001	<.001	<.001	<.001		.432	.036	<.001	<.001	.039	.334	.028	.218
DAN	FEF (L)	.422	.528	.092	.277	.235	.223	.062	.127	.098	.104	.102	.247	.617	.547	.432		.115	.033	.043	.737	.656	.776	.496
	FEF (R)	.980	.300	.808	.644	.263	.009	.032	.012	.017	.005	.010	.088	.010	.178	.036	.115		.012	.001	.127	.146	.113	.481
	IPS (L)	.992	.251	.207	.257	.037	.125	.001	.012	.016	.053	.009	<.001	<.001	<.001	<.001	.033	.012		<.001	.006	.008	.004	.551
	IPS (R)	.996	.259	.522	.323	.060	.010	<.001	.001	.009	.009	.002	.017	.002	.038	<.001	.043	.001	<.001		.236	.389	.113	.902
FPN	LPFC (L)	.381	.128	.117	.046	.487	.077	.611	.519	.076	.148	.861	<.001	.009	.114	.039	.737	.127	.006	.236		<.001	<.001	.002
	PPC (L)	.186	.053	.099	.009	.782	.228	.529	.529	.433	.702	.925	.135	.163	.188	.334	.656	.146	.008	.389	<.001		<.001	.001
	LPFC (R)	.432	.053	.211	.032	.314	.029	.091	.440	.329	.224	.669	.002	.002	.016	.028	.776	.113	.004	.113	<.001	<.001		.011
	PPC (R)	.136	.232	.036	.169	.773	.545	.968	.872	.182	.439	.836	.054	.130	.167	.218	.496	.481	.551	.902	.002	.001	.011	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 6.

Summary of p-values of one-tailed t-tests of the tumor patients group during stimulation with the outer circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.023	.014	<.001	.075	.492	.859	.793	.453	.900	.999	.865	.995	.965	.988	.190	.618	.946	.984	.045	.093	.328	.079
	LP (L)	.023		.003	.001	.004	.902	.034	.106	.580	.846	.926	.158	.039	.712	.036	.314	.007	.147	.106	.002	.019	.005	.034
	LP (R)	.014	.003		<.001	.009	.961	.184	.049	.763	.931	.977	.410	.748	.622	.453	.270	.242	.105	.064	.009	.016	.008	.004
	PCC	<.001	.001	<.001		.001	.774	.088	.016	.499	.895	.942	.258	.507	.743	.348	.035	.024	.026	.043	<.001	.001	.006	.003
VN	MED	.075	.004	.009	.001		.998	.133	.022	.580	.166	.042	.260	.293	.412	.160	.535	.082	.325	.121	.720	.293	.358	.127
	OCC	.492	.902	.961	.774	.998		.044	.114	.190	.193	.250	.290	.270	.781	.216	.059	.232	.485	.156	.364	.497	.097	.759
	LAT (L)	.859	.034	.184	.088	.133	.044		<.001	.272	.058	.101	.033	.001	.420	.004	.140	.069	<.001	<.001	.211	.343	.007	.884
	LAT (R)	.793	.106	.049	.016	.022	.114	<.001		.820	.457	.276	.365	.138	.545	.109	.092	.155	.004	<.001	.132	.568	.032	.633
SN	ACC	.453	.580	.763	.499	.580	.190	.272	.820		.001	<.001	<.001	<.001	<.001	<.001	.138	.189	.012	.036	.489	.562	.027	.223
	AINS (L)	.900	.846	.931	.895	.166	.193	.058	.457	.001		<.001	.006	.001	.006	<.001	.231	.551	.062	.028	.963	.789	.308	.314
	AINS (R)	.999	.926	.977	.942	.042	.250	.101	.276	<.001	<.001		.008	<.001	.001	<.001	.468	.197	.029	.007	.997	.732	.586	.724
	RPFC (L)	.865	.158	.410	.258	.260	.290	.033	.365	<.001	.006	.008		<.001	<.001	<.001	.282	.039	.001	.019	.094	.528	.001	.258
	RPFC (R)	.995	.039	.748	.507	.293	.270	.001	.138	<.001	.001	<.001	<.001		<.001	<.001	.715	.026	<.001	.003	.145	.351	.001	.333
	SMG (L)	.965	.712	.622	.743	.412	.781	.420	.545	<.001	.006	.001	<.001	<.001		.001	.351	.273	<.001	.015	.566	.488	.124	.662
	SMG (R)	.988	.036	.453	.348	.160	.216	.004	.109	<.001	<.001	<.001	<.001	<.001	.001		.046	.022	.003	<.001	.528	.449	.024	.198
DAN	FEF (L)	.190	.314	.270	.035	.535	.059	.140	.092	.138	.231	.468	.282	.715	.351	.046		.020	.020	.036	.320	.230	.203	.570
	FEF (R)	.618	.007	.242	.024	.082	.232	.069	.155	.189	.551	.197	.039	.026	.273	.022	.020		.061	.025	.304	.580	.247	.298
	IPS (L)	.946	.147	.105	.026	.325	.485	<.001	.004	.012	.062	.029	.001	<.001	<.001	.003	.020	.061		<.001	.046	.028	.002	.473
	IPS (R)	.984	.106	.064	.043	.121	.156	<.001	<.001	.036	.028	.007	.019	.003	.015	<.001	.036	.025	<.001		.728	.738	.039	.579
FPN	LPFC (L)	.045	.002	.009	<.001	.720	.364	.211	.132	.489	.963	.997	.094	.145	.566	.528	.320	.304	.046	.728		<.001	<.001	.001
	PPC (L)	.093	.019	.016	.001	.293	.497	.343	.568	.562	.789	.732	.528	.351	.488	.449	.230	.580	.028	.738	<.001		<.001	<.001
	LPFC (R)	.328	.005	.008	.006	.358	.097	.007	.032	.027	.308	.586	.001	.001	.124	.024	.203	.247	.002	.039	<.001	<.001		<.001
	PPC (R)	.079	.034	.004	.003	.127	.759	.884	.633	.223	.314	.724	.258	.333	.662	.198	.570	.298	.473	.579	.001	<.001	<.001	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 7.

Summary of p-values of one-tailed t-tests of the lesion patients group during stimulation with the inner circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.005	.002	.003	.754	.083	.933	.901	.480	.987	.978	.761	.870	.984	.993	.780	.328	.990	.971	.290	.253	.827	.739
	LP (L)	.005		.002	.006	.718	.616	.820	.765	.226	.778	.731	.276	.425	.679	.892	.447	.124	.685	.715	.059	.025	.483	.092
	LP (R)	.002	.002		.003	.899	.193	.975	.941	.678	.937	.881	.663	.712	.844	.890	.810	.144	.840	.874	.019	.003	.025	.005
	PCC	.003	.006	.003		.255	.023	.882	.932	.076	.748	.644	.232	.268	.891	.954	.594	.571	.943	.956	.093	.087	.376	.036
VN	MED	.754	.718	.899	.255		.830	.004	.005	.013	.009	.008	.007	.002	.007	.026	.116	.681	.050	.014	.937	.852	.347	.350
	OCC	.083	.616	.193	.023	.830		.276	.620	.713	.829	.753	.430	.433	.615	.591	.781	.671	.753	.805	.151	.735	.261	.872
	LAT (L)	.933	.820	.975	.882	.004	.276		.001	.287	.148	.134	.129	.124	.124	.047	.177	.219	.065	.027	.315	.745	.581	.892
	LAT (R)	.901	.765	.941	.932	.005	.620	.001		.287	.078	.193	.297	.087	.056	.019	.070	.563	.028	.002	.619	.957	.664	.975
SN	ACC	.480	.226	.678	.076	.013	.713	.287	.287		.001	.005	.001	.002	.020	.169	.137	.274	.018	.037	.543	.782	.923	.453
	AINS (L)	.987	.778	.937	.748	.009	.829	.148	.078	.001		<.001	<.001	<.001	<.001	.017	.084	.342	<.001	.001	.797	.864	.216	.254
	AINS (R)	.978	.731	.881	.644	.008	.753	.134	.193	.005	<.001		.001	<.001	.003	.004	.050	.108	.003	.001	.701	.754	.274	.393
	RPFC (L)	.761	.276	.663	.232	.007	.430	.129	.297	.001	<.001	.001		<.001	.006	.093	.189	.343	.006	.013	.404	.870	.362	.335
	RPFC (R)	.870	.425	.712	.268	.002	.433	.124	.087	.002	<.001	<.001	<.001		.002	.030	.071	.274	.002	.001	.368	.516	.063	.085
	SMG (L)	.984	.679	.844	.891	.007	.615	.124	.056	.020	<.001	.003	.006	.002		.007	.195	.336	.004	.005	.469	.507	.090	.157
	SMG (R)	.993	.892	.890	.954	.026	.591	.047	.019	.169	.017	.004	.093	.030	.007		.006	.204	.007	.003	.415	.430	.074	.139
DAN	FEF (L)	.780	.447	.810	.594	.116	.781	.177	.070	.137	.084	.050	.189	.071	.195	.006		.032	.067	.012	.330	.613	.343	.500
	FEF (R)	.328	.124	.144	.571	.681	.671	.219	.563	.274	.342	.108	.343	.274	.336	.204	.032		.242	.249	.112	.103	.570	.438
	IPS (L)	.990	.685	.840	.943	.050	.753	.065	.028	.018	<.001	.003	.006	.002	.004	.007	.067	.242		<.001	.125	.470	.095	.375
	IPS (R)	.971	.715	.874	.956	.014	.805	.027	.002	.037	.001	.001	.013	.001	.005	.003	.012	.249	<.001		.144	.720	.079	.756
FPN	LPFC (L)	.290	.059	.019	.093	.937	.151	.315	.619	.543	.797	.701	.404	.368	.469	.415	.330	.112	.125	.144		.012	.003	.082
	PPC (L)	.253	.025	.003	.087	.852	.735	.745	.957	.782	.864	.754	.870	.516	.507	.430	.613	.103	.470	.720	.012		.002	<.001
	LPFC (R)	.827	.483	.025	.376	.347	.261	.581	.664	.923	.216	.274	.362	.063	.090	.074	.343	.570	.095	.079	.003	.002		.001
	PPC (R)	.739	.092	.005	.036	.350	.872	.892	.975	.453	.254	.393	.335	.085	.157	.139	.500	.438	.375	.756	.082	<.001	.001	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 8.

Summary of p-values of one-tailed t-tests of the lesion patients group during stimulation with the middle circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.008	.024	.002	.199	.228	.908	.690	.797	.997	.999	.932	.945	.999	.997	.726	.936	>.999	>.999	.740	.284	.701	.668
	LP (L)	.008		.001	.005	.539	.803	.792	.817	.480	.960	.960	.565	.623	.922	.945	.561	.686	.880	.955	.156	.027	.268	.125
	LP (R)	.024	.001		.001	.742	.542	.844	.549	.737	.998	.986	.830	.794	.876	.960	.661	.826	.885	.958	.098	.022	.001	.013
	PCC	.002	.005	.001		.091	.158	.370	.400	.110	.962	.978	.323	.591	.972	.962	.936	.920	.897	.952	.115	.204	.461	.242
VN	MED	.199	.539	.742	.091		.111	.020	.007	.003	.017	.066	.002	.020	.033	.083	.934	.692	.670	.465	.978	.999	.950	.838
	OCC	.228	.803	.542	.158	.111		.005	<.001	.221	.352	.464	.368	.267	.333	.100	.412	.340	.345	.378	.111	.643	.177	.529
	LAT (L)	.908	.792	.844	.370	.020	.005		.001	.065	.079	.038	.050	.043	.070	.002	.244	.062	.003	.002	.084	.244	.071	.248
	LAT (R)	.690	.817	.549	.400	.007	<.001	.001		.003	.007	.015	.052	.018	.026	.005	.483	.127	.001	.001	.136	.309	.407	.771
SN	ACC	.797	.480	.737	.110	.003	.221	.065	.003		.003	.007	.001	.001	.016	.045	.379	.286	.039	.044	.315	.294	.768	.587
	AINS (L)	.997	.960	.998	.962	.017	.352	.079	.007	.003		<.001	<.001	.003	.001	.011	.491	.440	.005	.011	.298	.560	.325	.634
	AINS (R)	.999	.960	.986	.978	.066	.464	.038	.015	.007	<.001		<.001	.001	.003	.001	.458	.116	.005	.004	.344	.599	.128	.371
	RPFC (L)	.932	.565	.830	.323	.002	.368	.050	.052	.001	<.001	<.001		<.001	<.001	.009	.336	.128	.010	.002	.013	.468	.230	.497
	RPFC (R)	.945	.623	.794	.591	.020	.267	.043	.018	.001	.003	.001	<.001		.036	.003	.384	.119	.006	<.001	.311	.455	.112	.204
	SMG (L)	.999	.922	.876	.972	.033	.333	.070	.026	.016	.001	.003	<.001	.036		.006	.631	.649	.004	.049	.109	.351	.084	.295
	SMG (R)	.997	.945	.960	.962	.083	.100	.002	.005	.045	.011	.001	.009	.003	.006		.675	.143	.002	.002	.127	.503	.140	.265
DAN	FEF (L)	.726	.561	.661	.936	.934	.412	.244	.483	.379	.491	.458	.336	.384	.631	.675		.070	.107	.130	.412	.905	.887	.916
	FEF (R)	.936	.686	.826	.920	.692	.340	.062	.127	.286	.440	.116	.128	.119	.649	.143	.070		.017	.010	.336	.581	.529	.482
	IPS (L)	>.999	.880	.885	.897	.670	.345	.003	.001	.039	.005	.005	.010	.006	.004	.002	.107	.017		<.001	.053	.465	.275	.325
	IPS (R)	>.999	.955	.958	.952	.465	.378	.002	.001	.044	.011	.004	.002	<.001	.049	.002	.130	.010	<.001		.279	.623	.372	.577
FPN	LPFC (L)	.740	.156	.098	.115	.978	.111	.084	.136	.315	.298	.344	.013	.311	.109	.127	.412	.336	.053	.279		.008	.009	.115
	PPC (L)	.284	.027	.022	.204	.999	.643	.244	.309	.294	.560	.599	.468	.455	.351	.503	.905	.581	.465	.623	.008		<.001	.009
	LPFC (R)	.701	.268	.001	.461	.950	.177	.071	.407	.768	.325	.128	.230	.112	.084	.140	.887	.529	.275	.372	.009	<.001		.002
	PPC (R)	.668	.125	.013	.242	.838	.529	.248	.771	.587	.634	.371	.497	.204	.295	.265	.916	.482	.325	.577	.115	.009	.002	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 9.

Summary of p-values of one-tailed t-tests of the lesion patients group during stimulation with the outer circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.002	.001	.001	.407	.058	.848	.747	.863	>.999	>.999	.778	.963	.994	.995	.939	.833	.998	.974	.747	.446	.649	.317
	LP (L)	.002		<.001	.004	.821	.348	.590	.713	.897	.996	.994	.938	.896	.711	.937	.851	.682	.827	.892	.049	.030	.337	.121
	LP (R)	.001	<.001		.006	.965	.034	.953	.526	.938	.992	.999	.945	.813	.931	.965	.759	.437	.876	.928	.021	.030	.045	.035
	PCC	.001	.004	.006		.471	.012	.332	.783	.367	.988	.993	.592	.715	.964	.964	.968	.726	.733	.893	.139	.158	.383	.208
VN	MED	.407	.821	.965	.471		.929	.048	.001	.011	.169	.001	.134	.017	.003	.101	.350	.108	.138	.021	.966	.988	.759	.873
	OCC	.058	.348	.034	.012	.929		.089	.538	.105	.830	.810	.300	.339	.772	.281	.871	.205	.405	.488	.056	.306	.008	.025
	LAT (L)	.848	.590	.953	.332	.048	.089		.003	.258	.172	.088	.088	.017	.084	.010	.067	.060	.011	.004	.042	.711	.006	.439
	LAT (R)	.747	.713	.526	.783	.001	.538	.003		.096	.202	.019	.299	.007	.082	.007	.067	.052	.004	<.001	.089	.799	.136	.848
SN	ACC	.863	.897	.938	.367	.011	.105	.258	.096		.001	.002	.002	.005	.011	.098	.180	.186	.017	.104	.024	.107	.698	.566
	AINS (L)	>.999	.996	.992	.988	.169	.830	.172	.202	.001		.006	.001	.004	.012	.030	.090	.276	.020	.172	.536	.387	.900	.982
	AINS (R)	>.999	.994	.999	.993	.001	.810	.088	.019	.002	.006		.008	.004	.001	<.001	.065	.115	.001	.001	.840	.895	.222	.585
	RPFC (L)	.778	.938	.945	.592	.134	.300	.088	.299	.002	.001	.008		.001	<.001	.084	.198	.763	.025	.156	.257	.173	.603	.797
	RPFC (R)	.963	.896	.813	.715	.017	.339	.017	.007	.005	.004	.004	.001		.019	.006	.091	.053	<.001	.001	.282	.297	.042	.245
	SMG (L)	.994	.711	.931	.964	.003	.772	.084	.082	.011	.012	.001	<.001	.019		.014	.034	.337	.012	.042	.018	.172	.044	.373
	SMG (R)	.995	.937	.965	.964	.101	.281	.010	.007	.098	.030	<.001	.084	.006	.014		.075	.041	.001	<.001	.032	.422	.076	.123
DAN	FEF (L)	.939	.851	.759	.968	.350	.871	.067	.067	.180	.090	.065	.198	.091	.034	.075		.135	.143	.095	.652	.900	.234	.663
	FEF (R)	.833	.682	.437	.726	.108	.205	.060	.052	.186	.276	.115	.763	.053	.337	.041	.135		.139	.049	.379	.629	.095	.105
	IPS (L)	.998	.827	.876	.733	.138	.405	.011	.004	.017	.020	.001	.025	<.001	.012	.001	.143	.139		<.001	.041	.194	.154	.372
	IPS (R)	.974	.892	.928	.893	.021	.488	.004	<.001	.104	.172	.001	.156	.001	.042	<.001	.095	.049	<.001		.133	.848	.168	.386
FPN	LPFC (L)	.747	.049	.021	.139	.966	.056	.042	.089	.024	.536	.840	.257	.282	.018	.032	.652	.379	.041	.133		.001	.001	.021
	PPC (L)	.446	.030	.030	.158	.988	.306	.711	.799	.107	.387	.895	.173	.297	.172	.422	.900	.629	.194	.848	.001		.008	.002
	LPFC (R)	.649	.337	.045	.383	.759	.008	.006	.136	.698	.900	.222	.603	.042	.044	.076	.234	.095	.154	.168	.001	.008		<.001
	PPC (R)	.317	.121	.035	.208	.873	.025	.439	.848	.566	.982	.585	.797	.245	.373	.123	.663	.105	.372	.386	.021	.002	<.001	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 10.

Summary of p-values of one-tailed t-tests of the healthy control group > tumor patients group during stimulation with the inner circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.605	.663	.780	.450	.119	.171	.310	.640	.346	.798	.155	.004	.768	.330	.949	.540	.856	.267	.092	.257	.093	.161
	LP (L)	.605		.279	.732	.584	.032	.700	.704	.415	.150	.691	.665	.424	.675	.830	.982	.721	.996	.977	.035	.037	.139	.175
	LP (R)	.663	.279		.767	.945	.017	.649	.828	.351	.121	.203	.388	.045	.915	.797	.269	.267	.958	.556	.273	.158	.205	.011
	PCC	.780	.732	.767		.844	.373	.997	.991	.043	.109	.276	.003	.002	.247	.633	.966	.749	.983	.835	.371	.522	.130	.133
VN	MED	.450	.584	.945	.844		.289	.927	.992	.297	.695	.602	.843	.119	.269	.398	.845	.478	.909	.937	.361	.214	.032	.081
	OCC	.119	.032	.017	.373	.289		.297	.088	.856	.575	.525	.616	.857	.116	.181	.929	.991	.349	.838	.037	.056	.533	.256
	LAT (L)	.171	.700	.649	.997	.927	.297		.051	.992	.670	.360	>.999	.990	.404	.693	.791	.776	.968	.975	.421	.054	.683	.112
	LAT (R)	.310	.704	.828	.991	.992	.088	.051		.436	.343	.265	.783	.274	.212	.641	.896	.891	.819	.949	.357	.037	.230	.062
SN	ACC	.640	.415	.351	.043	.297	.856	.992	.436		.606	.757	.952	.813	.608	.633	.953	.947	.500	.831	.373	.235	.408	.262
	AINS (L)	.346	.150	.121	.109	.695	.575	.670	.343	.606		.984	.964	.988	.894	.907	.731	.638	.433	.794	.077	.122	.419	.405
	AINS (R)	.798	.691	.203	.276	.602	.525	.360	.265	.757	.984		.993	.901	.699	.284	.815	.860	.180	.696	.208	.069	.161	.104
	RPFC (L)	.155	.665	.388	.003	.843	.616	>.999	.783	.952	.964	.993		.978	.996	.996	.979	.912	.974	.989	.148	.143	.386	.421
	RPFC (R)	.004	.424	.045	.002	.119	.857	.990	.274	.813	.988	.901	.978		.440	.453	.822	.921	.896	.991	.260	.143	.501	.137
	SMG (L)	.768	.675	.915	.247	.269	.116	.404	.212	.608	.894	.699	.996	.440		.168	.911	.882	.560	.673	.188	.127	.348	.366
	SMG (R)	.330	.830	.797	.633	.398	.181	.693	.641	.633	.907	.284	.996	.453	.168		.983	.992	.728	.963	.639	.166	.620	.494
DAN	FEF (L)	.949	.982	.269	.966	.845	.929	.791	.896	.953	.731	.815	.979	.822	.911	.983		.709	.760	.723	.285	.663	.328	.757
	FEF (R)	.540	.721	.267	.749	.478	.991	.776	.891	.947	.638	.860	.912	.921	.882	.992	.709		.764	.995	.851	.218	.760	.293
	IPS (L)	.856	.996	.958	.983	.909	.349	.968	.819	.500	.433	.180	.974	.896	.560	.728	.760	.764		.226	.989	.930	.957	.803
	IPS (R)	.267	.977	.556	.835	.937	.838	.975	.949	.831	.794	.696	.989	.991	.673	.963	.723	.995	.226		.899	.300	.867	.726
FPN	LPFC (L)	.092	.035	.273	.371	.361	.037	.421	.357	.373	.077	.208	.148	.260	.188	.639	.285	.851	.989	.899		.063	.705	.248
	PPC (L)	.257	.037	.158	.522	.214	.056	.054	.037	.235	.122	.069	.143	.143	.127	.166	.663	.218	.930	.300	.063		.096	.296
	LPFC (R)	.093	.139	.205	.130	.032	.533	.683	.230	.408	.419	.161	.386	.501	.348	.620	.328	.760	.957	.867	.705	.096		<.001
	PPC (R)	.161	.175	.011	.133	.081	.256	.112	.062	.262	.405	.104	.421	.137	.366	.494	.757	.293	.803	.726	.248	.296	<.001	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 11.

Summary of p-values of one-tailed t-tests of the tumor patients group > healthy control group during stimulation with the inner circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.546	.261	.332	.756	.852	.853	.869	.328	.419	.332	.667	.980	.122	.414	.018	.410	.165	.516	.939	.665	.838	.803
	LP (L)	.546		.759	.395	.446	.963	.340	.544	.636	.591	.226	.200	.400	.160	.040	.027	.270	.005	.021	>.999	.968	.953	.862
	LP (R)	.261	.759		.278	.070	.990	.542	.338	.466	.843	.647	.457	.850	.047	.146	.264	.677	.096	.359	.926	.901	.910	.995
	PCC	.332	.395	.278		.238	.619	.005	.011	.813	.878	.564	.958	.978	.276	.176	.013	.315	.009	.053	.844	.367	.701	.832
VN	MED	.756	.446	.070	.238		.698	.088	.008	.763	.356	.167	.152	.645	.196	.088	.234	.374	.024	.018	.490	.587	.862	.843
	OCC	.852	.963	.990	.619	.698		.487	.829	.074	.486	.207	.367	.113	.864	.656	.091	.048	.808	.179	.972	.961	.512	.673
	LAT (L)	.853	.340	.542	.005	.088	.487		.974	.022	.334	.427	<.001	.019	.491	.086	.324	.343	.057	.052	.584	.939	.450	.833
	LAT (R)	.869	.544	.338	.011	.008	.829	.974		.526	.663	.504	.065	.596	.698	.100	.141	.137	.262	.104	.708	.966	.683	.901
SN	ACC	.328	.636	.466	.813	.763	.074	.022	.526		.445	.291	.059	.079	.286	.253	.173	.060	.444	.119	.270	.672	.243	.508
	AINS (L)	.419	.591	.843	.878	.356	.486	.334	.663	.445		.037	.089	.010	.132	.223	.328	.280	.588	.269	.456	.735	.398	.558
	AINS (R)	.332	.226	.647	.564	.167	.207	.427	.504	.291	.037		.014	.027	.178	.550	.517	.090	.688	.118	.484	.722	.402	.712
	RPFC (L)	.667	.200	.457	.958	.152	.367	<.001	.065	.059	.089	.014		.006	.021	.007	.127	.072	.062	.035	.569	.851	.366	.383
	RPFC (R)	.980	.400	.850	.978	.645	.113	.019	.596	.079	.010	.027	.006		.238	.349	.477	.071	.074	.004	.404	.699	.241	.684
	SMG (L)	.122	.160	.047	.276	.196	.864	.491	.698	.286	.132	.178	.021	.238		.720	.293	.100	.242	.256	.566	.693	.446	.346
	SMG (R)	.414	.040	.146	.176	.088	.656	.086	.100	.253	.223	.550	.007	.349	.720		.187	.020	.208	.050	.052	.498	.133	.216
DAN	FEF (L)	.018	.027	.264	.013	.234	.091	.324	.141	.173	.328	.517	.127	.477	.293	.187		.238	.239	.390	.621	.473	.675	.173
	FEF (R)	.410	.270	.677	.315	.374	.048	.343	.137	.060	.280	.090	.072	.071	.100	.020	.238		.348	.012	.272	.853	.375	.756
	IPS (L)	.165	.005	.096	.009	.024	.808	.057	.262	.444	.588	.688	.062	.074	.242	.208	.239	.348		.653	.002	.017	.016	.138
	IPS (R)	.516	.021	.359	.053	.018	.179	.052	.104	.119	.269	.118	.035	.004	.256	.050	.390	.012	.653		.022	.250	.008	.102
FPN	LPFC (L)	.939	>.999	.926	.844	.490	.972	.584	.708	.270	.456	.484	.569	.404	.566	.052	.621	.272	.002	.022		.848	.323	.719
	PPC (L)	.665	.968	.901	.367	.587	.961	.939	.966	.672	.735	.722	.851	.699	.693	.498	.473	.853	.017	.250	.848		.726	.514
	LPFC (R)	.838	.953	.910	.701	.862	.512	.450	.683	.243	.398	.402	.366	.241	.446	.133	.675	.375	.016	.008	.323	.726		.997
	PPC (R)	.803	.862	.995	.832	.843	.673	.833	.901	.508	.558	.712	.383	.684	.346	.216	.173	.756	.138	.102	.719	.514	.997	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 12.

Summary of p-values of one-tailed t-tests of the healthy control group > tumor patients group during stimulation with the middle circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.081	.439	.676	.630	.492	.821	.756	.519	.424	.411	.081	.026	.511	.814	.701	.032	.776	.193	.663	.572	.218	.459
	LP (L)	.081		.201	.586	.230	.433	.980	.903	.770	.764	.854	.453	.821	.695	.995	.427	.695	.984	.986	.103	.103	.361	.086
	LP (R)	.439	.201		.647	.607	.128	.812	.849	.913	.688	.797	.401	.378	.807	.876	.852	.212	.990	.824	.189	.167	.239	.377
	PCC	.676	.586	.647		.570	.943	.998	.977	.685	.783	.917	.030	.145	.292	.718	.411	.466	.972	.822	.457	.453	.515	.208
VN	MED	.630	.230	.607	.570		.363	.721	.953	.944	.706	.947	.762	.420	.868	.781	.777	.208	.903	.888	.629	.298	.345	.312
	OCC	.492	.433	.128	.943	.363		.527	.320	.950	.826	.196	.921	.788	.465	.581	.922	.960	.621	.890	.835	.558	.769	.329
	LAT (L)	.821	.980	.812	.998	.721	.527		.071	.745	.599	.438	.880	.934	.730	.658	.530	.301	.775	.567	.406	.259	.623	.141
	LAT (R)	.756	.903	.849	.977	.953	.320	.071		.828	.502	.367	.454	.509	.323	.294	.682	.782	.388	.702	.182	.083	.251	.220
SN	ACC	.519	.770	.913	.685	.944	.950	.745	.828		.709	.238	.938	.598	.778	.796	.764	.967	.829	.969	.969	.696	.499	.177
	AINS (L)	.424	.764	.688	.783	.706	.826	.599	.502	.709		.875	.989	.927	.761	.800	.789	.971	.800	.991	.859	.756	.844	.674
	AINS (R)	.411	.854	.797	.917	.947	.196	.438	.367	.238	.875		.964	.533	.538	.095	.692	.826	.541	.979	.817	.612	.345	.096
	RPFC (L)	.081	.453	.401	.030	.762	.921	.880	.454	.938	.989	.964		>.999	.998	.997	.465	.817	.997	.862	.977	.532	.976	.858
	RPFC (R)	.026	.821	.378	.145	.420	.788	.934	.509	.598	.927	.533	>.999		.942	.977	.121	.895	.964	.959	.999	.751	.891	.173
	SMG (L)	.511	.695	.807	.292	.868	.465	.730	.323	.778	.761	.538	.998	.942		.380	.220	.955	.498	.517	.561	.171	.988	.737
	SMG (R)	.814	.995	.876	.718	.781	.581	.658	.294	.796	.800	.095	.997	.977	.380		.107	.747	.925	.977	.909	.576	.749	.201
DAN	FEF (L)	.701	.427	.852	.411	.777	.922	.530	.682	.764	.789	.692	.465	.121	.220	.107		.751	.516	.183	.285	.270	.284	.681
	FEF (R)	.032	.695	.212	.466	.208	.960	.301	.782	.967	.971	.826	.817	.895	.955	.747	.751		.728	.983	.970	.593	.811	.494
	IPS (L)	.776	.984	.990	.972	.903	.621	.775	.388	.829	.800	.541	.997	.964	.498	.925	.516	.728		.599	.957	.645	.999	.496
	IPS (R)	.193	.986	.824	.822	.888	.890	.567	.702	.969	.991	.979	.862	.959	.517	.977	.183	.983	.599		.915	.519	.936	.341
FPN	LPFC (L)	.663	.103	.189	.457	.629	.835	.406	.182	.969	.859	.817	.977	.999	.561	.909	.285	.970	.957	.915		.635	.943	.782
	PPC (L)	.572	.103	.167	.453	.298	.558	.259	.083	.696	.756	.612	.532	.751	.171	.576	.270	.593	.645	.519	.635		.888	.569
	LPFC (R)	.218	.361	.239	.515	.345	.769	.623	.251	.499	.844	.345	.976	.891	.988	.749	.284	.811	.999	.936	.943	.888		.064
	PPC (R)	.459	.086	.377	.208	.312	.329	.141	.220	.177	.674	.096	.858	.173	.737	.201	.681	.494	.496	.341	.782	.569	.064	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 13.

Summary of p-values of one-tailed t-tests of the tumor patients group > healthy control group during stimulation with the middle circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.891	.515	.529	.312	.561	.066	.144	.333	.501	.537	.867	.951	.262	.101	.057	.956	.259	.646	.476	.359	.811	.548
	LP (L)	.891		.698	.308	.572	.556	.016	.106	.174	.340	.195	.599	.163	.199	.002	.324	.133	.024	.004	.943	.859	.773	.922
	LP (R)	.515	.698		.280	.270	.821	.063	.104	.092	.383	.307	.465	.710	.135	.074	.059	.563	.014	.086	.874	.801	.840	.688
	PCC	.529	.308	.280		.294	.038	.000	.011	.412	.298	.184	.980	.906	.377	.234	.284	.294	.025	.037	.729	.533	.698	.844
VN	MED	.312	.572	.270	.294		.581	.187	.126	.119	.379	.089	.273	.456	.152	.204	.123	.540	.133	.093	.266	.290	.367	.597
	OCC	.561	.556	.821	.038	.581		.298	.471	.058	.280	.731	.119	.218	.654	.475	.059	.050	.390	.044	.044	.179	.103	.370
	LAT (L)	.066	.016	.063	.000	.187	.298		.946	.515	.685	.701	.118	.035	.472	.437	.741	.684	.408	.506	.464	.550	.101	.644
	LAT (R)	.144	.106	.104	.011	.126	.471	.946		.409	.761	.812	.469	.387	.852	.829	.540	.235	.790	.370	.671	.749	.516	.643
SN	ACC	.333	.174	.092	.412	.119	.058	.515	.409		.303	.806	.130	.573	.322	.410	.357	.078	.354	.132	.049	.457	.750	.738
	AINS (L)	.501	.340	.383	.298	.379	.280	.685	.761	.303		.230	.012	.083	.264	.598	.199	.099	.286	.044	.072	.275	.172	.315
	AINS (R)	.537	.195	.307	.184	.089	.731	.701	.812	.806	.230		.053	.532	.591	.990	.346	.268	.686	.096	.217	.575	.729	.911
	RPFC (L)	.867	.599	.465	.980	.273	.119	.118	.469	.130	.012	.053		.003	.003	.019	.409	.142	.003	.177	.031	.455	.077	.213
	RPFC (R)	.951	.163	.710	.906	.456	.218	.035	.387	.573	.083	.532	.003		.036	.032	.879	.084	.025	.031	.003	.257	.214	.830
	SMG (L)	.262	.199	.135	.377	.152	.654	.472	.852	.322	.264	.591	.003	.036		.740	.819	.101	.539	.498	.489	.855	.033	.259
	SMG (R)	.101	.002	.074	.234	.204	.475	.437	.829	.410	.598	.990	.019	.032	.740		.867	.264	.049	.043	.080	.385	.185	.578
DAN	FEF (L)	.057	.324	.059	.284	.123	.059	.741	.540	.357	.199	.346	.409	.879	.819	.867		.274	.677	.845	.757	.811	.821	.418
	FEF (R)	.956	.133	.563	.294	.540	.050	.684	.235	.078	.099	.268	.142	.084	.101	.264	.274		.144	.008	.051	.285	.200	.517
	IPS (L)	.259	.024	.014	.025	.133	.390	.408	.790	.354	.286	.686	.003	.025	.539	.049	.677	.144		.505	.019	.207	.002	.465
	IPS (R)	.646	.004	.086	.037	.093	.044	.506	.370	.132	.044	.096	.177	.031	.498	.043	.845	.008	.505		.123	.336	.038	.578
FPN	LPFC (L)	.476	.943	.874	.729	.266	.044	.464	.671	.049	.072	.217	.031	.003	.489	.080	.757	.051	.019	.123		.727	.266	.352
	PPC (L)	.359	.859	.801	.533	.290	.179	.550	.749	.457	.275	.575	.455	.257	.855	.385	.811	.285	.207	.336	.727		.337	.491
	LPFC (R)	.811	.773	.840	.698	.367	.103	.101	.516	.750	.172	.729	.077	.214	.033	.185	.821	.200	.002	.038	.266	.337		.967
	PPC (R)	.548	.922	.688	.844	.597	.370	.644	.643	.738	.315	.911	.213	.830	.259	.578	.418	.517	.465	.578	.352	.491	.967	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 14.

Summary of p-values of one-tailed t-tests of the healthy control group > tumor patients group during stimulation with the outer circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.373	.415	.664	.474	.328	.344	.640	.195	.326	.316	.011	.048	.610	.818	.961	.600	.977	.714	.686	.403	.301	.646
	LP (L)	.373		.701	.569	.743	.636	.949	.888	.774	.830	.873	.870	.999	.852	.996	.766	.976	.978	.953	.522	.059	.918	.851
	LP (R)	.415	.701		.610	.973	.024	.710	.914	.488	.500	.649	.713	.332	.816	.889	.802	.722	.992	.990	.778	.438	.792	.535
	PCC	.664	.569	.610		.707	.526	.925	.979	.216	.379	.824	.214	.397	.515	.843	.978	.954	.975	.937	.998	.691	.924	.854
VN	MED	.474	.743	.973	.707		.555	.388	.787	.226	.740	.896	.487	.811	.452	.613	.962	.977	.269	.635	.506	.596	.790	.923
	OCC	.328	.636	.024	.526	.555		.363	.074	.697	.769	.770	.511	.405	.312	.745	.970	.072	.668	.681	.462	.371	.360	.008
	LAT (L)	.344	.949	.710	.925	.388	.363		.021	.907	.977	.721	.995	.998	.270	.962	.984	.807	.982	.797	.665	.502	.929	.075
	LAT (R)	.640	.888	.914	.979	.787	.074	.021		.453	.666	.328	.816	.917	.118	.648	.984	.526	.589	.857	.627	.233	.798	.150
SN	ACC	.195	.774	.488	.216	.226	.697	.907	.453		.463	.663	.965	.971	.870	.697	.690	.535	.907	.941	.553	.576	.531	.275
	AINS (L)	.326	.830	.500	.379	.740	.769	.977	.666	.463		.813	.793	.574	.368	.508	.917	.194	.764	.958	.048	.438	.313	.446
	AINS (R)	.316	.873	.649	.824	.896	.770	.721	.328	.663	.813		.913	.610	.512	.050	.617	.308	.526	.823	.021	.407	.145	.022
	RPFC (L)	.011	.870	.713	.214	.487	.511	.995	.816	.965	.793	.913		>.999	.999	.940	.787	.844	.997	.977	.521	.570	.995	.533
	RPFC (R)	.048	.999	.332	.397	.811	.405	.998	.917	.971	.574	.610	>.999		.383	.537	.052	.744	.974	.959	.836	.758	.676	.065
	SMG (L)	.610	.852	.816	.515	.452	.312	.270	.118	.870	.368	.512	.999	.383		.028	.353	.642	.398	.230	.235	.362	.543	.085
	SMG (R)	.818	.996	.889	.843	.613	.745	.962	.648	.697	.508	.050	.940	.537	.028		.685	.823	.596	.780	.667	.604	.486	.162
DAN	FEF (L)	.961	.766	.802	.978	.962	.970	.984	.984	.690	.917	.617	.787	.052	.353	.685		.921	.753	.683	.341	.485	.288	.308
	FEF (R)	.600	.976	.722	.954	.977	.072	.807	.526	.535	.194	.308	.844	.744	.642	.823	.921		.643	.914	.965	.333	.832	.520
	IPS (L)	.977	.978	.992	.975	.269	.668	.982	.589	.907	.764	.526	.997	.974	.398	.596	.753	.643		.310	.882	.936	.989	.530
	IPS (R)	.714	.953	.990	.937	.635	.681	.797	.857	.941	.958	.823	.977	.959	.230	.780	.683	.914	.310		.502	.344	.952	.353
FPN	LPFC (L)	.686	.522	.778	.998	.506	.462	.665	.627	.553	.048	.021	.521	.836	.235	.667	.341	.965	.882	.502		.620	.906	.933
	PPC (L)	.403	.059	.438	.691	.596	.371	.502	.233	.576	.438	.407	.570	.758	.362	.604	.485	.333	.936	.344	.620		.855	.883
	LPFC (R)	.301	.918	.792	.924	.790	.360	.929	.798	.531	.313	.145	.995	.676	.543	.486	.288	.832	.989	.952	.906	.855		.078
	PPC (R)	.646	.851	.535	.854	.923	.008	.075	.150	.275	.446	.022	.533	.065	.085	.162	.308	.520	.530	.353	.933	.883	.078	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 15.

Summary of p-values of one-tailed t-tests of the tumor patients group > healthy control group during stimulation with the outer circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.800	.563	.424	.515	.605	.615	.441	.650	.537	.629	.958	.903	.382	.284	.020	.280	.077	.407	.206	.515	.533	.458
	LP (L)	.800		.191	.416	.296	.359	.054	.155	.258	.410	.213	.061	.001	.215	.006	.172	.007	.032	.022	.875	.907	.040	.245
	LP (R)	.563	.191		.209	.045	.947	.325	.098	.532	.654	.494	.226	.704	.271	.135	.092	.181	.041	.040	.193	.393	.268	.547
	PCC	.424	.416	.209		.372	.313	.052	.022	.865	.625	.227	.812	.475	.500	.136	.004	.013	.023	.027	.010	.229	.039	.180
VN	MED	.515	.296	.045	.372		.422	.454	.154	.841	.372	.046	.737	.325	.551	.088	.094	.013	.655	.238	.645	.379	.150	.068
	OCC	.605	.359	.947	.313	.422		.641	.913	.184	.151	.314	.459	.537	.728	.188	.037	.929	.439	.258	.464	.439	.496	.959
	LAT (L)	.615	.054	.325	.052	.454	.641		.940	.074	.029	.266	.010	.001	.753	.028	.082	.144	.150	.156	.369	.532	.025	.875
	LAT (R)	.441	.155	.098	.022	.154	.913	.940		.494	.202	.697	.394	.128	.832	.278	.101	.578	.538	.123	.555	.812	.104	.754
SN	ACC	.650	.258	.532	.865	.841	.184	.074	.494		.268	.111	.027	.042	.082	.164	.422	.441	.085	.041	.205	.488	.361	.647
	AINS (L)	.537	.410	.654	.625	.372	.151	.029	.202	.268		.065	.176	.332	.563	.560	.136	.798	.163	.012	.756	.473	.510	.372
	AINS (R)	.629	.213	.494	.227	.046	.314	.266	.697	.111	.065		.102	.440	.495	.774	.535	.846	.416	.094	.938	.555	.853	.938
	RPFC (L)	.958	.061	.226	.812	.737	.459	.010	.394	.027	.176	.102		<.001	<.001	.034	.227	.070	.014	.047	.219	.426	.004	.482
	RPFC (R)	.903	.001	.704	.475	.325	.537	.001	.128	.042	.332	.440	<.001		.551	.311	.947	.103	.062	.017	.142	.180	.316	.924
	SMG (L)	.382	.215	.271	.500	.551	.728	.753	.832	.082	.563	.495	<.001	.551		.969	.731	.372	.278	.643	.598	.628	.467	.786
	SMG (R)	.284	.006	.135	.136	.088	.188	.028	.278	.164	.560	.774	.034	.311	.969		.376	.170	.214	.057	.383	.450	.526	.816
DAN	FEF (L)	.020	.172	.092	.004	.094	.037	.082	.101	.422	.136	.535	.227	.947	.731	.376		.072	.530	.565	.559	.498	.420	.665
	FEF (R)	.280	.007	.181	.013	.013	.929	.144	.578	.441	.798	.846	.070	.103	.372	.170	.072		.360	.133	.439	.871	.465	.787
	IPS (L)	.077	.032	.041	.023	.655	.439	.150	.538	.085	.163	.416	.014	.062	.278	.214	.530	.360		.658	.063	.076	.002	.483
	IPS (R)	.407	.022	.040	.027	.238	.258	.156	.123	.041	.012	.094	.047	.017	.643	.057	.565	.133	.658		.470	.751	.041	.695
FPN	LPFC (L)	.206	.875	.193	.010	.645	.464	.369	.555	.205	.756	.938	.219	.142	.598	.383	.559	.439	.063	.470		.631	.123	.092
	PPC (L)	.515	.907	.393	.229	.379	.439	.532	.812	.488	.473	.555	.426	.180	.628	.450	.498	.871	.076	.751	.631		.140	.065
	LPFC (R)	.533	.040	.268	.039	.150	.496	.025	.104	.361	.510	.853	.004	.316	.467	.526	.420	.465	.002	.041	.123	.140		.936
	PPC (R)	.458	.245	.547	.180	.068	.959	.875	.754	.647	.372	.938	.482	.924	.786	.816	.665	.787	.483	.695	.092	.065	.936	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 16.

Summary of p-values of one-tailed t-tests of the healthy control group > lesion patients group during stimulation with the inner circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.915	.679	.924	.268	.744	.516	.504	.983	.836	.940	.427	.624	.493	.253	.197	.437	.488	.769	.423	.330	.201	.527
	LP (L)	.915		.322	.700	.458	.845	.730	.825	.927	.743	.758	.833	.843	.707	.222	.314	.802	.507	.547	.187	.606	.057	.439
	LP (R)	.679	.322		.302	.211	.902	.833	.941	.903	.790	.686	.614	.664	.769	.100	.091	.807	.550	.436	.287	.245	.078	.222
	PCC	.924	.700	.302		.371	.900	.542	.696	.964	.968	.810	.754	.803	.591	.047	.293	.571	.397	.325	.360	.258	.106	.156
VN	MED	.268	.458	.211	.371		.276	.950	.881	.952	.951	.937	.961	.968	.935	.758	.490	.300	.852	.772	.655	.371	.861	.809
	OCC	.744	.845	.902	.900	.276		.001	<.001	.151	.405	.174	.116	.083	.136	.565	.837	.975	.084	.107	.203	.601	.154	.212
	LAT (L)	.516	.730	.833	.542	.950	.001		.280	.408	.729	.441	.706	.366	.569	.892	.923	.962	.610	.822	.214	.530	.199	.157
	LAT (R)	.504	.825	.941	.696	.881	<.001	.280		.719	.932	.568	.874	.878	.432	.990	.984	.833	.867	.984	.137	.300	.299	.178
SN	ACC	.983	.927	.903	.964	.952	.151	.408	.719		.491	.442	.912	.744	.613	.155	.559	.211	.686	.165	.847	.709	.573	.623
	AINS (L)	.836	.743	.790	.968	.951	.405	.729	.932	.491		.808	.986	.994	.685	.667	.575	.324	.990	.938	.753	.707	.998	.985
	AINS (R)	.940	.758	.686	.810	.937	.174	.441	.568	.442	.808		.974	.939	.676	.566	.836	.765	.763	.904	.723	.691	.872	.593
	RPFC (L)	.427	.833	.614	.754	.961	.116	.706	.874	.912	.986	.974		.959	.859	.388	.423	.623	.836	.732	.863	.428	.751	.341
	RPFC (R)	.624	.843	.664	.803	.968	.083	.366	.878	.744	.994	.939	.959		.984	.692	.917	.867	.946	.926	.853	.852	.796	.687
	SMG (L)	.493	.707	.769	.591	.935	.136	.569	.432	.613	.685	.676	.859	.984		.801	.764	.582	.839	.745	.850	.860	.990	.960
	SMG (R)	.253	.222	.100	.047	.758	.565	.892	.990	.155	.667	.566	.388	.692	.801		.797	.255	.659	.799	.974	.933	.975	.804
DAN	FEF (L)	.197	.314	.091	.293	.490	.837	.923	.984	.559	.575	.836	.423	.917	.764	.797		.617	.473	.818	.908	.488	.965	.458
	FEF (R)	.437	.802	.807	.571	.300	.975	.962	.833	.211	.324	.765	.623	.867	.582	.255	.617		.438	.243	.993	.901	.966	.746
	IPS (L)	.488	.507	.550	.397	.852	.084	.610	.867	.686	.990	.763	.836	.946	.839	.659	.473	.438		.927	.856	.813	.934	.563
	IPS (R)	.769	.547	.436	.325	.772	.107	.822	.984	.165	.938	.904	.732	.926	.745	.799	.818	.243	.927		.960	.830	.921	.212
FPN	LPFC (L)	.423	.187	.287	.360	.655	.203	.214	.137	.847	.753	.723	.863	.853	.850	.974	.908	.993	.856	.960		.146	.214	.182
	PPC (L)	.330	.606	.245	.258	.371	.601	.530	.300	.709	.707	.691	.428	.852	.860	.933	.488	.901	.813	.830	.146		.163	.692
	LPFC (R)	.201	.057	.078	.106	.861	.154	.199	.299	.573	.998	.872	.751	.796	.990	.975	.965	.966	.934	.921	.214	.163		.702
	PPC (R)	.527	.439	.222	.156	.809	.212	.157	.178	.623	.985	.593	.341	.687	.960	.804	.458	.746	.563	.212	.182	.692	.702	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 17.

Summary of p-values of one-tailed t-tests of the lesion patients group > healthy control group during stimulation with the inner circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.063	.321	.048	.647	.129	.338	.341	.127	.559	.147	.822	.555	.690	.810	.760	.547	.509	.254	.275	.579	.671	.383
	LP (L)	.063		.551	.124	.401	.141	.318	.151	.111	.463	.356	.361	.215	.411	.733	.707	.139	.491	.371	.501	.236	.758	.222
	LP (R)	.321	.551		.510	.754	.043	.207	.112	.163	.414	.450	.691	.590	.291	.779	.931	.213	.661	.595	.308	.788	.772	.713
	PCC	.048	.124	.510		.780	.101	.524	.492	.143	.047	.319	.648	.563	.771	.975	.625	.143	.850	.785	.353	.859	.918	.792
VN	MED	.647	.401	.754	.780		.613	.048	.133	.055	.021	.130	.021	.040	.161	.349	.251	.577	.320	.225	.699	.818	.436	.392
	OCC	.129	.141	.043	.101	.613		.996	.999	.811	.596	.821	.805	.812	.853	.465	.178	.041	.692	.753	.662	.583	.632	.937
	LAT (L)	.338	.318	.207	.524	.048	.996		.540	.501	.250	.705	.167	.497	.495	.156	.063	.076	.307	.151	.850	.710	.865	.933
	LAT (R)	.341	.151	.112	.492	.133	.999	.540		.346	.089	.624	.178	.144	.554	.038	.011	.188	.108	.016	.926	.876	.732	.898
SN	ACC	.127	.111	.163	.143	.055	.811	.501	.346		.238	.380	.081	.375	.269	.787	.121	.487	.534	.802	.402	.500	.836	.612
	AINS (L)	.559	.463	.414	.047	.021	.596	.250	.089	.238		.063	.002	.024	.078	.173	.106	.715	.007	.058	.561	.385	.060	.032
	AINS (R)	.147	.356	.450	.319	.130	.821	.705	.624	.380	.063		.012	.103	.308	.540	.026	.115	.398	.279	.612	.569	.573	.661
	RPFC (L)	.822	.361	.691	.648	.021	.805	.167	.178	.081	.002	.012		.074	.020	.519	.333	.538	.155	.185	.415	.745	.557	.824
	RPFC (R)	.555	.215	.590	.563	.040	.812	.497	.144	.375	.024	.103	.074		.021	.419	.036	.218	.090	.110	.261	.365	.465	.631
	SMG (L)	.690	.411	.291	.771	.161	.853	.495	.554	.269	.078	.308	.020	.021		.380	.091	.320	.199	.254	.444	.342	.115	.140
	SMG (R)	.810	.733	.779	.975	.349	.465	.156	.038	.787	.173	.540	.519	.419	.380		.101	.387	.552	.323	.075	.228	.104	.295
DAN	FEF (L)	.760	.707	.931	.625	.251	.178	.063	.011	.121	.106	.026	.333	.036	.091	.101		.577	.425	.171	.268	.506	.096	.333
	FEF (R)	.547	.139	.213	.143	.577	.041	.076	.188	.487	.715	.115	.538	.218	.320	.387	.577		.516	.573	.019	.062	.106	.106
	IPS (L)	.509	.491	.661	.850	.320	.692	.307	.108	.534	.007	.398	.155	.090	.199	.552	.425	.516		.374	.354	.503	.361	.782
	IPS (R)	.254	.371	.595	.785	.225	.753	.151	.016	.802	.058	.279	.185	.110	.254	.323	.171	.573	.374		.115	.507	.332	.893
FPN	LPFC (L)	.275	.501	.308	.353	.699	.662	.850	.926	.402	.561	.612	.415	.261	.444	.075	.268	.019	.354	.115		.845	.545	.680
	PPC (L)	.579	.236	.788	.859	.818	.583	.710	.876	.500	.385	.569	.745	.365	.342	.228	.506	.062	.503	.507	.845		.946	.568
	LPFC (R)	.671	.758	.772	.918	.436	.632	.865	.732	.836	.060	.573	.557	.465	.115	.104	.096	.106	.361	.332	.545	.946		.524
	PPC (R)	.383	.222	.713	.792	.392	.937	.933	.898	.612	.032	.661	.824	.631	.140	.295	.333	.106	.782	.893	.680	.568	.524	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 18.

Summary of p-values of one-tailed t-tests of the lesion patients group > healthy control group during stimulation with the middle circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.806	.469	.648	.485	.265	.283	.819	.163	.042	.037	.005	.069	.484	.204	.658	.788	.219	.320	.529	.754	.046	.103
	LP (L)	.806		.361	.379	.592	.245	.717	.928	.943	.623	.528	.508	.661	.548	.617	.569	.970	.390	.570	.053	.571	.236	.578
	LP (R)	.469	.361		.391	.470	.548	.762	.959	.823	.534	.413	.400	.380	.362	.553	.398	.974	.612	.689	.091	.779	.265	.649
	PCC	.648	.379	.391		.651	.810	.904	.968	.957	.669	.430	.097	.198	.354	.119	.278	.732	.511	.768	.004	.066	.036	.093
VN	MED	.485	.592	.470	.651		.669	.565	.603	.910	.893	.850	.448	.402	.984	.500	.406	.175	.714	.590	.095	.081	.116	.430
	OCC	.265	.245	.548	.810	.669		.713	.985	.207	.550	.344	.183	.426	.946	.911	.470	.695	.839	.684	.984	.960	.725	.772
	LAT (L)	.283	.717	.762	.904	.565	.713		.121	.762	.583	.506	.853	.829	.752	.970	.584	.631	.753	.507	.925	.900	.623	.769
	LAT (R)	.819	.928	.959	.968	.603	.985	.121		.942	.678	.496	.911	.951	.754	.909	.259	.235	.695	.451	.873	.911	.695	.642
SN	ACC	.163	.943	.823	.957	.910	.207	.762	.942		.346	.285	.932	.843	.880	.221	.684	.525	.881	.719	.994	.993	.397	.306
	AINS (L)	.042	.623	.534	.669	.893	.550	.583	.678	.346		.539	.999	.801	.977	.555	.494	.136	.975	.827	.995	.923	.734	.335
	AINS (R)	.037	.528	.413	.430	.850	.344	.506	.496	.285	.539		.998	.738	.888	.669	.520	.500	.923	.767	.982	.902	.883	.575
	RPFC (L)	.005	.508	.400	.097	.448	.183	.853	.911	.932	.999	.998		.919	.993	.709	.894	.797	.973	.995	.984	.560	.455	.212
	RPFC (R)	.069	.661	.380	.198	.402	.426	.829	.951	.843	.801	.738	.919		.829	.595	.548	.837	.971	.978	.945	.734	.620	.606
	SMG (L)	.484	.548	.362	.354	.984	.946	.752	.754	.880	.977	.888	.993	.829		.731	.562	.200	.524	.557	.756	.584	.786	.539
	SMG (R)	.204	.617	.553	.119	.500	.911	.970	.909	.221	.555	.669	.709	.595	.731		.393	.640	.961	.918	.983	.792	.920	.695
DAN	FEF (L)	.658	.569	.398	.278	.406	.470	.584	.259	.684	.494	.520	.894	.548	.562	.393		.767	.600	.571	.841	.162	.339	.228
	FEF (R)	.788	.970	.974	.732	.175	.695	.631	.235	.525	.136	.500	.797	.837	.200	.640	.767		.719	.453	.766	.846	.946	.966
	IPS (L)	.219	.390	.612	.511	.714	.839	.753	.695	.881	.975	.923	.973	.971	.524	.961	.600	.719		.860	.788	.354	.909	.810
	IPS (R)	.320	.570	.689	.768	.590	.684	.507	.451	.719	.827	.767	.995	.978	.557	.918	.571	.453	.860		.771	.714	.858	.692
FPN	LPFC (L)	.529	.053	.091	.004	.095	.984	.925	.873	.994	.995	.982	.984	.945	.756	.983	.841	.766	.788	.771		.085	.636	.137
	PPC (L)	.754	.571	.779	.066	.081	.960	.900	.911	.993	.923	.902	.560	.734	.584	.792	.162	.846	.354	.714	.085		.774	.617
	LPFC (R)	.046	.236	.265	.036	.116	.725	.623	.695	.397	.734	.883	.455	.620	.786	.920	.339	.946	.909	.858	.636	.774		.279
	PPC (R)	.103	.578	.649	.093	.430	.772	.769	.642	.306	.335	.575	.212	.606	.539	.695	.228	.966	.810	.692	.137	.617	.279	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 19.

Summary of p-values of one-tailed t-tests of the healthy control group > lesion patients group during stimulation with the middle circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.265	.653	.231	.212	.681	.732	.229	.732	.904	.975	.989	.898	.634	.780	.527	.432	.632	.745	.541	.421	.897	.841
	LP (L)	.265		.731	.564	.450	.845	.317	.106	.040	.290	.461	.479	.239	.412	.390	.579	.218	.552	.410	.900	.419	.661	.198
	LP (R)	.653	.731		.800	.532	.439	.178	.051	.166	.407	.635	.728	.671	.585	.421	.774	.344	.317	.301	.857	.323	.633	.278
	PCC	.231	.564	.800		.278	.207	.100	.047	.056	.259	.532	.734	.691	.813	.761	.942	.596	.594	.313	.971	.938	.903	.780
VN	MED	.212	.450	.532	.278		.344	.511	.455	.059	.056	.202	.188	.206	.035	.312	.779	.947	.356	.462	.974	.947	.832	.322
	OCC	.681	.845	.439	.207	.344		.503	.275	.791	.477	.762	.794	.668	.063	.223	.165	.216	.101	.402	.044	.185	.485	.549
	LAT (L)	.732	.317	.178	.100	.511	.503		.938	.131	.456	.499	.133	.193	.123	.026	.200	.292	.076	.324	.130	.094	.729	.381
	LAT (R)	.229	.106	.051	.047	.455	.275	.938		.024	.429	.586	.062	.082	.148	.116	.356	.544	.086	.297	.154	.131	.613	.618
SN	ACC	.732	.040	.166	.056	.059	.791	.131	.024		.666	.523	.121	.083	.176	.719	.356	.410	.206	.182	.122	.017	.723	.625
	AINS (L)	.904	.290	.407	.259	.056	.477	.456	.429	.666		.514	<.001	.165	.046	.494	.485	.736	.098	.293	.022	.088	.366	.647
	AINS (R)	.975	.461	.635	.532	.202	.762	.499	.586	.523	.514		.007	.190	.082	.313	.415	.407	.057	.197	.060	.141	.473	.511
	RPFC (L)	.989	.479	.728	.734	.188	.794	.133	.062	.121	<.001	.007		.043	.001	.128	.228	.496	.047	.004	.224	.542	.529	.642
	RPFC (R)	.898	.239	.671	.691	.206	.668	.193	.082	.083	.165	.190	.043		.183	.321	.481	.260	.107	.059	.223	.349	.524	.435
	SMG (L)	.634	.412	.585	.813	.035	.063	.123	.148	.176	.046	.082	.001	.183		.370	.531	.797	.486	.597	.150	.383	.274	.435
	SMG (R)	.780	.390	.421	.761	.312	.223	.026	.116	.719	.494	.313	.128	.321	.370		.547	.366	.092	.156	.027	.232	.186	.379
DAN	FEF (L)	.527	.579	.774	.942	.779	.165	.200	.356	.356	.485	.415	.228	.481	.531	.547		.238	.428	.507	.346	.946	.828	.764
	FEF (R)	.432	.218	.344	.596	.947	.216	.292	.544	.410	.736	.407	.496	.260	.797	.366	.238		.293	.458	.268	.227	.095	.014
	IPS (L)	.632	.552	.317	.594	.356	.101	.076	.086	.206	.098	.057	.047	.107	.486	.092	.428	.293		.092	.224	.652	.228	.355
	IPS (R)	.745	.410	.301	.313	.462	.402	.324	.297	.182	.293	.197	.004	.059	.597	.156	.507	.458	.092		.122	.320	.400	.437
FPN	LPFC (L)	.541	.900	.857	.971	.974	.044	.130	.154	.122	.022	.060	.224	.223	.150	.027	.346	.268	.224	.122		.742	.239	.688
	PPC (L)	.421	.419	.323	.938	.947	.185	.094	.131	.017	.088	.141	.542	.349	.383	.232	.946	.227	.652	.320	.742		.172	.271
	LPFC (R)	.897	.661	.633	.903	.832	.485	.729	.613	.723	.366	.473	.529	.524	.274	.186	.828	.095	.228	.400	.239	.172		.744
	PPC (R)	.841	.198	.278	.780	.322	.549	.381	.618	.625	.647	.511	.642	.435	.435	.379	.764	.014	.355	.437	.688	.271	.744	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 20.

Summary of p-values of one-tailed t-tests of the healthy control group > lesion patients group during stimulation with the outer circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.789	.604	.975	.795	.819	.413	.520	.700	.202	.380	.096	.017	.806	.226	.451	.756	.446	.610	.562	.729	.161	.454
	LP (L)	.789		.257	.068	.126	.682	.586	.686	.770	.292	.215	.188	.269	.760	.308	.379	.700	.808	.795	.282	.694	.120	.504
	LP (R)	.604	.257		.128	.102	.633	.091	.777	.597	.283	.029	.167	.393	.755	.383	.498	.933	.828	.565	.704	.846	.120	.476
	PCC	.975	.068	.128		.155	.994	.876	.955	.766	.137	.083	.077	.073	.218	.038	.412	.602	.818	.553	.523	.483	.204	.060
VN	MED	.795	.126	.102	.155		.637	.851	.780	.966	.495	.886	.193	.122	.765	.544	.543	.094	.522	.800	.031	.012	.496	.299
	OCC	.819	.682	.633	.994	.637		.011	.025	.749	.710	.309	.676	.698	.710	.861	.473	.967	.635	.701	.650	.589	.334	.843
	LAT (L)	.413	.586	.091	.876	.851	.011		.455	.593	.625	.561	.783	.972	.899	.976	.865	.983	.680	.985	.603	.201	.295	.568
	LAT (R)	.520	.686	.777	.955	.780	.025	.455		.933	.831	.696	.926	.995	.859	.987	.867	.968	.882	.999	.694	.285	.372	.721
SN	ACC	.700	.770	.597	.766	.966	.749	.593	.933		.370	.274	.726	.360	.747	.070	.372	.368	.849	.688	.992	.992	.649	.468
	AINS (L)	.202	.292	.283	.137	.495	.710	.625	.831	.370		.579	.683	.934	.617	.180	.403	.011	.284	.188	.512	.844	.603	.231
	AINS (R)	.380	.215	.029	.083	.886	.309	.561	.696	.274	.579		.703	.888	.595	.716	.777	.147	.093	.549	.729	.382	.647	.407
	RPFC (L)	.096	.188	.167	.077	.193	.676	.783	.926	.726	.683	.703		.065	.786	.132	.738	.115	.364	.803	.762	.811	.415	.091
	RPFC (R)	.017	.269	.393	.073	.122	.698	.972	.995	.360	.934	.888	.065		.884	.975	.931	.710	.909	.968	.724	.788	.869	.411
	SMG (L)	.806	.760	.755	.218	.765	.710	.899	.859	.747	.617	.595	.786	.884		.252	.569	.110	.549	.154	.974	.920	.966	.794
	SMG (R)	.226	.308	.383	.038	.544	.861	.976	.987	.070	.180	.716	.132	.975	.252		.708	.235	.909	.806	.976	.860	.959	.868
DAN	FEF (L)	.451	.379	.498	.412	.543	.473	.865	.867	.372	.403	.777	.738	.931	.569	.708		.738	.466	.836	.469	.199	.960	.670
	FEF (R)	.756	.700	.933	.602	.094	.967	.983	.968	.368	.011	.147	.115	.710	.110	.235	.738		.134	.298	.780	.799	.963	.981
	IPS (L)	.446	.808	.828	.818	.522	.635	.680	.882	.849	.284	.093	.364	.909	.549	.909	.466	.134		.834	.879	.576	.790	.563
	IPS (R)	.610	.795	.565	.553	.800	.701	.985	.999	.688	.188	.549	.803	.968	.154	.806	.836	.298	.834		.941	.509	.846	.717
FPN	LPFC (L)	.562	.282	.704	.523	.031	.650	.603	.694	.992	.512	.729	.762	.724	.974	.976	.469	.780	.879	.941		.028	.394	.429
	PPC (L)	.729	.694	.846	.483	.012	.589	.201	.285	.992	.844	.382	.811	.788	.920	.860	.199	.799	.576	.509	.028		.150	.480
	LPFC (R)	.161	.120	.120	.204	.496	.334	.295	.372	.649	.603	.647	.415	.869	.966	.959	.960	.963	.790	.846	.394	.150		.498
	PPC (R)	.454	.504	.476	.060	.299	.843	.568	.721	.468	.231	.407	.091	.411	.794	.868	.670	.981	.563	.717	.429	.480	.498	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 21.

Summary of p-values of one-tailed t-tests of the lesion patients group > healthy control group during stimulation with the outer circle.

		DMN				VN				SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	MED	OCC	LAT (L)	LAT (R)	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.192	.340	.128	.250	.101	.171	.257	.657	.864	.526	.946	.976	.230	.770	.789	.619	.369	.221	.547	.489	.633	.200
	LP (L)	.192		.833	.849	.801	.381	.320	.328	.109	.626	.740	.904	.798	.265	.588	.803	.672	.221	.200	.479	.506	.790	.193
	LP (R)	.340	.833		.900	.794	.303	.638	.086	.397	.796	.972	.955	.775	.249	.389	.806	.336	.119	.162	.242	.292	.780	.308
	PCC	.128	.849	.900		.795	.002	.044	.055	.317	.887	.874	.942	.921	.878	.881	.870	.810	.265	.482	.382	.592	.800	.744
VN	MED	.250	.801	.794	.795		.276	.346	.438	.095	.709	.283	.550	.608	.500	.781	.414	.930	.722	.498	.975	.977	.736	.621
	OCC	.101	.381	.303	.002	.276		.972	.955	.234	.526	.788	.498	.368	.173	.101	.261	.041	.185	.163	.487	.608	.528	.308
	LAT (L)	.171	.320	.638	.044	.346	.972		.655	.443	.650	.751	.105	.020	.100	.092	.086	.088	.193	.024	.363	.728	.340	.495
	LAT (R)	.257	.328	.086	.055	.438	.955	.655		.079	.316	.468	.058	.003	.067	.029	.070	.063	.024	<.001	.268	.581	.361	.509
SN	ACC	.657	.109	.397	.317	.095	.234	.443	.079		.606	.772	.281	.585	.435	.966	.440	.636	.511	.601	.029	.016	.544	.639
	AINS (L)	.864	.626	.796	.887	.709	.526	.650	.316	.606		.473	.222	.064	.504	.909	.291	.934	.923	.790	.798	.233	.718	.982
	AINS (R)	.526	.740	.972	.874	.283	.788	.751	.468	.772	.473		.206	.084	.406	.450	.081	.705	.988	.435	.522	.662	.588	.816
	RPFC (L)	.946	.904	.955	.942	.550	.498	.105	.058	.281	.222	.206		.946	.159	.696	.226	.967	.478	.083	.521	.628	.811	.920
	RPFC (R)	.976	.798	.775	.921	.608	.368	.020	.003	.585	.064	.084	.946		.063	.024	.051	.516	.066	.015	.474	.352	.255	.590
	SMG (L)	.230	.265	.249	.878	.500	.173	.100	.067	.435	.504	.406	.159	.063		.810	.163	.795	.478	.778	.059	.057	.092	.436
	SMG (R)	.770	.588	.389	.881	.781	.101	.092	.029	.966	.909	.450	.696	.024	.810		.300	.744	.188	.272	.011	.060	.035	.148
DAN	FEF (L)	.789	.803	.806	.870	.414	.261	.086	.070	.440	.291	.081	.226	.051	.163	.300		.490	.378	.340	.369	.721	.027	.225
	FEF (R)	.619	.672	.336	.810	.930	.041	.088	.063	.636	.934	.705	.967	.516	.795	.744	.490		.844	.693	.211	.178	.009	.021
	IPS (L)	.369	.221	.119	.265	.722	.185	.193	.024	.511	.923	.988	.478	.066	.478	.188	.378	.844		.371	.361	.392	.249	.657
	IPS (R)	.221	.200	.162	.482	.498	.163	.024	<.001	.601	.790	.435	.083	.015	.778	.272	.340	.693	.371		.138	.450	.118	.324
FPN	LPFC (L)	.547	.479	.242	.382	.975	.487	.363	.268	.029	.798	.522	.521	.474	.059	.011	.369	.211	.361	.138		.925	.514	.619
	PPC (L)	.489	.506	.292	.592	.977	.608	.728	.581	.016	.233	.662	.628	.352	.057	.060	.721	.178	.392	.450	.925		.849	.481
	LPFC (R)	.633	.790	.780	.800	.736	.528	.340	.361	.544	.718	.588	.811	.255	.092	.035	.027	.009	.249	.118	.514	.849		.404
	PPC (R)	.200	.193	.308	.744	.621	.308	.495	.509	.639	.982	.816	.920	.590	.436	.148	.225	.021	.657	.324	.619	.481	.404	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, LAT: Lateral visual areas, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MED: Medial visual areas, MPFC: Medial prefrontal cortex, OCC: Occipital cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network, VN: Visual network.

Supplementary Table 22.

Summary of p-values of one-tailed t-tests of the healthy control group > diffuse tumor growth pattern group during verb generation.

		DMN				SN							DAN				FPN				LN			
	ROI	MPFC	LP (L)	LP (R)	PCC	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)	IFG (L)	IFG (R)	pSTG (L)	pSTG (R)
DMN	MPFC		.039	.043	.030	.996	>.999	>.999	>.999	>.999	.998	.994	.786	.430	.995	.971	.980	.824	.860	.700	.985	.915	.098	.228
	LP (L)	.039		.098	.308	.758	.714	.527	.821	.944	.990	.441	.411	.296	.838	.255	.011	.619	.007	.205	.109	.220	.623	.052
	LP (R)	.043	.098		.231	.370	.816	.865	.963	.847	.617	.987	.210	.338	.453	.724	.824	.189	.087	.779	.918	.898	.017	.966
	PCC	.030	.308	.231		.504	.953	.906	.861	.922	.995	.996	.493	.444	.990	.996	.917	.751	.073	.781	.954	.513	.403	.818
SN	ACC	.996	.758	.370	.504		<.001	<.001	.892	.989	.082	.063	.701	.214	.659	.712	.999	.982	.987	.612	.803	.449	.022	.074
	AINS (L)	>.999	.714	.816	.953	<.001		<.001	.023	.001	.048	.027	.127	.067	.189	.213	.834	.826	.460	.266	.748	.112	.226	.009
	AINS (R)	>.999	.527	.865	.906	<.001	<.001		.043	.015	.005	.038	.008	.002	.076	.280	.964	.520	.986	.668	.872	.628	.096	.316
	RPFC (L)	>.999	.821	.963	.861	.892	.023	.043		.784	.077	.009	.860	.131	.875	.792	.999	.927	.996	.908	.987	.943	.107	.469
	RPFC (R)	>.999	.944	.847	.922	.989	.001	.015	.784		.005	.169	.791	.338	.914	.931	.997	.991	>.999	.822	.977	>.999	.460	.629
	SMG (L)	.998	.990	.617	.995	.082	.048	.005	.077	.005		<.001	.621	.104	.829	.024	.811	>.999	.577	.503	.997	.819	.999	.174
	SMG (R)	.994	.441	.987	.996	.063	.027	.038	.009	.169	<.001		.121	.028	.003	.379	.934	.801	.894	.998	.962	.828	.006	.995
DAN	FEF (L)	.786	.411	.210	.493	.701	.127	.008	.860	.791	.621	.121		.379	.018	.032	.950	.999	.971	.974	.878	.309	.914	.419
	FEF (R)	.430	.296	.338	.444	.214	.067	.002	.131	.338	.104	.028	.379		.028	.050	.572	.439	.984	.538	.247	.505	.091	.531
	IPS (L)	.995	.838	.453	.990	.659	.189	.076	.875	.914	.829	.003	.018	.028		.001	.859	>.999	.750	.933	.908	.570	.975	.287
	IPS (R)	.971	.255	.724	.996	.712	.213	.280	.792	.931	.024	.379	.032	.050	.001		.849	.914	.697	.993	.937	.766	.199	.978
FPN	LPFC (L)	.980	.011	.824	.917	.999	.834	.964	.999	.997	.811	.934	.950	.572	.859	.849		<.001	.106	.212	.154	.702	.075	.692
	PPC (L)	.824	.619	.189	.751	.982	.826	.520	.927	.991	>.999	.801	.999	.439	>.999	.914	<.001		<.001	.017	.176	.112	.568	.042
	LPFC (R)	.860	.007	.087	.073	.987	.460	.986	.996	>.999	.577	.894	.971	.984	.750	.697	.106	<.001		.001	.633	.959	.120	.353
	PPC (R)	.700	.205	.779	.781	.612	.266	.668	.908	.822	.503	.998	.974	.538	.933	.993	.212	.017	.001		.463	.626	.035	.719
LN	IFG (L)	.985	.109	.918	.954	.803	.748	.872	.987	.977	.997	.962	.878	.247	.908	.937	.154	.176	.633	.463		.073	.033	.416
	IFG (R)	.915	.220	.898	.513	.449	.112	.628	.943	>.999	.819	.828	.309	.505	.570	.766	.702	.112	.959	.626	.073		.017	.029
	pSTG (L)	.098	.623	.017	.403	.022	.226	.096	.107	.460	.999	.006	.914	.091	.975	.199	.075	.568	.120	.035	.033	.017		<.001
	pSTG (R)	.228	.052	.966	.818	.074	.009	.316	.469	.629	.174	.995	.419	.531	.287	.978	.692	.042	.353	.719	.416	.029	<.001	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IFG: Inferior frontal gyrus, IPS: Intraparietal sulcus, LN: Language network, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, pSTG: Posterior superior frontal gyrus, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network.

Supplementary Table 23.

Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > healthy control group during verb generation.

		DMN				SN							DAN				FPN				LN			
	ROI	MPFC	LP (L)	LP (R)	PCC	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)	IFG (L)	IFG (R)	pSTG (L)	pSTG (R)
DMN	MPFC		.961	.957	.970	.004	<.001	<.001	<.001	<.001	.002	.006	.214	.570	.005	.029	.020	.176	.140	.300	.015	.085	.902	.772
	LP (L)	.961		.902	.692	.242	.286	.473	.179	.056	.010	.559	.589	.704	.162	.745	.989	.381	.993	.795	.891	.780	.377	.948
	LP (R)	.957	.902		.769	.630	.184	.135	.037	.153	.383	.013	.790	.662	.547	.276	.176	.811	.913	.221	.082	.102	.983	.034
	PCC	.970	.692	.769		.496	.047	.094	.139	.078	.005	.004	.507	.556	.010	.004	.083	.249	.927	.219	.046	.487	.597	.182
SN	ACC	.004	.242	.630	.496		>.999	>.999	.108	.011	.918	.937	.299	.786	.341	.288	.001	.018	.013	.388	.197	.551	.978	.926
	AINS (L)	<.001	.286	.184	.047	>.999		>.999	.977	.999	.952	.973	.873	.933	.811	.787	.166	.174	.540	.734	.252	.888	.774	.991
	AINS (R)	<.001	.473	.135	.094	>.999	>.999		.957	.985	.995	.962	.992	.998	.924	.720	.036	.480	.014	.332	.128	.372	.904	.684
	RPFC (L)	<.001	.179	.037	.139	.108	.977	.957		.216	.923	.991	.140	.869	.125	.208	.001	.073	.004	.092	.013	.057	.893	.531
	RPFC (R)	<.001	.056	.153	.078	.011	.999	.985	.216		.995	.831	.209	.662	.086	.069	.003	.009	<.001	.178	.023	<.001	.540	.371
	SMG (L)	.002	.010	.383	.005	.918	.952	.995	.923	.995		>.999	.379	.896	.171	.976	.189	<.001	.423	.497	.003	.181	.001	.826
	SMG (R)	.006	.559	.013	.004	.937	.973	.962	.991	.831	>.999		.879	.972	.997	.621	.066	.199	.106	.002	.038	.172	.994	.005
DAN	FEF (L)	.214	.589	.790	.507	.299	.873	.992	.140	.209	.379	.879		.621	.982	.968	.050	.001	.029	.026	.122	.691	.086	.581
	FEF (R)	.570	.704	.662	.556	.786	.933	.998	.869	.662	.896	.972	.621		.972	.950	.428	.561	.016	.462	.753	.495	.909	.469
	IPS (L)	.005	.162	.547	.010	.341	.811	.924	.125	.086	.171	.997	.982	.972		.999	.141	<.001	.250	.067	.092	.430	.025	.713
	IPS (R)	.029	.745	.276	.004	.288	.787	.720	.208	.069	.976	.621	.968	.950	.999		.151	.086	.303	.007	.063	.234	.801	.022
FPN	LPFC (L)	.020	.989	.176	.083	.001	.166	.036	.001	.003	.189	.066	.050	.428	.141	.151		>.999	.894	.788	.846	.298	.925	.308
	PPC (L)	.176	.381	.811	.249	.018	.174	.480	.073	.009	<.001	.199	.001	.561	<.001	.086	>.999		>.999	.983	.824	.888	.432	.958
	LPFC (R)	.140	.993	.913	.927	.013	.540	.014	.004	<.001	.423	.106	.029	.016	.250	.303	.894	>.999		.999	.367	.041	.880	.647
	PPC (R)	.300	.795	.221	.219	.388	.734	.332	.092	.178	.497	.002	.026	.462	.067	.007	.788	.983	.999		.537	.374	.965	.281
LN	IFG (L)	.015	.891	.082	.046	.197	.252	.128	.013	.023	.003	.038	.122	.753	.092	.063	.846	.824	.367	.537		.927	.967	.584
	IFG (R)	.085	.780	.102	.487	.551	.888	.372	.057	<.001	.181	.172	.691	.495	.430	.234	.298	.888	.041	.374	.927		.983	.971
	pSTG (L)	.902	.377	.983	.597	.978	.774	.904	.893	.540	.001	.994	.086	.909	.025	.801	.925	.432	.880	.965	.967	.983		>.999
	pSTG (R)	.772	.948	.034	.182	.926	.991	.684	.531	.371	.826	.005	.581	.469	.713	.022	.308	.958	.647	.281	.584	.971	>.999	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IFG: Inferior frontal gyrus, IPS: Intraparietal sulcus, LN: Language network, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, pSTG: Posterior superior frontal gyrus, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network.

Supplementary Table 24.

Summary of p-values of one-tailed t-tests of the healthy control group > uniform tumor growth pattern group during verb generation.

		DMN				SN							DAN				FPN				LN			
	ROI	MPFC	LP (L)	LP (R)	PCC	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)	IFG (L)	IFG (R)	pSTG (L)	pSTG (R)
DMN	MPFC		.131	.014	.013	.996	.999	.999	.999	>.999	.999	.981	.944	.761	.989	.795	.999	.836	.943	.630	.999	.943	.073	.306
	LP (L)	.131		.364	.435	.058	.672	.660	.133	.282	.962	.747	.104	.008	.555	.023	.028	.450	.006	.465	.252	.075	.862	.470
	LP (R)	.014	.364		.261	.188	.966	.965	.201	.615	.865	.986	.112	.090	.324	.247	.678	.445	.074	.945	.888	.896	.310	.976
	PCC	.013	.435	.261		.383	.998	.985	.522	.681	.995	>.999	.660	.041	.998	.852	.823	.857	.063	.946	.958	.614	.739	.916
SN	ACC	.996	.058	.188	.383		.004	.003	>.999	>.999	.151	.150	.999	.932	.824	.793	>.999	.639	.982	.568	.933	.486	.005	.025
	AINS (L)	.999	.672	.966	.998	.004		.016	.023	.002	.331	.295	.481	.094	.553	.105	.404	.638	.136	.633	.964	.408	.219	.130
	AINS (R)	.999	.660	.965	.985	.003	.016		.070	.052	.017	.457	.108	.001	.156	.183	.792	.845	.530	.924	.974	.828	.089	.614
	RPFC (L)	.999	.133	.201	.522	>.999	.023	.070		>.999	.057	.034	>.999	.887	.973	.742	>.999	.754	.996	.600	.969	.902	.005	.069
	RPFC (R)	>.999	.282	.615	.681	>.999	.002	.052	>.999		.047	.193	>.999	.812	.982	.889	>.999	.940	>.999	.710	.998	>.999	.219	.427
	SMG (L)	.999	.962	.865	.995	.151	.331	.017	.057	.047		<.001	.350	.001	.622	.004	.911	.998	.592	.774	>.999	.959	.987	.584
	SMG (R)	.981	.747	.986	>.999	.150	.295	.457	.034	.193	<.001		.384	.008	.157	.338	.780	.988	.358	>.999	.982	.988	.191	.959
DAN	FEF (L)	.944	.104	.112	.660	.999	.481	.108	>.999	>.999	.350	.384		.989	.442	.649	.999	.988	.999	.778	.917	.789	.942	.465
	FEF (R)	.761	.008	.090	.041	.932	.094	.001	.887	.812	.001	.008	.989		.010	.055	.971	.348	.983	.190	.263	.533	.028	.160
	IPS (L)	.989	.555	.324	.998	.824	.553	.156	.973	.982	.622	.157	.442	.010		.016	.915	>.999	.771	.908	.991	.680	.587	.186
	IPS (R)	.795	.023	.247	.852	.793	.105	.183	.742	.889	.004	.338	.649	.055	.016		.927	.883	.522	.992	.978	.740	.072	.531
FPN	LPFC (L)	.999	.028	.678	.823	>.999	.404	.792	>.999	>.999	.911	.780	.999	.971	.915	.927		.001	.745	.234	.324	.745	.036	.423
	PPC (L)	.836	.450	.445	.857	.639	.638	.845	.754	.940	.998	.988	.988	.348	>.999	.883	.001		.004	.010	.309	.109	.036	.021
	LPFC (R)	.943	.006	.074	.063	.982	.136	.530	.996	>.999	.592	.358	.999	.983	.771	.522	.745	.004		<.001	.575	.470	.060	.035
	PPC (R)	.630	.465	.945	.946	.568	.633	.924	.600	.710	.774	>.999	.778	.190	.908	.992	.234	.010	<.001		.589	.567	.113	.669
LN	IFG (L)	.999	.252	.888	.958	.933	.964	.974	.969	.998	>.999	.982	.917	.263	.991	.978	.324	.309	.575	.589		.403	.009	.436
	IFG (R)	.943	.075	.896	.614	.486	.408	.828	.902	>.999	.959	.988	.789	.533	.680	.740	.745	.109	.470	.567	.403		.002	.096
	pSTG (L)	.073	.862	.310	.739	.005	.219	.089	.005	.219	.987	.191	.942	.028	.587	.072	.036	.036	.060	.113	.009	.002		.001
	pSTG (R)	.306	.470	.976	.916	.025	.130	.614	.069	.427	.584	.959	.465	.160	.186	.531	.423	.021	.035	.669	.436	.096	.001	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IFG: Inferior frontal gyrus, IPS: Intraparietal sulcus, LN: Language network, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, pSTG: Posterior superior frontal gyrus, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network.

Supplementary Table 25.

Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern > healthy control group group during verb generation.

		DMN				SN							DAN				FPN				LN			
	ROI	MPFC	LP (L)	LP (R)	PCC	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)	IFG (L)	IFG (R)	pSTG (L)	pSTG (R)
DMN	MPFC		.869	.986	.987	.004	.001	.001	.001	<.001	.001	.019	.056	.239	.011	.205	.001	.164	.057	.370	.001	.057	.927	.694
	LP (L)	.869		.636	.565	.942	.328	.340	.867	.718	.038	.253	.896	.992	.445	.977	.972	.550	.994	.535	.748	.925	.138	.530
	LP (R)	.986	.636		.739	.812	.034	.035	.799	.385	.135	.014	.888	.910	.676	.753	.322	.555	.926	.055	.112	.104	.690	.024
	PCC	.987	.565	.739		.617	.002	.015	.478	.319	.005	<.001	.340	.959	.002	.148	.177	.143	.937	.054	.042	.386	.261	.084
SN	ACC	.004	.942	.812	.617		.996	.997	<.001	<.001	.849	.850	.001	.068	.176	.207	<.001	.361	.018	.432	.067	.514	.995	.975
	AINS (L)	.001	.328	.034	.002	.996		.984	.977	.998	.669	.705	.519	.906	.447	.895	.596	.362	.864	.367	.036	.592	.781	.870
	AINS (R)	.001	.340	.035	.015	.997	.984		.930	.948	.983	.543	.892	.999	.844	.817	.208	.155	.470	.076	.026	.172	.911	.386
	RPFC (L)	.001	.867	.799	.478	<.001	.977	.930		<.001	.943	.966	<.001	.113	.027	.258	<.001	.246	.004	.400	.031	.098	.995	.931
	RPFC (R)	<.001	.718	.385	.319	<.001	.998	.948	<.001		.953	.807	<.001	.188	.018	.111	<.001	.060	<.001	.290	.002	<.001	.781	.573
	SMG (L)	.001	.038	.135	.005	.849	.669	.983	.943	.953		>.999	.650	.999	.378	.996	.089	.002	.408	.226	<.001	.041	.013	.416
	SMG (R)	.019	.253	.014	<.001	.850	.705	.543	.966	.807	>.999		.616	.992	.843	.662	.220	.012	.642	<.001	.018	.012	.809	.041
DAN	FEF (L)	.056	.896	.888	.340	.001	.519	.892	<.001	<.001	.650	.616		.011	.558	.351	.001	.012	.001	.222	.083	.211	.058	.535
	FEF (R)	.239	.992	.910	.959	.068	.906	.999	.113	.188	.999	.992	.011		.990	.945	.029	.652	.017	.810	.737	.467	.972	.840
	IPS (L)	.011	.445	.676	.002	.176	.447	.844	.027	.018	.378	.843	.558	.990		.984	.085	<.001	.229	.092	.009	.320	.413	.814
	IPS (R)	.205	.977	.753	.148	.207	.895	.817	.258	.111	.996	.662	.351	.945	.984		.073	.117	.478	.008	.022	.260	.928	.469
FPN	LPFC (L)	.001	.972	.322	.177	<.001	.596	.208	<.001	<.001	.089	.220	.001	.029	.085	.073		.999	.255	.766	.676	.255	.964	.577
	PPC (L)	.164	.550	.555	.143	.361	.362	.155	.246	.060	.002	.012	.012	.652	<.001	.117	.999		.996	.990	.691	.891	.964	.979
	LPFC (R)	.057	.994	.926	.937	.018	.864	.470	.004	<.001	.408	.642	.001	.017	.229	.478	.255	.996		>.999	.425	.530	.940	.965
	PPC (R)	.370	.535	.055	.054	.432	.367	.076	.400	.290	.226	<.001	.222	.810	.092	.008	.766	.990	>.999		.411	.433	.887	.331
LN	IFG (L)	.001	.748	.112	.042	.067	.036	.026	.031	.002	<.001	.018	.083	.737	.009	.022	.676	.691	.425	.411		.597	.991	.564
	IFG (R)	.057	.925	.104	.386	.514	.592	.172	.098	<.001	.041	.012	.211	.467	.320	.260	.255	.891	.530	.433	.597		.998	.904
	pSTG (L)	.927	.138	.690	.261	.995	.781	.911	.995	.781	.013	.809	.058	.972	.413	.928	.964	.964	.940	.887	.991	.998		.999
	pSTG (R)	.694	.530	.024	.084	.975	.870	.386	.931	.573	.416	.041	.535	.840	.814	.469	.577	.979	.965	.331	.564	.904	.999	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IFG: Inferior frontal gyrus, IPS: Intraparietal sulcus, LN: Language network, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, pSTG: Posterior superior frontal gyrus, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network.

Supplementary Table 26.

Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern > diffuse tumor growth pattern group during verb generation.

		DMN				SN							DAN				FPN				LN			
	ROI	MPFC	LP (L)	LP (R)	PCC	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)	IFG (L)	IFG (R)	pSTG (L)	pSTG (R)
DMN	MPFC		.414	.800	.723	.220	.377	.359	.391	.535	.287	.561	.167	.185	.532	.810	.050	.441	.267	.567	.057	.373	.626	.460
	LP (L)	.414		.222	.388	.987	.512	.349	.976	.983	.600	.213	.842	.962	.758	.896	.520	.657	.710	.253	.353	.761	.211	.103
	LP (R)	.800	.222		.521	.725	.170	.117	.989	.724	.213	.388	.684	.854	.627	.878	.624	.253	.650	.203	.442	.445	.080	.387
	PCC	.723	.388	.521		.629	.065	.135	.783	.761	.282	.151	.337	.963	.269	.896	.576	.333	.657	.172	.405	.380	.169	.196
SN	ACC	.220	.987	.725	.629		.455	.532	.007	.026	.449	.402	.004	.021	.315	.393	.044	.921	.349	.532	.167	.472	.842	.858
	AINS (L)	.377	.512	.170	.065	.455		.014	.593	.558	.153	.141	.205	.480	.202	.678	.855	.689	.826	.201	.120	.190	.527	.181
	AINS (R)	.359	.349	.117	.135	.532	.014		.468	.511	.320	.056	.243	.844	.387	.674	.803	.172	.977	.133	.143	.229	.530	.226
	RPFC (L)	.391	.976	.989	.783	.007	.593	.468		.001	.620	.428	.001	.025	.179	.523	.047	.687	.418	.825	.462	.533	.946	.930
	RPFC (R)	.535	.983	.724	.761	.026	.558	.511	.001		.435	.556	.002	.106	.129	.445	.006	.638	.394	.599	.105	.126	.788	.678
	SMG (L)	.287	.600	.213	.282	.449	.153	.320	.620	.435		.480	.747	.987	.693	.805	.318	.427	.477	.230	.034	.156	.791	.168
	SMG (R)	.561	.213	.388	.151	.402	.141	.056	.428	.556	.480		.225	.866	.053	.586	.750	.030	.948	.166	.246	.044	.108	.683
DAN	FEF (L)	.167	.842	.684	.337	.004	.205	.243	.001	.002	.747	.225		.004	.043	.025	.125	.795	.053	.833	.294	.129	.401	.463
	FEF (R)	.185	.962	.854	.963	.021	.480	.844	.025	.106	.987	.866	.004		.784	.686	.032	.599	.430	.858	.509	.472	.859	.890
	IPS (L)	.532	.758	.627	.269	.315	.202	.387	.179	.129	.693	.053	.043	.784		.238	.362	.476	.461	.559	.220	.390	.922	.636
	IPS (R)	.810	.896	.878	.896	.393	.678	.674	.523	.445	.805	.586	.025	.686	.238		.377	.544	.654	.587	.200	.498	.810	.946
FPN	LPFC (L)	.050	.520	.624	.576	.044	.855	.803	.047	.006	.318	.750	.125	.032	.362	.377		.634	.044	.510	.352	.381	.685	.753
	PPC (L)	.441	.657	.253	.333	.921	.689	.172	.687	.638	.427	.030	.795	.599	.476	.544	.634		.268	.612	.338	.488	.959	.728
	LPFC (R)	.267	.710	.650	.657	.349	.826	.977	.418	.394	.477	.948	.053	.430	.461	.654	.044	.268		.789	.549	.945	.708	.936
	PPC (R)	.567	.253	.203	.172	.532	.201	.133	.825	.599	.230	.166	.833	.858	.559	.587	.510	.612	.789		.384	.547	.338	.524
LN	IFG (L)	.057	.353	.442	.405	.167	.120	.143	.462	.105	.034	.246	.294	.509	.220	.200	.352	.338	.549	.384		.130	.705	.499
	IFG (R)	.373	.761	.445	.380	.472	.190	.229	.533	.126	.156	.044	.129	.472	.390	.498	.381	.488	.945	.547	.130		.948	.412
	pSTG (L)	.626	.211	.080	.169	.842	.527	.530	.946	.788	.791	.108	.401	.859	.922	.810	.685	.959	.708	.338	.705	.948		.076
	pSTG (R)	.460	.103	.387	.196	.858	.181	.226	.930	.678	.168	.683	.463	.890	.636	.946	.753	.728	.936	.524	.499	.412	.076	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IFG: Inferior frontal gyrus, IPS: Intraparietal sulcus, LN: Language network, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, pSTG: Posterior superior frontal gyrus, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network.

Supplementary Table 27.

Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern > uniform tumor growth pattern group during verb generation.

		DMN				SN							DAN				FPN				LN			
	ROI	MPFC	LP (L)	LP (R)	PCC	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)	IFG (L)	IFG (R)	pSTG (L)	pSTG (R)
DMN	MPFC		.586	.200	.277	.780	.623	.641	.609	.465	.713	.439	.833	.815	.468	.190	.950	.559	.733	.433	.943	.627	.374	.540
	LP (L)	.586		.778	.612	.013	.488	.651	.024	.017	.400	.787	.158	.038	.242	.104	.480	.343	.290	.747	.647	.239	.789	.897
	LP (R)	.200	.778		.479	.275	.830	.883	.011	.276	.787	.612	.316	.146	.373	.122	.376	.747	.350	.797	.558	.555	.920	.613
	PCC	.277	.612	.479		.371	.935	.865	.217	.239	.718	.849	.663	.037	.731	.104	.424	.667	.343	.828	.595	.620	.831	.804
SN	ACC	.780	.013	.275	.371		.545	.468	.993	.974	.551	.598	.996	.979	.685	.607	.956	.079	.651	.468	.833	.528	.158	.142
	AINS (L)	.623	.488	.830	.935	.545		.986	.407	.442	.847	.859	.795	.520	.798	.322	.145	.311	.174	.799	.880	.810	.473	.819
	AINS (R)	.641	.651	.883	.865	.468	.986		.532	.489	.680	.944	.757	.156	.613	.326	.197	.828	.023	.867	.857	.771	.470	.774
	RPFC (L)	.609	.024	.011	.217	.993	.407	.532		.999	.380	.572	.999	.975	.821	.477	.953	.313	.582	.175	.538	.467	.054	.070
	RPFC (R)	.465	.017	.276	.239	.974	.442	.489	.999		.565	.444	.998	.894	.871	.555	.994	.362	.606	.401	.895	.874	.212	.322
	SMG (L)	.713	.400	.787	.718	.551	.847	.680	.380	.565		.520	.253	.013	.307	.195	.682	.573	.523	.770	.966	.844	.209	.832
	SMG (R)	.439	.787	.612	.849	.598	.859	.944	.572	.444	.520		.775	.134	.947	.414	.250	.970	.052	.834	.754	.956	.892	.317
DAN	FEF (L)	.833	.158	.316	.663	.996	.795	.757	.999	.998	.253	.775		.996	.957	.975	.875	.205	.947	.167	.706	.871	.599	.537
	FEF (R)	.815	.038	.146	.037	.979	.520	.156	.975	.894	.013	.134	.996		.216	.314	.968	.401	.570	.142	.491	.528	.141	.110
	IPS (L)	.468	.242	.373	.731	.685	.798	.613	.821	.871	.307	.947	.957	.216		.762	.638	.524	.539	.441	.780	.610	.078	.364
	IPS (R)	.190	.104	.122	.104	.607	.322	.326	.477	.555	.195	.414	.975	.314	.762		.623	.456	.346	.413	.800	.502	.190	.054
FPN	LPFC (L)	.950	.480	.376	.424	.956	.145	.197	.953	.994	.682	.250	.875	.968	.638	.623		.366	.956	.490	.648	.619	.315	.247
	PPC (L)	.559	.343	.747	.667	.079	.311	.828	.313	.362	.573	.970	.205	.401	.524	.456	.366		.732	.388	.662	.512	.041	.272
	LPFC (R)	.733	.290	.350	.343	.651	.174	.023	.582	.606	.523	.052	.947	.570	.539	.346	.956	.732		.211	.451	.055	.292	.064
	PPC (R)	.433	.747	.797	.828	.468	.799	.867	.175	.401	.770	.834	.167	.142	.441	.413	.490	.388	.211		.616	.453	.662	.476
LN	IFG (L)	.943	.647	.558	.595	.833	.880	.857	.538	.895	.966	.754	.706	.491	.780	.800	.648	.662	.451	.616		.870	.295	.501
	IFG (R)	.627	.239	.555	.620	.528	.810	.771	.467	.874	.844	.956	.871	.528	.610	.502	.619	.512	.055	.453	.870		.052	.588
	pSTG (L)	.374	.789	.920	.831	.158	.473	.470	.054	.212	.209	.892	.599	.141	.078	.190	.315	.041	.292	.662	.295	.052		.924
	pSTG (R)	.540	.897	.613	.804	.142	.819	.774	.070	.322	.832	.317	.537	.110	.364	.054	.247	.272	.064	.476	.501	.588	.924	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IFG: Inferior frontal gyrus, IPS: Intraparietal sulcus, LN: Language network, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, pSTG: Posterior superior frontal gyrus, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network.

Supplementary Table 28.

Summary of p-values of one-tailed t-tests of the healthy control group > diffuse tumor growth pattern group during antonym generation.

		DMN				SN							DAN				FPN				LN			
	ROI	MPFC	LP (L)	LP (R)	PCC	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)	IFG (L)	IFG (R)	pSTG (L)	pSTG (R)
DMN	MPFC		.263	.199	.420	.998	>.999	.992	.999	>.999	.997	.985	.816	.687	.904	.925	.981	.395	.891	.556	.990	.853	.632	.419
	LP (L)	.263		.127	.834	.629	.774	.265	.606	.628	.948	.317	.632	.011	.939	.212	.076	.803	.006	.090	.754	.388	.992	.252
	LP (R)	.199	.127		.848	.408	.861	.952	.346	.408	.708	.967	.153	.269	.142	.765	.238	.043	.001	.482	.993	.931	.252	.998
	PCC	.420	.834	.848		.419	.932	.872	.585	.852	.982	.958	.697	.542	.995	.999	.553	.624	.112	.950	.986	.879	.805	.976
SN	ACC	.998	.629	.408	.419		.002	<.001	.979	.949	.458	.058	.975	.859	.546	.965	>.999	.953	.990	.565	.899	.803	.058	.008
	AINS (L)	>.999	.774	.861	.932	.002		<.001	.094	.058	.262	.004	.147	.087	.212	.150	.967	.794	.889	.370	.984	.346	.211	.002
	AINS (R)	.992	.265	.952	.872	<.001	<.001		<.001	.001	.020	.169	.106	.277	.043	.363	.799	.593	.691	.635	.902	.978	.003	.380
	RPFC (L)	.999	.606	.346	.585	.979	.094	<.001		.986	.145	.011	.937	.862	.913	.943	>.999	.795	.871	.244	.981	.411	.028	.025
	RPFC (R)	>.999	.628	.408	.852	.949	.058	.001	.986		.006	.030	.932	.975	.790	.976	.999	.923	.998	.697	.960	.944	.097	.086
	SMG (L)	.997	.948	.708	.982	.458	.262	.020	.145	.006		<.001	.450	.186	.293	.030	.932	.989	.813	.753	.966	.913	.845	.074
	SMG (R)	.985	.317	.967	.958	.058	.004	.169	.011	.030	<.001		.185	.552	.002	.489	.821	.784	.795	>.999	.799	.999	.014	.988
DAN	FEF (L)	.816	.632	.153	.697	.975	.147	.106	.937	.932	.450	.185		.672	.282	.448	.999	.979	.992	.863	.165	.541	.574	.157
	FEF (R)	.687	.011	.269	.542	.859	.087	.277	.862	.975	.186	.552	.672		.101	.504	.951	.402	.990	.927	.287	.841	.132	.587
	IPS (L)	.904	.939	.142	.995	.546	.212	.043	.913	.790	.293	.002	.282	.101		<.001	.985	>.999	.702	.920	.763	.598	.889	.158
	IPS (R)	.925	.212	.765	.999	.965	.150	.363	.943	.976	.030	.489	.448	.504	<.001		.928	.766	.838	.997	.510	.976	.043	.975
FPN	LPFC (L)	.981	.076	.238	.553	>.999	.967	.799	>.999	.999	.932	.821	.999	.951	.985	.928		.004	.133	.095	.758	.432	.311	.763
	PPC (L)	.395	.803	.043	.624	.953	.794	.593	.795	.923	.989	.784	.979	.402	>.999	.766	.004		.006	.004	.238	.146	.918	.236
	LPFC (R)	.891	.006	.001	.112	.990	.889	.691	.871	.998	.813	.795	.992	.990	.702	.838	.133	.006		.002	.781	.888	.525	.325
	PPC (R)	.556	.090	.482	.950	.565	.370	.635	.244	.697	.753	>.999	.863	.927	.920	.997	.095	.004	.002		.852	.707	.278	.992
LN	IFG (L)	.990	.754	.993	.986	.899	.984	.902	.981	.960	.966	.799	.165	.287	.763	.510	.758	.238	.781	.852		.022	.296	.261
	IFG (R)	.853	.388	.931	.879	.803	.346	.978	.411	.944	.913	.999	.541	.841	.598	.976	.432	.146	.888	.707	.022		.011	.158
	pSTG (L)	.632	.992	.252	.805	.058	.211	.003	.028	.097	.845	.014	.574	.132	.889	.043	.311	.918	.525	.278	.296	.011		<.001
	pSTG (R)	.419	.252	.998	.976	.008	.002	.380	.025	.086	.074	.988	.157	.587	.158	.975	.763	.236	.325	.992	.261	.158	<.001	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IFG: Inferior frontal gyrus, IPS: Intraparietal sulcus, LN: Language network, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, pSTG: Posterior superior frontal gyrus, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network.

Supplementary Table 29.

Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > healthy control group during antonym generation.

		DMN				SN							DAN				FPN				LN			
	ROI	MPFC	LP (L)	LP (R)	PCC	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)	IFG (L)	IFG (R)	pSTG (L)	pSTG (R)
DMN	MPFC		.737	.801	.580	.002	<.001	.008	.001	<.001	.003	.015	.184	.313	.096	.075	.019	.605	.109	.444	.010	.147	.368	.581
	LP (L)	.737		.873	.166	.371	.226	.735	.394	.372	.052	.683	.368	.989	.061	.788	.924	.197	.994	.910	.246	.612	.008	.748
	LP (R)	.801	.873		.152	.592	.139	.048	.654	.592	.292	.033	.847	.731	.858	.235	.762	.957	.999	.518	.007	.069	.748	.002
	PCC	.580	.166	.152		.581	.068	.128	.415	.148	.018	.042	.303	.458	.005	.001	.447	.376	.888	.050	.014	.121	.195	.024
SN	ACC	.002	.371	.592	.581		.998	>.999	.021	.051	.542	.942	.025	.141	.454	.035	<.001	.047	.010	.435	.101	.197	.942	.992
	AINS (L)	<.001	.226	.139	.068	.998		>.999	.906	.942	.738	.996	.853	.913	.788	.850	.033	.206	.111	.630	.016	.654	.789	.998
	AINS (R)	.008	.735	.048	.128	>.999	>.999		>.999	.999	.980	.831	.894	.723	.957	.637	.201	.407	.309	.365	.098	.022	.997	.620
	RPFC (L)	.001	.394	.654	.415	.021	.906	>.999		.014	.855	.989	.063	.138	.087	.057	<.001	.205	.129	.756	.019	.589	.972	.975
	RPFC (R)	<.001	.372	.592	.148	.051	.942	.999	.014		.994	.970	.068	.025	.210	.024	.001	.077	.002	.303	.040	.056	.903	.914
	SMG (L)	.003	.052	.292	.018	.542	.738	.980	.855	.994		>.999	.550	.814	.707	.970	.068	.011	.187	.247	.034	.087	.155	.926
	SMG (R)	.015	.683	.033	.042	.942	.996	.831	.989	.970	>.999		.815	.448	.998	.511	.179	.216	.205	<.001	.201	.001	.986	.012
DAN	FEF (L)	.184	.368	.847	.303	.025	.853	.894	.063	.068	.550	.815		.328	.718	.552	.001	.021	.008	.137	.835	.459	.426	.843
	FEF (R)	.313	.989	.731	.458	.141	.913	.723	.138	.025	.814	.448	.328		.899	.496	.049	.598	.010	.073	.713	.159	.868	.413
	IPS (L)	.096	.061	.858	.005	.454	.788	.957	.087	.210	.707	.998	.718	.899		>.999	.015	<.001	.298	.080	.237	.402	.111	.842
	IPS (R)	.075	.788	.235	.001	.035	.850	.637	.057	.024	.970	.511	.552	.496	>.999		.072	.234	.162	.003	.490	.024	.957	.025
FPN	LPFC (L)	.019	.924	.762	.447	<.001	.033	.201	<.001	.001	.068	.179	.001	.049	.015	.072		.996	.867	.905	.242	.568	.689	.237
	PPC (L)	.605	.197	.957	.376	.047	.206	.407	.205	.077	.011	.216	.021	.598	<.001	.234	.996		.994	.996	.762	.854	.082	.764
	LPFC (R)	.109	.994	.999	.888	.010	.111	.309	.129	.002	.187	.205	.008	.010	.298	.162	.867	.994		.998	.219	.112	.475	.675
	PPC (R)	.444	.910	.518	.050	.435	.630	.365	.756	.303	.247	<.001	.137	.073	.080	.003	.905	.996	.998		.148	.293	.722	.008
LN	IFG (L)	.010	.246	.007	.014	.101	.016	.098	.019	.040	.034	.201	.835	.713	.237	.490	.242	.762	.219	.148		.978	.704	.739
	IFG (R)	.147	.612	.069	.121	.197	.654	.022	.589	.056	.087	.001	.459	.159	.402	.024	.568	.854	.112	.293	.978		.989	.842
	pSTG (L)	.368	.008	.748	.195	.942	.789	.997	.972	.903	.155	.986	.426	.868	.111	.957	.689	.082	.475	.722	.704	.989		>.999
	pSTG (R)	.581	.748	.002	.024	.992	.998	.620	.975	.914	.926	.012	.843	.413	.842	.025	.237	.764	.675	.008	.739	.842	>.999	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IFG: Inferior frontal gyrus, IPS: Intraparietal sulcus, LN: Language network, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, pSTG: Posterior superior frontal gyrus, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network.

Supplementary Table 30.

Summary of p-values of one-tailed t-tests of the healthy control group > uniform tumor growth pattern group during antonym generation.

		DMN				SN							DAN				FPN				LN			
	ROI	MPFC	LP (L)	LP (R)	PCC	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)	IFG (L)	IFG (R)	pSTG (L)	pSTG (R)
DMN	MPFC		.281	.462	.471	>.999	.996	.992	>.999	>.999	.970	.988	.924	.882	.984	.901	.992	.743	.915	.876	.993	.567	.159	.504
	LP (L)	.281		.454	.708	.392	.670	.476	.071	.107	.474	.354	.417	.016	.489	.068	.032	.608	.030	.312	.634	.472	.846	.606
	LP (R)	.462	.454		.955	.993	.998	.998	.792	.825	.588	.993	.568	.711	.945	.977	.838	.655	.150	.972	.974	.944	.439	>.999
	PCC	.471	.708	.955		.919	.979	.946	.626	.419	.986	.994	.931	.452	>.999	>.999	.727	.670	.193	.955	.993	.617	.860	>.999
SN	ACC	>.999	.392	.993	.919		.001	.002	.999	.985	.208	.169	.999	.673	.713	.948	>.999	.998	.999	.995	>.999	>.999	.014	.754
	AINS (L)	.996	.670	.998	.979	.001		<.001	.164	.008	.353	.052	.169	.005	.126	.094	.992	.972	.643	.924	.997	.886	.442	.043
	AINS (R)	.992	.476	.998	.946	.002	<.001		.020	.005	.062	.523	.459	.071	.115	.335	.998	.921	.601	.989	.999	.998	.109	.672
	RPFC (L)	>.999	.071	.792	.626	.999	.164	.020		.997	.129	.022	>.999	.965	.942	.731	>.999	.922	.986	.494	>.999	.939	.007	.128
	RPFC (R)	>.999	.107	.825	.419	.985	.008	.005	.997		.001	.037	>.999	.992	.926	.872	>.999	.945	.953	.434	.992	.998	.001	.144
	SMG (L)	.970	.474	.588	.986	.208	.353	.062	.129	.001		.001	.306	.208	.484	.022	.864	.962	.693	.650	.934	.959	.776	.263
	SMG (R)	.988	.354	.993	.994	.169	.052	.523	.022	.037	.001		.235	.111	.052	.373	.832	.957	.564	>.999	.905	>.999	.232	.999
DAN	FEF (L)	.924	.417	.568	.931	.999	.169	.459	>.999	>.999	.306	.235		.992	.654	.565	.995	.992	>.999	.970	.764	.634	.541	.450
	FEF (R)	.882	.016	.711	.452	.673	.005	.071	.965	.992	.208	.111	.992		.349	.425	.858	.785	.995	.915	.510	.803	.039	.777
	IPS (L)	.984	.489	.945	>.999	.713	.126	.115	.942	.926	.484	.052	.654	.349		.018	.994	>.999	.991	.999	.996	.767	.813	.836
	IPS (R)	.901	.068	.977	>.999	.948	.094	.335	.731	.872	.022	.373	.565	.425	.018		.885	.965	.899	>.999	.893	.980	.084	.997
FPN	LPFC (L)	.992	.032	.838	.727	>.999	.992	.998	>.999	>.999	.864	.832	.995	.858	.994	.885		.024	.620	.298	.999	.982	.083	.878
	PPC (L)	.743	.608	.655	.670	.998	.972	.921	.922	.945	.962	.957	.992	.785	>.999	.965	.024		.214	.025	.940	.229	.807	.565
	LPFC (R)	.915	.030	.150	.193	.999	.643	.601	.986	.953	.693	.564	>.999	.995	.991	.899	.620	.214		<.001	.989	.805	.307	.771
	PPC (R)	.876	.312	.972	.955	.995	.924	.989	.494	.434	.650	>.999	.970	.915	.999	>.999	.298	.025	<.001		.999	.736	.075	.994
LN	IFG (L)	.993	.634	.974	.993	>.999	.997	.999	>.999	.992	.934	.905	.764	.510	.996	.893	.999	.940	.989	.999		.723	.065	.528
	IFG (R)	.567	.472	.944	.617	>.999	.886	.998	.939	.998	.959	>.999	.634	.803	.767	.980	.982	.229	.805	.736	.723		.043	.360
	pSTG (L)	.159	.846	.439	.860	.014	.442	.109	.007	.001	.776	.232	.541	.039	.813	.084	.083	.807	.307	.075	.065	.043		<.001
	pSTG (R)	.504	.606	>.999	>.999	.754	.043	.672	.128	.144	.263	.999	.450	.777	.836	.997	.878	.565	.771	.994	.528	.360	<.001	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IFG: Inferior frontal gyrus, IPS: Intraparietal sulcus, LN: Language network, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, pSTG: Posterior superior frontal gyrus, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network.

Supplementary Table 31.

Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern > healthy control group group during antonym generation.

		DMN				SN							DAN				FPN				LN			
	ROI	MPFC	LP (L)	LP (R)	PCC	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)	IFG (L)	IFG (R)	pSTG (L)	pSTG (R)
DMN	MPFC		.719	.538	.529	<.001	.004	.008	<.001	<.001	.030	.012	.076	.118	.016	.099	.008	.257	.085	.124	.007	.433	.841	.496
	LP (L)	.719		.546	.292	.608	.330	.524	.929	.893	.526	.646	.583	.984	.511	.932	.968	.392	.970	.688	.366	.528	.154	.394
	LP (R)	.538	.546		.045	.007	.002	.002	.208	.175	.412	.007	.432	.289	.055	.023	.162	.345	.850	.028	.026	.056	.561	<.001
	PCC	.529	.292	.045		.081	.021	.054	.374	.581	.014	.006	.069	.548	<.001	<.001	.273	.330	.807	.045	.007	.383	.140	<.001
SN	ACC	<.001	.608	.007	.081		.999	.998	.001	.015	.792	.831	.001	.327	.287	.052	<.001	.002	.001	.005	<.001	<.001	.986	.246
	AINS (L)	.004	.330	.002	.021	.999		>.999	.836	.992	.647	.948	.831	.995	.874	.906	.008	.028	.357	.076	.003	.114	.558	.957
	AINS (R)	.008	.524	.002	.054	.998	>.999		.980	.995	.938	.477	.541	.929	.885	.665	.002	.079	.399	.011	.001	.002	.891	.328
	RPFC (L)	<.001	.929	.208	.374	.001	.836	.980		.003	.871	.978	<.001	.035	.058	.269	<.001	.078	.014	.506	<.001	.061	.993	.872
	RPFC (R)	<.001	.893	.175	.581	.015	.992	.995	.003		.999	.963	<.001	.008	.074	.128	<.001	.055	.047	.566	.008	.002	.999	.856
	SMG (L)	.030	.526	.412	.014	.792	.647	.938	.871	.999		.999	.694	.792	.516	.978	.136	.038	.307	.350	.066	.041	.224	.737
	SMG (R)	.012	.646	.007	.006	.831	.948	.477	.978	.963	.999		.765	.889	.948	.627	.168	.043	.436	<.001	.095	<.001	.768	.001
DAN	FEF (L)	.076	.583	.432	.069	.001	.831	.541	<.001	<.001	.694	.765		.008	.346	.435	.005	.008	<.001	.030	.236	.366	.459	.550
	FEF (R)	.118	.984	.289	.548	.327	.995	.929	.035	.008	.792	.889	.008		.651	.575	.142	.215	.005	.085	.490	.197	.961	.223
	IPS (L)	.016	.511	.055	<.001	.287	.874	.885	.058	.074	.516	.948	.346	.651		.982	.006	<.001	.009	.001	.004	.233	.187	.164
	IPS (R)	.099	.932	.023	<.001	.052	.906	.665	.269	.128	.978	.627	.435	.575	.982		.115	.035	.101	<.001	.107	.020	.916	.003
FPN	LPFC (L)	.008	.968	.162	.273	<.001	.008	.002	<.001	<.001	.136	.168	.005	.142	.006	.115		.976	.380	.702	.001	.018	.917	.122
	PPC (L)	.257	.392	.345	.330	.002	.028	.079	.078	.055	.038	.043	.008	.215	<.001	.035	.976		.786	.975	.060	.771	.193	.435
	LPFC (R)	.085	.970	.850	.807	.001	.357	.399	.014	.047	.307	.436	<.001	.005	.009	.101	.380	.786		>.999	.011	.195	.693	.229
	PPC (R)	.124	.688	.028	.045	.005	.076	.011	.506	.566	.350	<.001	.030	.085	.001	<.001	.702	.975	>.999		.001	.264	.925	.006
LN	IFG (L)	.007	.366	.026	.007	<.001	.003	.001	<.001	.008	.066	.095	.236	.490	.004	.107	.001	.060	.011	.001		.277	.935	.472
	IFG (R)	.433	.528	.056	.383	<.001	.114	.002	.061	.002	.041	<.001	.366	.197	.233	.020	.018	.771	.195	.264	.277		.957	.640
	pSTG (L)	.841	.154	.561	.140	.986	.558	.891	.993	.999	.224	.768	.459	.961	.187	.916	.917	.193	.693	.925	.935	.957		>.999
	pSTG (R)	.496	.394	<.001	<.001	.246	.957	.328	.872	.856	.737	.001	.550	.223	.164	.003	.122	.435	.229	.006	.472	.640	>.999	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IFG: Inferior frontal gyrus, IPS: Intraparietal sulcus, LN: Language network, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, pSTG: Posterior superior frontal gyrus, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network.

Supplementary Table 32.

Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern > diffuse tumor growth pattern group during antonym generation.

		DMN				SN							DAN				FPN				LN			
	ROI	MPFC	LP (L)	LP (R)	PCC	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)	IFG (L)	IFG (R)	pSTG (L)	pSTG (R)
DMN	MPFC		.545	.294	.467	.055	.510	.431	.068	.372	.685	.463	.334	.284	.130	.435	.324	.208	.447	.148	.310	.730	.866	.440
	LP (L)	.545		.183	.595	.686	.579	.314	.939	.923	.890	.500	.656	.541	.889	.778	.764	.671	.448	.257	.586	.434	.846	.225
	LP (R)	.294	.183		.204	.011	.039	.122	.145	.155	.586	.182	.196	.137	.005	.079	.055	.034	.063	.071	.347	.331	.375	.157
	PCC	.467	.595	.204		.094	.284	.314	.450	.835	.296	.110	.253	.571	.052	.341	.316	.436	.393	.469	.277	.703	.391	.022
SN	ACC	.055	.686	.011	.094		.497	.141	.148	.324	.723	.310	.198	.670	.334	.460	.019	.095	.157	.010	.024	.010	.811	.015
	AINS (L)	.510	.579	.039	.284	.497		.039	.449	.854	.457	.218	.514	.844	.619	.636	.260	.149	.752	.057	.147	.090	.330	.250
	AINS (R)	.431	.314	.122	.314	.141	.039		.169	.290	.465	.231	.231	.821	.398	.541	.013	.150	.576	.025	.033	.125	.155	.257
	RPFC (L)	.068	.939	.145	.450	.148	.449	.169		.387	.621	.450	.019	.160	.325	.717	.087	.238	.140	.289	.072	.086	.861	.346
	RPFC (R)	.372	.923	.155	.835	.324	.854	.290	.387		.876	.595	.010	.254	.226	.652	.144	.324	.772	.717	.246	.100	.976	.451
	SMG (L)	.685	.890	.586	.296	.723	.457	.465	.621	.876		.170	.640	.554	.352	.637	.530	.505	.602	.578	.343	.256	.502	.283
	SMG (R)	.463	.500	.182	.110	.310	.218	.231	.450	.595	.170		.514	.879	.248	.594	.440	.149	.705	.403	.276	.250	.169	.139
DAN	FEF (L)	.334	.656	.196	.253	.198	.514	.231	.019	.010	.640	.514		.043	.191	.413	.581	.225	.070	.228	.088	.392	.515	.235
	FEF (R)	.284	.541	.137	.571	.670	.844	.821	.160	.254	.554	.879	.043		.221	.577	.625	.141	.399	.479	.315	.469	.787	.328
	IPS (L)	.130	.889	.005	.052	.334	.619	.398	.325	.226	.352	.248	.191	.221		.159	.225	.137	.020	.025	.090	.335	.577	.042
	IPS (R)	.435	.778	.079	.341	.460	.636	.541	.717	.652	.637	.594	.413	.577	.159		.511	.126	.306	.043	.160	.303	.519	.081
FPN	LPFC (L)	.324	.764	.055	.316	.019	.260	.013	.087	.144	.530	.440	.581	.625	.225	.511		.339	.150	.270	.042	.043	.811	.239
	PPC (L)	.208	.671	.034	.436	.095	.149	.150	.238	.324	.505	.149	.225	.141	.137	.126	.339		.071	.362	.052	.429	.648	.223
	LPFC (R)	.447	.448	.063	.393	.157	.752	.576	.140	.772	.602	.705	.070	.399	.020	.306	.150	.071		.880	.179	.634	.707	.135
	PPC (R)	.148	.257	.071	.469	.010	.057	.025	.289	.717	.578	.403	.228	.479	.025	.043	.270	.362	.880		.030	.404	.810	.312
LN	IFG (L)	.310	.586	.347	.277	.024	.147	.033	.072	.246	.343	.276	.088	.315	.090	.160	.042	.052	.179	.030		.032	.800	.265
	IFG (R)	.730	.434	.331	.703	.010	.090	.125	.086	.100	.256	.250	.392	.469	.335	.303	.043	.429	.634	.404	.032		.445	.342
	pSTG (L)	.866	.846	.375	.391	.811	.330	.155	.861	.976	.502	.169	.515	.787	.577	.519	.811	.648	.707	.810	.800	.445		.400
	pSTG (R)	.440	.225	.157	.022	.015	.250	.257	.346	.451	.283	.139	.235	.328	.042	.081	.239	.223	.135	.312	.265	.342	.400	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IFG: Inferior frontal gyrus, IPS: Intraparietal sulcus, LN: Language network, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, pSTG: Posterior superior frontal gyrus, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network.

Supplementary Table 33.

Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern > uniform tumor growth pattern group during antonym generation.

		DMN				SN							DAN				FPN				LN			
	ROI	MPFC	LP (L)	LP (R)	PCC	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)	IFG (L)	IFG (R)	pSTG (L)	pSTG (R)
DMN	MPFC		.455	.706	.533	.945	.490	.569	.932	.628	.315	.537	.666	.716	.870	.565	.676	.792	.553	.852	.690	.270	.134	.560
	LP (L)	.455		.817	.405	.314	.421	.686	.061	.077	.110	.500	.344	.459	.111	.222	.236	.329	.552	.743	.414	.566	.154	.775
	LP (R)	.706	.817		.796	.989	.961	.878	.855	.845	.414	.818	.804	.863	.995	.921	.945	.966	.937	.929	.653	.669	.625	.843
	PCC	.533	.405	.796		.906	.716	.686	.550	.165	.704	.890	.747	.429	.948	.659	.684	.564	.607	.531	.723	.297	.609	.978
SN	ACC	.945	.314	.989	.906		.503	.859	.852	.676	.277	.690	.802	.330	.666	.540	.981	.905	.843	.990	.976	.990	.189	.985
	AINS (L)	.490	.421	.961	.716	.503		.961	.551	.146	.543	.782	.486	.156	.381	.364	.740	.851	.248	.943	.853	.910	.670	.750
	AINS (R)	.569	.686	.878	.686	.859	.961		.831	.710	.535	.769	.769	.179	.602	.459	.987	.850	.424	.975	.967	.875	.845	.743
	RPFC (L)	.932	.061	.855	.550	.852	.551	.831		.613	.379	.550	.981	.840	.675	.283	.913	.762	.860	.711	.928	.914	.139	.654
	RPFC (R)	.628	.077	.845	.165	.676	.146	.710	.613		.124	.405	.990	.746	.774	.348	.856	.676	.228	.283	.754	.900	.024	.549
	SMG (L)	.315	.110	.414	.704	.277	.543	.535	.379	.124		.830	.360	.446	.648	.363	.470	.495	.398	.422	.657	.744	.498	.717
	SMG (R)	.537	.500	.818	.890	.690	.782	.769	.550	.405	.830		.486	.121	.752	.406	.560	.851	.295	.597	.724	.750	.831	.861
DAN	FEF (L)	.666	.344	.804	.747	.802	.486	.769	.981	.990	.360	.486		.957	.809	.587	.419	.775	.930	.772	.912	.608	.485	.765
	FEF (R)	.716	.459	.863	.429	.330	.156	.179	.840	.746	.446	.121	.957		.779	.423	.375	.859	.601	.521	.685	.531	.213	.672
	IPS (L)	.870	.111	.995	.948	.666	.381	.602	.675	.774	.648	.752	.809	.779		.841	.775	.863	.980	.975	.910	.665	.423	.958
	IPS (R)	.565	.222	.921	.659	.540	.364	.459	.283	.348	.363	.406	.587	.423	.841		.489	.874	.694	.957	.840	.697	.481	.919
FPN	LPFC (L)	.676	.236	.945	.684	.981	.740	.987	.913	.856	.470	.560	.419	.375	.775	.489		.661	.850	.730	.958	.957	.189	.761
	PPC (L)	.792	.329	.966	.564	.905	.851	.850	.762	.676	.495	.851	.775	.859	.863	.874	.661		.929	.638	.948	.571	.352	.777
	LPFC (R)	.553	.552	.937	.607	.843	.248	.424	.860	.228	.398	.295	.930	.601	.980	.694	.850	.929		.120	.821	.366	.293	.865
	PPC (R)	.852	.743	.929	.531	.990	.943	.975	.711	.283	.422	.597	.772	.521	.975	.957	.730	.638	.120		.970	.596	.190	.688
LN	IFG (L)	.690	.414	.653	.723	.976	.853	.967	.928	.754	.657	.724	.912	.685	.910	.840	.958	.948	.821	.970		.968	.200	.735
	IFG (R)	.270	.566	.669	.297	.990	.910	.875	.914	.900	.744	.750	.608	.531	.665	.697	.957	.571	.366	.596	.968		.555	.658
	pSTG (L)	.134	.154	.625	.609	.189	.670	.845	.139	.024	.498	.831	.485	.213	.423	.481	.189	.352	.293	.190	.200	.555		.600
	pSTG (R)	.560	.775	.843	.978	.985	.750	.743	.654	.549	.717	.861	.765	.672	.958	.919	.761	.777	.865	.688	.735	.658	.600	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IFG: Inferior frontal gyrus, IPS: Intraparietal sulcus, LN: Language network, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, pSTG: Posterior superior frontal gyrus, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network.

Supplementary Table 34.

Summary of p-values of one-tailed t-tests of the healthy control group > diffuse tumor growth pattern group during syntax generation.

		DMN				SN							DAN				FPN				LN			
	ROI	MPFC	LP (L)	LP (R)	PCC	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)	IFG (L)	IFG (R)	pSTG (L)	pSTG (R)
DMN	MPFC		.169	.112	.169	.996	>.999	.999	>.999	>.999	.977	.993	.963	.798	>.999	.986	.999	.991	.997	.557	.986	.963	.636	.165
	LP (L)	.169		.045	.843	.966	.992	.981	.956	.993	.999	1.000	.871	.237	.998	.923	.405	.988	.699	.775	.512	.806	.994	.754
	LP (R)	.112	.045		.863	.911	.971	>.999	.987	.984	.822	1.000	.842	.727	.978	.997	.892	.905	.422	.999	.565	.989	.397	.997
	PCC	.169	.843	.863		.735	.978	.995	.963	.950	.997	1.000	.766	.871	>.999	>.999	.995	.989	.410	.969	.997	>.999	.996	>.999
SN	ACC	.996	.966	.911	.735		<.001	.002	.929	.985	.325	.131	.873	.942	.929	.935	>.999	.868	.987	.938	.959	.954	.045	.268
	AINS (L)	>.999	.992	.971	.978	<.001		<.001	.037	.001	.162	.011	.047	.070	.190	.021	.850	.739	.762	.562	.973	.194	.344	.013
	AINS (R)	.999	.981	>.999	.995	.002	<.001		.004	.005	.049	.131	.108	.466	.475	.657	.943	.799	.808	.910	.890	.985	.095	.937
	RPFC (L)	>.999	.956	.987	.963	.929	.037	.004		.964	.194	.014	.983	.993	.963	.812	>.999	.966	.999	.662	.998	.999	.345	.169
	RPFC (R)	>.999	.993	.984	.950	.985	.001	.005	.964		.030	.039	.766	.974	.869	.956	>.999	.883	>.999	.895	.987	.996	.088	.172
	SMG (L)	.977	.999	.822	.997	.325	.162	.049	.194	.030		<.001	.275	.457	>.999	.659	.993	.994	.742	.774	>.999	.983	>.999	.480
	SMG (R)	.993	>.999	>.999	>.999	.131	.011	.131	.014	.039	<.001		.522	.480	.553	.897	.981	.910	.825	>.999	.992	.999	.910	.999
DAN	FEF (L)	.963	.871	.842	.766	.873	.047	.108	.983	.766	.275	.522		.692	.266	.164	>.999	>.999	.999	>.999	.501	.946	.563	.682
	FEF (R)	.798	.237	.727	.871	.942	.070	.466	.993	.974	.457	.480	.692		.011	.649	.974	.901	.998	>.999	.336	.809	.119	.705
	IPS (L)	>.999	.998	.978	>.999	.929	.190	.475	.963	.869	>.999	.553	.266	.011		.021	.999	>.999	.963	>.999	.974	>.999	.999	.985
	IPS (R)	.986	.923	.997	>.999	.935	.021	.657	.812	.956	.659	.897	.164	.649	.021		.970	.945	.985	>.999	.534	.989	.545	.999
FPN	LPFC (L)	.999	.405	.892	.995	>.999	.850	.943	>.999	>.999	.993	.981	>.999	.974	.999	.970		.008	.243	.014	.800	.691	.439	.916
	PPC (L)	.991	.988	.905	.989	.868	.739	.799	.966	.883	.994	.910	>.999	.901	>.999	.945	.008		.102	<.001	.442	.956	.966	.591
	LPFC (R)	.997	.699	.422	.410	.987	.762	.808	.999	>.999	.742	.825	.999	.998	.963	.985	.243	.102		.002	.804	.650	.239	.201
	PPC (R)	.557	.775	.999	.969	.938	.562	.910	.662	.895	.774	>.999	>.999	>.999	>.999	>.999	.014	<.001	.002		.842	.754	.466	.862
LN	IFG (L)	.986	.512	.565	.997	.959	.973	.890	.998	.987	>.999	.992	.501	.336	.974	.534	.800	.442	.804	.842		.018	.039	.207
	IFG (R)	.963	.806	.989	>.999	.954	.194	.985	.999	.996	.983	.999	.946	.809	>.999	.989	.691	.956	.650	.754	.018		.005	.273
	pSTG (L)	.636	.994	.397	.996	.045	.344	.095	.345	.088	>.999	.910	.563	.119	.999	.545	.439	.966	.239	.466	.039	.005		<.001
	pSTG (R)	.165	.754	.997	>.999	.268	.013	.937	.169	.172	.480	.999	.682	.705	.985	.999	.916	.591	.201	.862	.207	.273	<.001	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IFG: Inferior frontal gyrus, IPS: Intraparietal sulcus, LN: Language network, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, pSTG: Posterior superior frontal gyrus, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network.

Supplementary Table 35.

Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > healthy control group during syntax generation.

		DMN				SN							DAN				FPN				LN			
	ROI	MPFC	LP (L)	LP (R)	PCC	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)	IFG (L)	IFG (R)	pSTG (L)	pSTG (R)
DMN	MPFC		.831	.888	.831	.004	<.001	.001	<.001	<.001	.023	.007	.037	.202	<.001	.014	.001	.009	.003	.443	.014	.037	.364	.835
	LP (L)	.831		.955	.157	.034	.008	.019	.044	.007	.001	<.001	.129	.763	.002	.077	.595	.012	.301	.225	.488	.194	.006	.246
	LP (R)	.888	.955		.137	.089	.029	<.001	.013	.016	.178	<.001	.158	.273	.022	.003	.108	.095	.578	.001	.435	.011	.603	.003
	PCC	.831	.157	.137		.265	.022	.005	.037	.050	.003	<.001	.234	.129	<.001	<.001	.005	.011	.590	.031	.003	<.001	.004	<.001
SN	ACC	.004	.034	.089	.265		>.999	.998	.071	.015	.675	.869	.127	.058	.071	.065	<.001	.132	.013	.062	.041	.046	.955	.732
	AINS (L)	<.001	.008	.029	.022	>.999		>.999	.963	.999	.838	.989	.953	.930	.810	.979	.150	.261	.238	.438	.027	.806	.656	.987
	AINS (R)	.001	.019	<.001	.005	.998	>.999		.996	.995	.951	.869	.892	.534	.525	.343	.057	.201	.192	.090	.110	.015	.905	.063
	RPFC (L)	<.001	.044	.013	.037	.071	.963	.996		.036	.806	.986	.017	.007	.037	.188	<.001	.034	.001	.338	.002	.001	.655	.831
	RPFC (R)	<.001	.007	.016	.050	.015	.999	.995	.036		.970	.961	.234	.026	.131	.044	<.001	.117	<.001	.105	.013	.004	.912	.828
	SMG (L)	.023	.001	.178	.003	.675	.838	.951	.806	.970		>.999	.725	.543	<.001	.341	.007	.006	.258	.226	<.001	.017	<.001	.520
	SMG (R)	.007	<.001	<.001	<.001	.869	.989	.869	.986	.961	>.999		.478	.520	.447	.103	.019	.090	.175	<.001	.008	.001	.090	.001
DAN	FEF (L)	.037	.129	.158	.234	.127	.953	.892	.017	.234	.725	.478		.308	.734	.836	<.001	<.001	.001	<.001	.499	.054	.437	.318
	FEF (R)	.202	.763	.273	.129	.058	.930	.534	.007	.026	.543	.520	.308		.989	.351	.026	.099	.002	<.001	.664	.191	.881	.295
	IPS (L)	<.001	.002	.022	<.001	.071	.810	.525	.037	.131	<.001	.447	.734	.989		.979	.001	<.001	.037	<.001	.026	<.001	.001	.015
	IPS (R)	.014	.077	.003	<.001	.065	.979	.343	.188	.044	.341	.103	.836	.351	.979		.030	.055	.015	<.001	.466	.011	.455	.001
FPN	LPFC (L)	.001	.595	.108	.005	<.001	.150	.057	<.001	<.001	.007	.019	<.001	.026	.001	.030		.992	.757	.986	.200	.309	.561	.084
	PPC (L)	.009	.012	.095	.011	.132	.261	.201	.034	.117	.006	.090	<.001	.099	<.001	.055	.992		.898	>.999	.558	.044	.034	.409
	LPFC (R)	.003	.301	.578	.590	.013	.238	.192	.001	<.001	.258	.175	.001	.002	.037	.015	.757	.898		.998	.196	.350	.761	.799
	PPC (R)	.443	.225	.001	.031	.062	.438	.090	.338	.105	.226	<.001	<.001	<.001	<.001	<.001	.986	>.999	.998		.158	.246	.534	.138
LN	IFG (L)	.014	.488	.435	.003	.041	.027	.110	.002	.013	<.001	.008	.499	.664	.026	.466	.200	.558	.196	.158		.982	.961	.793
	IFG (R)	.037	.194	.011	<.001	.046	.806	.015	.001	.004	.017	.001	.054	.191	<.001	.011	.309	.044	.350	.246	.982		.995	.727
	pSTG (L)	.364	.006	.603	.004	.955	.656	.905	.655	.912	<.001	.090	.437	.881	.001	.455	.561	.034	.761	.534	.961	.995		>.999
	pSTG (R)	.835	.246	.003	<.001	.732	.987	.063	.831	.828	.520	.001	.318	.295	.015	.001	.084	.409	.799	.138	.793	.727	>.999	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IFG: Inferior frontal gyrus, IPS: Intraparietal sulcus, LN: Language network, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, pSTG: Posterior superior frontal gyrus, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network.

Supplementary Table 36.

Summary of p-values of one-tailed t-tests of the healthy control group > uniform tumor growth pattern group during syntax generation.

		DMN				SN							DAN				FPN				LN			
	ROI	MPFC	LP (L)	LP (R)	PCC	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)	IFG (L)	IFG (R)	pSTG (L)	pSTG (R)
DMN	MPFC		.228	.001	.002	>.999	>.999	>.999	>.999	>.999	.851	.956	.997	.988	.997	.976	>.999	.891	>.999	.557	>.999	.984	.360	.039
	LP (L)	.228		.306	.918	.737	.948	.962	.639	.872	.995	.997	.257	.089	.995	.819	.413	.998	.741	.930	.493	.488	.999	.824
	LP (R)	.001	.306		.829	.623	.983	.978	.785	.584	.963	>.999	.632	.177	.959	>.999	.846	.987	.230	>.999	.878	.452	.832	>.999
	PCC	.002	.918	.829		.126	.855	.917	.169	.209	>.999	>.999	.799	.494	>.999	>.999	.455	>.999	.041	>.999	.978	.721	.998	.998
SN	ACC	>.999	.737	.623	.126		<.001	.012	>.999	>.999	.013	.077	.992	.980	.485	.271	>.999	.873	.999	.402	.998	.999	.001	.007
	AINS (L)	>.999	.948	.983	.855	<.001		.008	.008	<.001	.020	.037	.088	.017	.018	.003	.738	.709	.313	.676	>.999	.941	.006	.004
	AINS (R)	>.999	.962	.978	.917	.012	.008		.020	.007	.002	.089	.067	.285	.132	.072	.991	.976	.860	.425	>.999	>.999	.003	.200
	RPFC (L)	>.999	.639	.785	.169	>.999	.008	.020		>.999	<.001	<.001	>.999	.993	.369	.077	>.999	.621	>.999	.365	>.999	>.999	.013	.004
	RPFC (R)	>.999	.872	.584	.209	>.999	<.001	.007	>.999		<.001	<.001	.979	.876	.102	.044	>.999	.662	.999	.100	>.999	>.999	.008	.003
	SMG (L)	.851	.995	.963	>.999	.013	.020	.002	<.001	<.001		<.001	.454	.282	.999	.405	.866	>.999	.536	.997	>.999	.478	.998	.477
	SMG (R)	.956	.997	>.999	>.999	.077	.037	.089	<.001	<.001	<.001		.491	.267	.445	.777	.923	.965	.487	>.999	>.999	.987	.476	.997
DAN	FEF (L)	.997	.257	.632	.799	.992	.088	.067	>.999	.979	.454	.491		>.999	.692	.592	>.999	.991	.996	>.999	.367	.599	.233	.488
	FEF (R)	.988	.089	.177	.494	.980	.017	.285	.993	.876	.282	.267	>.999		.057	.185	.969	.834	.991	.979	.225	.499	.002	.299
	IPS (L)	.997	.995	.959	>.999	.485	.018	.132	.369	.102	.999	.445	.692	.057		.057	.941	>.999	.803	>.999	.860	.750	.954	.845
	IPS (R)	.976	.819	>.999	>.999	.271	.003	.072	.077	.044	.405	.777	.592	.185	.057		.490	>.999	.468	>.999	.296	.385	.061	.997
FPN	LPFC (L)	>.999	.413	.846	.455	>.999	.738	.991	>.999	>.999	.866	.923	>.999	.969	.941	.490		<.001	.978	.017	.968	.867	.056	.744
	PPC (L)	.891	.998	.987	>.999	.873	.709	.976	.621	.662	>.999	.965	.991	.834	>.999	>.999	<.001		.061	.066	.925	.659	.970	.702
	LPFC (R)	>.999	.741	.230	.041	.999	.313	.860	>.999	.999	.536	.487	.996	.991	.803	.468	.978	.061		<.001	>.999	.962	.073	.195
	PPC (R)	.557	.930	>.999	>.999	.402	.676	.425	.365	.100	.997	>.999	>.999	.979	>.999	>.999	.017	.066	<.001		.990	.440	.589	.992
LN	IFG (L)	>.999	.493	.878	.978	.998	>.999	>.999	>.999	>.999	>.999	>.999	.367	.225	.860	.296	.968	.925	>.999	.990		.702	.003	.569
	IFG (R)	.984	.488	.452	.721	.999	.941	>.999	>.999	>.999	.478	.987	.599	.499	.750	.385	.867	.659	.962	.440	.702		<.001	.004
	pSTG (L)	.360	.999	.832	.998	.001	.006	.003	.013	.008	.998	.476	.233	.002	.954	.061	.056	.970	.073	.589	.003	<.001		.006
	pSTG (R)	.039	.824	>.999	.998	.007	.004	.200	.004	.003	.477	.997	.488	.299	.845	.997	.744	.702	.195	.992	.569	.004	.006	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IFG: Inferior frontal gyrus, IPS: Intraparietal sulcus, LN: Language network, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, pSTG: Posterior superior frontal gyrus, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network.

Supplementary Table 37.

Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern > healthy control group group during syntax generation.

		DMN				SN							DAN				FPN				LN			
	ROI	MPFC	LP (L)	LP (R)	PCC	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)	IFG (L)	IFG (R)	pSTG (L)	pSTG (R)
DMN	MPFC		.772	.999	.998	<.001	<.001	<.001	<.001	<.001	.149	.044	.003	.012	.003	.024	<.001	.109	<.001	.443	<.001	.016	.640	.961
	LP (L)	.772		.694	.082	.263	.052	.038	.361	.128	.005	.003	.743	.911	.005	.181	.587	.002	.259	.070	.507	.512	.001	.176
	LP (R)	.999	.694		.171	.377	.017	.022	.215	.416	.037	<.001	.368	.823	.041	<.001	.154	.013	.770	<.001	.122	.548	.168	<.001
	PCC	.998	.082	.171		.874	.145	.083	.831	.791	<.001	<.001	.201	.506	<.001	<.001	.545	<.001	.959	<.001	.022	.279	.002	.002
SN	ACC	<.001	.263	.377	.874		>.999	.988	<.001	<.001	.987	.923	.008	.020	.515	.729	<.001	.127	.001	.598	.002	.001	.999	.993
	AINS (L)	<.001	.052	.017	.145	>.999		.992	.992	>.999	.980	.963	.912	.983	.982	.997	.262	.291	.687	.324	<.001	.059	.994	.996
	AINS (R)	<.001	.038	.022	.083	.988	.992		.980	.993	.998	.911	.933	.715	.868	.928	<.001	.024	.140	.575	<.001	<.001	.997	.800
	RPFC (L)	<.001	.361	.215	.831	<.001	.992	.980		<.001	>.999	>.999	<.001	.007	.631	.923	<.001	.379	<.001	.635	<.001	<.001	.987	.996
	RPFC (R)	<.001	.128	.416	.791	<.001	>.999	.993	<.001		>.999	>.999	.021	.124	.898	.956	<.001	.338	.001	.900	<.001	<.001	.992	.997
	SMG (L)	.149	.005	.037	<.001	.987	.980	.998	>.999	>.999		>.999	.546	.718	.001	.595	.134	<.001	.464	.003	<.001	.522	.002	.523
	SMG (R)	.044	.003	<.001	<.001	.923	.963	.911	>.999	>.999	>.999		.509	.733	.555	.223	.077	.035	.513	<.001	<.001	.013	.524	.003
DAN	FEF (L)	.003	.743	.368	.201	.008	.912	.933	<.001	.021	.546	.509		<.001	.308	.408	<.001	.009	.004	<.001	.633	.401	.767	.512
	FEF (R)	.012	.911	.823	.506	.020	.983	.715	.007	.124	.718	.733	<.001		.943	.815	.031	.166	.009	.021	.775	.501	.998	.701
	IPS (L)	.003	.005	.041	<.001	.515	.982	.868	.631	.898	.001	.555	.308	.943		.943	.059	<.001	.197	<.001	.140	.250	.046	.155
	IPS (R)	.024	.181	<.001	<.001	.729	.997	.928	.923	.956	.595	.223	.408	.815	.943		.510	<.001	.532	<.001	.704	.615	.939	.003
FPN	LPFC (L)	<.001	.587	.154	.545	<.001	.262	.009	<.001	<.001	.134	.077	<.001	.031	.059	.510		>.999	.022	.983	.032	.133	.944	.256
	PPC (L)	.109	.002	.013	<.001	.127	.291	.024	.379	.338	<.001	.035	.009	.166	<.001	<.001	>.999		.939	.934	.075	.341	.030	.298
	LPFC (R)	<.001	.259	.770	.959	.001	.687	.140	<.001	.001	.464	.513	.004	.009	.197	.532	.022	.939		>.999	<.001	.038	.927	.805
	PPC (R)	.443	.070	<.001	<.001	.598	.324	.575	.635	.900	.003	<.001	<.001	.021	<.001	<.001	.983	.934	>.999		.010	.560	.411	.008
LN	IFG (L)	<.001	.507	.122	.022	.002	<.001	<.001	<.001	<.001	<.001	<.001	.633	.775	.140	.704	.032	.075	<.001	.010		.298	.997	.431
	IFG (R)	.016	.512	.548	.279	.001	.059	<.001	<.001	<.001	.522	.013	.401	.501	.250	.615	.133	.341	.038	.560	.298		>.999	.996
	pSTG (L)	.640	.001	.168	.002	.999	.994	.997	.987	.992	.002	.524	.767	.998	.046	.939	.944	.030	.927	.411	.997	>.999		.994
	pSTG (R)	.961	.176	<.001	.002	.993	.996	.800	.996	.997	.523	.003	.512	.701	.155	.003	.256	.298	.805	.008	.431	.996	.994	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IFG: Inferior frontal gyrus, IPS: Intraparietal sulcus, LN: Language network, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, pSTG: Posterior superior frontal gyrus, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network.

Supplementary Table 38.

Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern > diffuse tumor growth pattern group during syntax generation.

		DMN				SN							DAN				FPN				LN			
	ROI	MPFC	LP (L)	LP (R)	PCC	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)	IFG (L)	IFG (R)	pSTG (L)	pSTG (R)
DMN	MPFC		.418	.901	.949	.182	.676	.252	.274	.390	.770	.759	.085	.141	.690	.604	.063	.872	.155	.498	.071	.326	.732	.759
	LP (L)	.418		.179	.384	.807	.677	.613	.847	.852	.596	.655	.938	.683	.562	.688	.497	.290	.443	.223	.515	.799	.296	.432
	LP (R)	.901	.179		.505	.786	.384	.878	.875	.940	.182	.344	.676	.901	.539	.298	.537	.114	.684	.198	.143	.974	.122	.292
	PCC	.949	.384	.505		.931	.752	.786	.973	.972	.241	.607	.470	.792	.186	.407	.973	.134	.897	.092	.638	.982	.314	.524
SN	ACC	.182	.807	.786	.931		.463	.329	.053	.110	.934	.639	.150	.259	.881	.951	.012	.351	.080	.900	.054	.032	.949	.940
	AINS (L)	.676	.677	.384	.752	.463		.036	.702	.703	.883	.345	.517	.774	.866	.712	.619	.513	.851	.391	.059	.012	.985	.619
	AINS (R)	.252	.613	.878	.786	.329	.036		.303	.444	.921	.720	.742	.697	.822	.947	.149	.094	.424	.866	.007	.009	.929	.968
	RPFC (L)	.274	.847	.875	.973	.053	.702	.303		.039	.991	.897	.127	.426	.935	.963	.051	.871	.314	.721	.260	.295	.944	.946
	RPFC (R)	.390	.852	.940	.972	.110	.703	.444	.039		.952	.963	.136	.667	.966	.995	.034	.700	.556	.984	.128	.209	.852	.949
	SMG (L)	.770	.596	.182	.241	.934	.883	.921	.991	.952		.499	.351	.678	.549	.697	.774	.094	.656	.038	.227	.954	.462	.502
	SMG (R)	.759	.655	.344	.607	.639	.345	.720	.897	.963	.499		.530	.710	.592	.674	.642	.184	.788	.242	.030	.640	.877	.478
DAN	FEF (L)	.085	.938	.676	.470	.150	.517	.742	.127	.136	.351	.530		.001	.130	.164	.576	.605	.667	.266	.643	.851	.784	.653
	FEF (R)	.141	.683	.901	.792	.259	.774	.697	.426	.667	.678	.710	.001		.392	.843	.444	.471	.575	.890	.680	.776	.952	.846
	IPS (L)	.690	.562	.539	.186	.881	.866	.822	.935	.966	.549	.592	.130	.392		.401	.890	.086	.811	.031	.779	.983	.788	.840
	IPS (R)	.604	.688	.298	.407	.951	.712	.947	.963	.995	.697	.674	.164	.843	.401		.933	.051	.974	.053	.720	.973	.926	.591
FPN	LPFC (L)	.063	.497	.537	.973	.012	.619	.149	.051	.034	.774	.642	.576	.444	.890	.933		.925	.025	.647	.227	.265	.886	.673
	PPC (L)	.872	.290	.114	.134	.351	.513	.094	.871	.700	.094	.184	.605	.471	.086	.051	.925		.663	.074	.085	.858	.538	.382
	LPFC (R)	.155	.443	.684	.897	.080	.851	.424	.314	.556	.656	.788	.667	.575	.811	.974	.025	.663		.981	.010	.110	.762	.564
	PPC (R)	.498	.223	.198	.092	.900	.391	.866	.721	.984	.038	.242	.266	.890	.031	.053	.647	.074	.981		.041	.751	.400	.111
LN	IFG (L)	.071	.515	.143	.638	.054	.059	.007	.260	.128	.227	.030	.643	.680	.779	.720	.227	.085	.010	.041		.011	.845	.196
	IFG (R)	.326	.799	.974	.982	.032	.012	.009	.295	.209	.954	.640	.851	.776	.983	.973	.265	.858	.110	.751	.011		.984	.988
	pSTG (L)	.732	.296	.122	.314	.949	.985	.929	.944	.852	.462	.877	.784	.952	.788	.926	.886	.538	.762	.400	.845	.984		.312
	pSTG (R)	.759	.432	.292	.524	.940	.619	.968	.946	.949	.502	.478	.653	.846	.840	.591	.673	.382	.564	.111	.196	.988	.312	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IFG: Inferior frontal gyrus, IPS: Intraparietal sulcus, LN: Language network, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, pSTG: Posterior superior frontal gyrus, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network.

Supplementary Table 39.

Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern > uniform tumor growth pattern group during syntax generation.

		DMN				SN							DAN				FPN				LN			
	ROI	MPFC	LP (L)	LP (R)	PCC	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)	IFG (L)	IFG (R)	pSTG (L)	pSTG (R)
DMN	MPFC		.582	.099	.051	.818	.324	.748	.726	.610	.230	.241	.915	.859	.310	.396	.937	.128	.845	.502	.929	.674	.268	.241
	LP (L)	.582		.821	.616	.193	.323	.387	.153	.148	.404	.345	.062	.317	.438	.312	.503	.710	.557	.777	.485	.201	.704	.568
	LP (R)	.099	.821		.495	.214	.616	.122	.125	.060	.818	.656	.324	.099	.461	.702	.463	.886	.316	.802	.857	.026	.878	.708
	PCC	.051	.616	.495		.069	.248	.214	.027	.028	.759	.393	.530	.208	.814	.593	.027	.866	.103	.908	.362	.018	.686	.476
SN	ACC	.818	.193	.214	.069		.537	.671	.947	.890	.066	.361	.850	.741	.119	.049	.988	.649	.920	.100	.946	.968	.051	.060
	AINS (L)	.324	.323	.616	.248	.537		.964	.298	.297	.117	.655	.483	.226	.134	.288	.381	.487	.149	.609	.941	.988	.015	.381
	AINS (R)	.748	.387	.122	.214	.671	.964		.697	.556	.079	.280	.258	.303	.178	.053	.851	.906	.576	.134	.993	.991	.071	.032
	RPFC (L)	.726	.153	.125	.027	.947	.298	.697		.961	.009	.103	.873	.574	.065	.037	.949	.129	.686	.279	.740	.705	.056	.054
	RPFC (R)	.610	.148	.060	.028	.890	.297	.556	.961		.048	.037	.864	.333	.034	.005	.966	.300	.444	.016	.872	.791	.148	.051
	SMG (L)	.230	.404	.818	.759	.066	.117	.079	.009	.048		.501	.649	.322	.451	.303	.226	.906	.344	.962	.773	.046	.538	.498
	SMG (R)	.241	.345	.656	.393	.361	.655	.280	.103	.037	.501		.470	.290	.408	.326	.358	.816	.212	.758	.970	.360	.123	.522
DAN	FEF (L)	.915	.062	.324	.530	.850	.483	.258	.873	.864	.649	.470		.999	.870	.836	.424	.395	.333	.734	.357	.149	.216	.347
	FEF (R)	.859	.317	.099	.208	.741	.226	.303	.574	.333	.322	.290	.999		.608	.157	.556	.529	.425	.110	.320	.224	.048	.154
	IPS (L)	.310	.438	.461	.814	.119	.134	.178	.065	.034	.451	.408	.870	.608		.599	.110	.914	.189	.969	.221	.017	.212	.160
	IPS (R)	.396	.312	.702	.593	.049	.288	.053	.037	.005	.303	.326	.836	.157	.599		.067	.949	.026	.947	.280	.027	.074	.409
FPN	LPFC (L)	.937	.503	.463	.027	.988	.381	.851	.949	.966	.226	.358	.424	.556	.110	.067		.075	.975	.353	.773	.735	.114	.327
	PPC (L)	.128	.710	.886	.866	.649	.487	.906	.129	.300	.906	.816	.395	.529	.914	.949	.075		.337	.926	.915	.142	.462	.618
	LPFC (R)	.845	.557	.316	.103	.920	.149	.576	.686	.444	.344	.212	.333	.425	.189	.026	.975	.337		.019	.990	.890	.238	.436
	PPC (R)	.502	.777	.802	.908	.100	.609	.134	.279	.016	.962	.758	.734	.110	.969	.947	.353	.926	.019		.959	.249	.600	.889
LN	IFG (L)	.929	.485	.857	.362	.946	.941	.993	.740	.872	.773	.970	.357	.320	.221	.280	.773	.915	.990	.959		.989	.155	.804
	IFG (R)	.674	.201	.026	.018	.968	.988	.991	.705	.791	.046	.360	.149	.224	.017	.027	.735	.142	.890	.249	.989		.016	.012
	pSTG (L)	.268	.704	.878	.686	.051	.015	.071	.056	.148	.538	.123	.216	.048	.212	.074	.114	.462	.238	.600	.155	.016		.688
	pSTG (R)	.241	.568	.708	.476	.060	.381	.032	.054	.051	.498	.522	.347	.154	.160	.409	.327	.618	.436	.889	.804	.012	.688	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IFG: Inferior frontal gyrus, IPS: Intraparietal sulcus, LN: Language network, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, pSTG: Posterior superior frontal gyrus, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SN: Salience network.

Supplementary Table 40.
Summary of p-values of one-tailed t-tests of the healthy control group > diffuse tumor growth pattern group during left hand movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.024	.044	.329	.927	.804	.492	.405	.957	.993	.906	.986	.957	.932	.518	.718	.928	.872	.945	.717	.997	.594
	LP (L)	.024		.420	.878	>.999	.942	.979	.612	.876	.906	.697	.867	.997	.963	.797	.515	.998	.999	.286	.693	.859	.727
	LP (R)	.044	.420		.204	.618	.901	.824	.343	.482	.952	.399	.013	.795	.783	.040	.151	.710	.973	.895	.987	.586	.988
	PCC	.329	.878	.204		.973	.757	.703	.140	.640	.623	.201	.194	.813	.772	.026	.102	.719	.849	.944	.789	.385	.941
SMN	Lat (L)	.927	>.999	.618	.973		.013	.158	.095	.247	.001	.509	.276	.372	.021	.006	.047	.349	.320	.937	.798	.865	.969
	Lat (R)	.804	.942	.901	.757	.013		.252	.269	.295	.701	.096	.567	.063	.498	.001	.060	.019	.814	.956	.782	.844	.991
	Sup	.492	.979	.824	.703	.158	.252		.240	.012	.037	.447	.150	.073	.160	.283	.691	.054	.448	.577	.609	.356	.953
SN	ACC	.405	.612	.343	.140	.095	.269	.240		.001	.013	.916	.930	.011	.216	.009	.143	.107	.897	.981	.326	.858	.773
	AINS (L)	.957	.876	.482	.640	.247	.295	.012	.001		.126	.006	.284	.022	.105	.028	.039	.012	.046	.138	.027	.229	.133
	AINS (R)	.993	.906	.952	.623	.001	.701	.037	.013	.126		.002	.053	.003	.085	.005	.115	.002	.175	.212	.047	.044	.318
	RPFC (L)	.906	.697	.399	.201	.509	.096	.447	.916	.006	.002		.695	.115	.063	.123	.144	.461	.769	.815	.256	.876	.443
	RPFC (R)	.986	.867	.013	.194	.276	.567	.150	.930	.284	.053	.695		.093	.239	.107	.155	.070	.070	.645	.193	.078	.351
	SMG (L)	.957	.997	.795	.813	.372	.063	.073	.011	.022	.003	.115	.093		.017	.030	.018	.039	.090	.563	.666	.330	.611
	SMG (R)	.932	.963	.783	.772	.021	.498	.160	.216	.105	.085	.063	.239	.017		.005	.034	.009	.242	.226	.163	.297	.970
DAN	FEF (L)	.518	.797	.040	.026	.006	.001	.283	.009	.028	.005	.123	.107	.030	.005		.019	.001	.018	.141	.115	.320	.317
	FEF (R)	.718	.515	.151	.102	.047	.060	.691	.143	.039	.115	.144	.155	.018	.034	.019		.019	.080	.749	.140	.397	.181
	IPS (L)	.928	.998	.710	.719	.349	.019	.054	.107	.012	.002	.461	.070	.039	.009	.001	.019		.104	.825	.966	.765	.950
	IPS (R)	.872	.999	.973	.849	.320	.814	.448	.897	.046	.175	.769	.070	.090	.242	.018	.080	.104		.876	.840	.297	.976
FPN	LPFC (L)	.945	.286	.895	.944	.937	.956	.577	.981	.138	.212	.815	.645	.563	.226	.141	.749	.825	.876		.185	.928	.706
	PPC (L)	.717	.693	.987	.789	.798	.782	.609	.326	.027	.047	.256	.193	.666	.163	.115	.140	.966	.840	.185		.746	.808
	LPFC (R)	.997	.859	.586	.385	.865	.844	.356	.858	.229	.044	.876	.078	.330	.297	.320	.397	.765	.297	.928	.746		.212
	PPC (R)	.594	.727	.988	.941	.969	.991	.953	.773	.133	.318	.443	.351	.611	.970	.317	.181	.950	.976	.706	.808	.212	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 41.
Summary of p-values of one-tailed t-tests of the healthy control group > diffuse tumor growth pattern group during right hand movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.040	.006	.294	.729	.887	.445	.458	.969	.998	.723	.769	.868	.923	.643	.472	.923	.715	.708	.834	.823	.485
	LP (L)	.040		.049	.457	.989	.558	.969	.431	.930	.950	.541	.951	.889	.913	.403	.828	.941	.885	.047	.624	.490	.686
	LP (R)	.006	.049		.163	.745	.777	.681	.424	.880	.864	.659	.662	.771	.685	.058	.732	.972	.952	.292	.746	.593	.966
	PCC	.294	.457	.163		.886	.771	.736	.064	.728	.567	.319	.078	.798	.646	.043	.547	.768	.791	.669	.689	.128	.893
SMN	Lat (L)	.729	.989	.745	.886		.002	.009	.004	.001	.002	.236	.061	.261	.017	.001	.137	.647	.039	.912	.923	.560	.332
	Lat (R)	.887	.558	.777	.771	.002		.001	.168	.013	.271	.267	.182	.010	.438	.008	.038	.021	.125	.741	.814	.822	.920
	Sup	.445	.969	.681	.736	.009	.001		.056	.008	<.001	.469	.001	.001	<.001	.161	.734	.038	.106	.966	.777	.798	.791
SN	ACC	.458	.431	.424	.064	.004	.168	.056		.002	.003	.379	.718	.063	.103	.209	.629	.162	.241	.818	.292	.615	.360
	AINS (L)	.969	.930	.880	.728	.001	.013	.008	.002		.131	.000	.055	.133	.024	.009	.145	.083	.025	.242	.085	.276	.027
	AINS (R)	.998	.950	.864	.567	.002	.271	<.001	.003	.131		.002	.001	.027	.009	.022	.043	.004	.011	.821	.084	.501	.077
	RPFC (L)	.723	.541	.659	.319	.236	.267	.469	.379	.000	.002		.481	.033	.060	.280	.394	.281	.694	.718	.049	.694	.155
	RPFC (R)	.769	.951	.662	.078	.061	.182	.001	.718	.055	.001	.481		.097	.015	.419	.259	.245	.244	.876	.350	.830	.190
	SMG (L)	.868	.889	.771	.798	.261	.010	.001	.063	.133	.027	.033	.097		.004	<.001	.028	.002	.006	.432	.780	.844	.954
	SMG (R)	.923	.913	.685	.646	.017	.438	<.001	.103	.024	.009	.060	.015	.004		.035	.094	.017	.096	.801	.378	.945	.702
DAN	FEF (L)	.643	.403	.058	.043	.001	.008	.161	.209	.009	.022	.280	.419	<.001	.035		.198	.001	.012	.464	.271	.801	.664
	FEF (R)	.472	.828	.732	.547	.137	.038	.734	.629	.145	.043	.394	.259	.028	.094	.198		.003	.033	.560	.141	.598	.551
	IPS (L)	.923	.941	.972	.768	.647	.021	.038	.162	.083	.004	.281	.245	.002	.017	.001	.003		.043	.733	.977	.604	.999
	IPS (R)	.715	.885	.952	.791	.039	.125	.106	.241	.025	.011	.694	.244	.006	.096	.012	.033	.043		.517	.707	.433	.986
FPN	LPFC (L)	.708	.047	.292	.669	.912	.741	.966	.818	.242	.821	.718	.876	.432	.801	.464	.560	.733	.517		.019	.556	.710
	PPC (L)	.834	.624	.746	.689	.923	.814	.777	.292	.085	.084	.049	.350	.780	.378	.271	.141	.977	.707	.019		.014	.313
	LPFC (R)	.823	.490	.593	.128	.560	.822	.798	.615	.276	.501	.694	.830	.844	.945	.801	.598	.604	.433	.556	.014		.218
	PPC (R)	.485	.686	.966	.893	.332	.920	.791	.360	.027	.077	.155	.190	.954	.702	.664	.551	.999	.986	.710	.313	.218	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 42.
Summary of p-values of one-tailed t-tests of the healthy control group > diffuse tumor growth pattern group during left foot movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.343	.308	.366	.988	.780	.519	.905	.958	.970	.988	.712	.962	.627	.774	.311	.998	.717	.923	.786	.964	.647
	LP (L)	.343		.369	.877	.966	.776	.754	.529	.811	.677	.867	.503	.972	.855	.497	.302	.922	.582	.570	.673	.575	.738
	LP (R)	.308	.369		.854	.441	.608	.468	.103	.260	.274	.336	.004	.643	.325	.162	.166	.392	.209	.144	.202	.187	.631
	PCC	.366	.877	.854		.197	.460	.142	.027	.189	.236	.215	.038	.610	.783	.026	.156	.292	.346	.318	.370	.214	.960
SMN	Lat (L)	.988	.966	.441	.197		.002	<.001	<.001	.135	.052	.077	.146	.156	.438	.004	.093	.004	.027	.724	.821	.401	.549
	Lat (R)	.780	.776	.608	.460	.002		.002	.001	.028	.065	.017	.486	.021	.622	.008	.113	.018	.682	.463	.618	.245	.777
	Sup	.519	.754	.468	.142	<.001	.002		.063	.009	.052	.018	.178	.010	.139	.543	.783	.038	.247	.547	.585	.427	.454
SN	ACC	.905	.529	.103	.027	<.001	.001	.063		<.001	<.001	.054	.470	.012	.008	.076	.111	.010	.017	.166	.165	.265	.511
	AINS (L)	.958	.811	.260	.189	.135	.028	.009	<.001		.020	.012	.135	.036	.185	.001	.076	.002	.016	.285	.368	.062	.267
	AINS (R)	.970	.677	.274	.236	.052	.065	.052	<.001	.020		.013	.087	.019	.031	.049	.142	.010	.006	.398	.191	.092	.270
	RPFC (L)	.988	.867	.336	.215	.077	.017	.018	.054	.012	.013		.353	.016	.093	.065	.183	<.001	.011	.506	.407	.277	.411
	RPFC (R)	.712	.503	.004	.038	.146	.486	.178	.470	.135	.087	.353		.112	.361	.259	.531	.134	.240	.164	.199	.559	.652
	SMG (L)	.962	.972	.643	.610	.156	.021	.010	.012	.036	.019	.016	.112		.360	.005	.070	.001	.016	.596	.876	.315	.716
	SMG (R)	.627	.855	.325	.783	.438	.622	.139	.008	.185	.031	.093	.361	.360		.158	.079	.262	.038	.147	.215	.100	.573
DAN	FEF (L)	.774	.497	.162	.026	.004	.008	.543	.076	.001	.049	.065	.259	.005	.158		.351	.076	.118	.421	.343	.696	.389
	FEF (R)	.311	.302	.166	.156	.093	.113	.783	.111	.076	.142	.183	.531	.070	.079	.351		.257	.616	.278	.386	.624	.413
	IPS (L)	.998	.922	.392	.292	.004	.018	.038	.010	.002	.010	<.001	.134	.001	.262	.076	.257		.035	.583	.759	.366	.686
	IPS (R)	.717	.582	.209	.346	.027	.682	.247	.017	.016	.006	.011	.240	.016	.038	.118	.616	.035		.048	.055	.012	.489
FPN	LPFC (L)	.923	.570	.144	.318	.724	.463	.547	.166	.285	.398	.506	.164	.596	.147	.421	.278	.583	.048		.051	.450	.134
	PPC (L)	.786	.673	.202	.370	.821	.618	.585	.165	.368	.191	.407	.199	.876	.215	.343	.386	.759	.055	.051		.045	.059
	LPFC (R)	.964	.575	.187	.214	.401	.245	.427	.265	.062	.092	.277	.559	.315	.100	.696	.624	.366	.012	.450	.045		.029
	PPC (R)	.647	.738	.631	.960	.549	.777	.454	.511	.267	.270	.411	.652	.716	.573	.389	.413	.686	.489	.134	.059	.029	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 43.
Summary of p-values of one-tailed t-tests of the healthy control group > diffuse tumor growth pattern group during right foot movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.150	.259	.246	.622	.877	.156	.354	.873	.860	.797	.961	.667	.731	.619	.340	.665	.531	.937	.517	.924	.350
	LP (L)	.150		.370	.933	.569	.847	.238	.147	.620	.758	.446	.723	.838	.622	.299	.175	.847	.758	.652	.542	.760	.399
	LP (R)	.259	.370		.773	.609	.685	.078	.094	.319	.473	.361	.142	.176	.473	.074	.127	.217	.163	.162	.683	.354	.765
	PCC	.246	.933	.773		.443	.546	.144	.006	.698	.461	.183	.263	.395	.287	.087	.055	.553	.633	.773	.816	.269	.679
SMN	Lat (L)	.622	.569	.609	.443		.098	.127	.185	.680	.531	.262	.272	.304	.503	.335	.001	.544	.667	.692	.540	.556	.717
	Lat (R)	.877	.847	.685	.546	.098		.020	.348	.128	.548	.112	.021	.013	.723	.136	.046	.103	.305	.188	.404	.312	.820
	Sup	.156	.238	.078	.144	.127	.020		.378	.326	.163	.580	.445	.058	.038	.621	.829	.263	.702	.294	.531	.268	.362
SN	ACC	.354	.147	.094	.006	.185	.348	.378		.049	.050	.544	.806	.040	.049	.396	.619	.085	.502	.491	.022	.763	.012
	AINS (L)	.873	.620	.319	.698	.680	.128	.326	.049		.576	.058	.085	.460	.635	.044	.209	.076	.134	.002	.054	.046	.100
	AINS (R)	.860	.758	.473	.461	.531	.548	.163	.050	.576		.057	.146	.243	.604	.052	.118	.075	.223	.050	.226	.016	.292
	RPFC (L)	.797	.446	.361	.183	.262	.112	.580	.544	.058	.057		.645	.063	.061	.222	.744	.081	.328	.014	.007	.702	.048
	RPFC (R)	.961	.723	.142	.263	.272	.021	.445	.806	.085	.146	.645		.138	.242	.150	.777	.026	.081	.011	.164	.202	.284
	SMG (L)	.667	.838	.176	.395	.304	.013	.058	.040	.460	.243	.063	.138		.167	.436	.190	.274	.125	.447	.218	.663	.468
	SMG (R)	.731	.622	.473	.287	.503	.723	.038	.049	.635	.604	.061	.242	.167		.075	.242	.063	.067	.165	.424	.271	.999
DAN	FEF (L)	.619	.299	.074	.087	.335	.136	.621	.396	.044	.052	.222	.150	.436	.075		.489	.015	.282	.051	.126	.054	.123
	FEF (R)	.340	.175	.127	.055	.001	.046	.829	.619	.209	.118	.744	.777	.190	.242	.489		.455	.905	.121	.039	.234	.191
	IPS (L)	.665	.847	.217	.553	.544	.103	.263	.085	.076	.075	.081	.026	.274	.063	.015	.455		.360	.123	.593	.037	.651
	IPS (R)	.531	.758	.163	.633	.667	.305	.702	.502	.134	.223	.328	.081	.125	.067	.282	.905	.360		.191	.600	.184	.754
FPN	LPFC (L)	.937	.652	.162	.773	.692	.188	.294	.491	.002	.050	.014	.011	.447	.165	.051	.121	.123	.191		.173	.356	.030
	PPC (L)	.517	.542	.683	.816	.540	.404	.531	.022	.054	.226	.007	.164	.218	.424	.126	.039	.593	.600	.173		.244	.039
	LPFC (R)	.924	.760	.354	.269	.556	.312	.268	.763	.046	.016	.702	.202	.663	.271	.054	.234	.037	.184	.356	.244		.094
	PPC (R)	.350	.399	.765	.679	.717	.820	.362	.012	.100	.292	.048	.284	.468	.999	.123	.191	.651	.754	.030	.039	.094	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 44.
Summary of p-values of one-tailed t-tests of the healthy control group > diffuse tumor growth pattern group during tongue movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.057	.068	.596	.845	.854	.410	.972	.997	.999	.998	.970	.979	.931	.614	.536	.892	.566	.819	.973	.729	.967
	LP (L)	.057		.104	.239	.921	.207	.735	.184	.941	.574	.389	.419	.895	.465	.816	.067	.954	.388	.108	.933	.302	.495
	LP (R)	.068	.104		.384	.180	.429	.537	.217	.474	.643	.367	.258	.404	.788	.203	.614	.413	.607	.675	.919	.123	.800
	PCC	.596	.239	.384		.675	.542	.730	.032	.787	.458	.039	.091	.469	.559	<.001	.116	.628	.690	.865	.870	.071	.896
SMN	Lat (L)	.845	.921	.180	.675		.004	.054	.074	.272	.073	.100	.053	.860	.066	.033	.064	.901	.292	.400	.840	.440	.307
	Lat (R)	.854	.207	.429	.542	.004		.208	.499	.067	.925	.491	.329	.072	.807	.001	.884	.005	.605	.960	.362	.923	.807
	Sup	.410	.735	.537	.730	.054	.208		.496	.024	.211	.447	.301	.130	.337	.332	.957	.170	.427	.976	.992	.612	.743
SN	ACC	.972	.184	.217	.032	.074	.499	.496		.223	.397	.938	.975	.052	.139	.066	.550	.013	.434	.980	.222	.819	.321
	AINS (L)	.997	.941	.474	.787	.272	.067	.024	.223		.040	.021	.078	.010	.007	.006	.077	.003	.013	.265	.530	.299	.024
	AINS (R)	.999	.574	.643	.458	.073	.925	.211	.397	.040		.000	.011	.030	.093	.038	.678	.003	.287	.582	.266	.308	.045
	RPFC (L)	.998	.389	.367	.039	.100	.491	.447	.938	.021	.000		.973	.006	.003	.417	.836	.122	.480	.965	.190	.804	.118
	RPFC (R)	.970	.419	.258	.091	.053	.329	.301	.975	.078	.011	.973		.004	.007	.549	.752	.025	.319	.950	.124	.787	.018
	SMG (L)	.979	.895	.404	.469	.860	.072	.130	.052	.010	.030	.006	.004		.032	.231	.314	.156	.052	.470	.943	.247	.059
	SMG (R)	.931	.465	.788	.559	.066	.807	.337	.139	.007	.093	.003	.007	.032		.017	.715	.040	.598	.839	.488	.308	.303
DAN	FEF (L)	.614	.816	.203	<.001	.033	.001	.332	.066	.006	.038	.417	.549	.231	.017		.170	.026	.060	.789	.511	.356	.306
	FEF (R)	.536	.067	.614	.116	.064	.884	.957	.550	.077	.678	.836	.752	.314	.715	.170		.042	.740	.621	.026	.412	.674
	IPS (L)	.892	.954	.413	.628	.901	.005	.170	.013	.003	.003	.122	.025	.156	.040	.026	.042		.050	.657	.999	.385	.600
	IPS (R)	.566	.388	.607	.690	.292	.605	.427	.434	.013	.287	.480	.319	.052	.598	.060	.740	.050		.818	.829	.469	.975
FPN	LPFC (L)	.819	.108	.675	.865	.400	.960	.976	.980	.265	.582	.965	.950	.470	.839	.789	.621	.657	.818		.009	.689	.667
	PPC (L)	.973	.933	.919	.870	.840	.362	.992	.222	.530	.266	.190	.124	.943	.488	.511	.026	.999	.829	.009		.147	.593
	LPFC (R)	.729	.302	.123	.071	.440	.923	.612	.819	.299	.308	.804	.787	.247	.308	.356	.412	.385	.469	.689	.147		.250
	PPC (R)	.967	.495	.800	.896	.307	.807	.743	.321	.024	.045	.118	.018	.059	.303	.306	.674	.600	.975	.667	.593	.250	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 45.
Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > healthy control group during left hand movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.976	.956	.671	.073	.196	.508	.595	.043	.007	.094	.014	.043	.068	.482	.282	.072	.128	.055	.283	.003	.406
	LP (L)	.976		.580	.122	<.001	.058	.021	.388	.124	.094	.303	.133	.003	.037	.203	.485	.002	.001	.714	.307	.141	.273
	LP (R)	.956	.580		.796	.382	.099	.176	.657	.518	.048	.601	.987	.205	.217	.960	.849	.290	.027	.105	.013	.414	.012
	PCC	.671	.122	.796		.027	.243	.297	.860	.360	.377	.799	.806	.187	.228	.974	.898	.281	.151	.056	.211	.615	.059
SMN	Lat (L)	.073	<.001	.382	.027		.987	.842	.905	.753	.999	.491	.724	.628	.979	.994	.953	.651	.680	.063	.202	.135	.031
	Lat (R)	.196	.058	.099	.243	.987		.748	.731	.705	.299	.904	.433	.937	.502	.999	.940	.981	.186	.044	.218	.156	.009
	Sup	.508	.021	.176	.297	.842	.748		.760	.988	.963	.553	.850	.927	.840	.717	.309	.946	.552	.423	.391	.644	.047
SN	ACC	.595	.388	.657	.860	.905	.731	.760		.999	.987	.084	.070	.989	.784	.991	.857	.893	.103	.019	.674	.142	.227
	AINS (L)	.043	.124	.518	.360	.753	.705	.988	.999		.874	.994	.716	.978	.895	.972	.961	.988	.954	.862	.973	.771	.867
	AINS (R)	.007	.094	.048	.377	.999	.299	.963	.987	.874		.998	.947	.997	.915	.995	.885	.998	.825	.788	.953	.956	.682
	RPFC (L)	.094	.303	.601	.799	.491	.904	.553	.084	.994	.998		.305	.885	.937	.877	.856	.539	.231	.185	.744	.124	.557
	RPFC (R)	.014	.133	.987	.806	.724	.433	.850	.070	.716	.947	.305		.907	.761	.893	.845	.930	.930	.355	.807	.922	.649
	SMG (L)	.043	.003	.205	.187	.628	.937	.927	.989	.978	.997	.885	.907		.983	.970	.982	.961	.910	.437	.334	.670	.389
	SMG (R)	.068	.037	.217	.228	.979	.502	.840	.784	.895	.915	.937	.761	.983		.995	.966	.991	.758	.774	.837	.703	.030
DAN	FEF (L)	.482	.203	.960	.974	.994	.999	.717	.991	.972	.995	.877	.893	.970	.995		.981	.999	.982	.859	.885	.680	.683
	FEF (R)	.282	.485	.849	.898	.953	.940	.309	.857	.961	.885	.856	.845	.982	.966	.981		.981	.920	.251	.860	.603	.819
	IPS (L)	.072	.002	.290	.281	.651	.981	.946	.893	.988	.998	.539	.930	.961	.991	.999	.981		.896	.175	.034	.235	.050
	IPS (R)	.128	.001	.027	.151	.680	.186	.552	.103	.954	.825	.231	.930	.910	.758	.982	.920	.896		.124	.160	.703	.024
FPN	LPFC (L)	.055	.714	.105	.056	.063	.044	.423	.019	.862	.788	.185	.355	.437	.774	.859	.251	.175	.124		.815	.072	.294
	PPC (L)	.283	.307	.013	.211	.202	.218	.391	.674	.973	.953	.744	.807	.334	.837	.885	.860	.034	.160	.815		.254	.192
	LPFC (R)	.003	.141	.414	.615	.135	.156	.644	.142	.771	.956	.124	.922	.670	.703	.680	.603	.235	.703	.072	.254		.788
	PPC (R)	.406	.273	.012	.059	.031	.009	.047	.227	.867	.682	.557	.649	.389	.030	.683	.819	.050	.024	.294	.192	.788	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 46.
Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > healthy control group during right hand movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.960	.994	.706	.271	.113	.555	.542	.031	.002	.277	.231	.132	.077	.357	.528	.077	.285	.292	.166	.177	.515
	LP (L)	.960		.951	.543	.011	.442	.031	.569	.070	.050	.459	.049	.111	.087	.597	.172	.059	.115	.953	.376	.510	.314
	LP (R)	.994	.951		.837	.255	.223	.319	.576	.120	.136	.341	.338	.229	.315	.942	.268	.028	.048	.708	.254	.407	.034
	PCC	.706	.543	.837		.114	.229	.264	.936	.272	.433	.681	.922	.202	.354	.957	.453	.232	.209	.331	.311	.872	.107
SMN	Lat (L)	.271	.011	.255	.114		.998	.991	.996	.999	.998	.764	.939	.739	.983	.999	.863	.353	.961	.088	.077	.440	.668
	Lat (R)	.113	.442	.223	.229	.998		.999	.832	.987	.729	.733	.818	.990	.562	.992	.962	.979	.875	.259	.186	.178	.080
	Sup	.555	.031	.319	.264	.991	.999		.944	.992	>.999	.531	.999	.999	>.999	.839	.266	.962	.894	.034	.223	.202	.209
SN	ACC	.542	.569	.576	.936	.996	.832	.944		.998	.997	.621	.282	.937	.897	.791	.371	.838	.759	.182	.708	.385	.640
	AINS (L)	.031	.070	.120	.272	.999	.987	.992	.998		.869	>.999	.945	.867	.976	.991	.855	.917	.975	.758	.915	.724	.973
	AINS (R)	.002	.050	.136	.433	.998	.729	>.999	.997	.869		.998	.999	.973	.991	.978	.957	.996	.989	.179	.916	.499	.923
	RPFC (L)	.277	.459	.341	.681	.764	.733	.531	.621	>.999	.998		.519	.967	.940	.720	.606	.719	.306	.282	.951	.306	.845
	RPFC (R)	.231	.049	.338	.922	.939	.818	.999	.282	.945	.999	.519		.903	.985	.581	.741	.755	.756	.124	.650	.170	.810
	SMG (L)	.132	.111	.229	.202	.739	.990	.999	.937	.867	.973	.967	.903		.996	>.999	.972	.998	.994	.568	.220	.156	.046
	SMG (R)	.077	.087	.315	.354	.983	.562	>.999	.897	.976	.991	.940	.985	.996		.965	.906	.983	.904	.199	.622	.055	.298
DAN	FEF (L)	.357	.597	.942	.957	.999	.992	.839	.791	.991	.978	.720	.581	>.999	.965		.802	.999	.988	.536	.729	.199	.336
	FEF (R)	.528	.172	.268	.453	.863	.962	.266	.371	.855	.957	.606	.741	.972	.906	.802		.997	.967	.440	.859	.402	.449
	IPS (L)	.077	.059	.028	.232	.353	.979	.962	.838	.917	.996	.719	.755	.998	.983	.999	.997		.957	.267	.023	.396	.001
	IPS (R)	.285	.115	.048	.209	.961	.875	.894	.759	.975	.989	.306	.756	.994	.904	.988	.967	.957		.483	.293	.567	.014
FPN	LPFC (L)	.292	.953	.708	.331	.088	.259	.034	.182	.758	.179	.282	.124	.568	.199	.536	.440	.267	.483		.981	.444	.290
	PPC (L)	.166	.376	.254	.311	.077	.186	.223	.708	.915	.916	.951	.650	.220	.622	.729	.859	.023	.293	.981		.986	.687
	LPFC (R)	.177	.510	.407	.872	.440	.178	.202	.385	.724	.499	.306	.170	.156	.055	.199	.402	.396	.567	.444	.986		.782
	PPC (R)	.515	.314	.034	.107	.668	.080	.209	.640	.973	.923	.845	.810	.046	.298	.336	.449	.001	.014	.290	.687	.782	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 47.
Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > healthy control group during left foot movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.657	.692	.634	.012	.220	.481	.095	.042	.030	.012	.288	.038	.373	.226	.689	.002	.283	.077	.214	.036	.353
	LP (L)	.657		.631	.123	.034	.224	.246	.471	.189	.323	.133	.497	.028	.145	.503	.698	.078	.418	.430	.327	.425	.262
	LP (R)	.692	.631		.146	.559	.392	.532	.897	.740	.726	.664	.996	.357	.675	.838	.834	.608	.791	.856	.798	.813	.369
	PCC	.634	.123	.146		.803	.540	.858	.973	.811	.764	.785	.962	.390	.217	.974	.844	.708	.654	.682	.630	.786	.040
SMN	Lat (L)	.012	.034	.559	.803		.998	>.999	>.999	.865	.948	.923	.854	.844	.562	.996	.907	.996	.973	.276	.179	.599	.451
	Lat (R)	.220	.224	.392	.540	.998		.998	.999	.972	.935	.983	.514	.979	.378	.992	.887	.982	.318	.537	.382	.755	.223
	Sup	.481	.246	.532	.858	>.999	.998		.937	.991	.948	.982	.822	.990	.861	.457	.217	.962	.753	.453	.415	.573	.546
SN	ACC	.095	.471	.897	.973	>.999	.999	.937		>.999	>.999	.946	.530	.988	.992	.924	.889	.990	.983	.834	.835	.735	.489
	AINS (L)	.042	.189	.740	.811	.865	.972	.991	>.999		.980	.988	.865	.964	.815	.999	.924	.998	.984	.715	.632	.938	.733
	AINS (R)	.030	.323	.726	.764	.948	.935	.948	>.999	.980		.987	.913	.981	.969	.951	.858	.990	.994	.602	.809	.908	.730
	RPFC (L)	.012	.133	.664	.785	.923	.983	.982	.946	.988	.987		.647	.984	.907	.935	.817	>.999	.989	.494	.593	.723	.589
	RPFC (R)	.288	.497	.996	.962	.854	.514	.822	.530	.865	.913	.647		.888	.639	.741	.469	.866	.760	.836	.801	.441	.348
	SMG (L)	.038	.028	.357	.390	.844	.979	.990	.988	.964	.981	.984	.888		.640	.995	.930	.999	.984	.404	.124	.685	.284
	SMG (R)	.373	.145	.675	.217	.562	.378	.861	.992	.815	.969	.907	.639	.640		.842	.921	.738	.962	.853	.785	.900	.427
DAN	FEF (L)	.226	.503	.838	.974	.996	.992	.457	.924	.999	.951	.935	.741	.995	.842		.649	.924	.882	.579	.657	.304	.611
	FEF (R)	.689	.698	.834	.844	.907	.887	.217	.889	.924	.858	.817	.469	.930	.921	.649		.743	.384	.722	.614	.376	.587
	IPS (L)	.002	.078	.608	.708	.996	.982	.962	.990	.998	.990	>.999	.866	.999	.738	.924	.743		.965	.417	.241	.634	.314
	IPS (R)	.283	.418	.791	.654	.973	.318	.753	.983	.984	.994	.989	.760	.984	.962	.882	.384	.965		.952	.945	.988	.511
FPN	LPFC (L)	.077	.430	.856	.682	.276	.537	.453	.834	.715	.602	.494	.836	.404	.853	.579	.722	.417	.952		.949	.550	.866
	PPC (L)	.214	.327	.798	.630	.179	.382	.415	.835	.632	.809	.593	.801	.124	.785	.657	.614	.241	.945	.949		.955	.941
	LPFC (R)	.036	.425	.813	.786	.599	.755	.573	.735	.938	.908	.723	.441	.685	.900	.304	.376	.634	.988	.550	.955		.971
	PPC (R)	.353	.262	.369	.040	.451	.223	.546	.489	.733	.730	.589	.348	.284	.427	.611	.587	.314	.511	.866	.941	.971	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 48.
Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > healthy control group during right foot movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.850	.741	.754	.378	.123	.844	.646	.127	.140	.203	.039	.333	.269	.381	.660	.335	.469	.063	.483	.076	.650
	LP (L)	.850		.630	.067	.431	.153	.762	.853	.380	.242	.554	.277	.162	.378	.701	.825	.153	.242	.348	.458	.240	.601
	LP (R)	.741	.630		.227	.391	.315	.922	.906	.681	.527	.639	.858	.824	.527	.926	.873	.783	.837	.838	.317	.646	.235
	PCC	.754	.067	.227		.557	.454	.856	.994	.302	.539	.817	.737	.605	.713	.913	.945	.447	.367	.227	.184	.731	.321
SMN	Lat (L)	.378	.431	.391	.557		.902	.873	.815	.320	.469	.738	.728	.696	.497	.665	.999	.456	.333	.308	.460	.444	.283
	Lat (R)	.123	.153	.315	.454	.902		.980	.652	.872	.452	.888	.979	.987	.277	.864	.954	.897	.695	.812	.596	.688	.180
	Sup	.844	.762	.922	.856	.873	.980		.622	.674	.837	.420	.555	.942	.962	.379	.171	.737	.298	.706	.469	.732	.638
SN	ACC	.646	.853	.906	.994	.815	.652	.622		.951	.950	.456	.194	.960	.951	.604	.381	.915	.498	.509	.978	.237	.988
	AINS (L)	.127	.380	.681	.302	.320	.872	.674	.951		.424	.942	.915	.540	.365	.956	.791	.924	.866	.998	.946	.954	.900
	AINS (R)	.140	.242	.527	.539	.469	.452	.837	.950	.424		.943	.854	.757	.396	.948	.882	.925	.777	.950	.774	.984	.708
	RPFC (L)	.203	.554	.639	.817	.738	.888	.420	.456	.942	.943		.355	.937	.939	.778	.256	.919	.672	.986	.993	.298	.952
	RPFC (R)	.039	.277	.858	.737	.728	.979	.555	.194	.915	.854	.355		.862	.758	.850	.223	.974	.919	.989	.836	.798	.716
	SMG (L)	.333	.162	.824	.605	.696	.987	.942	.960	.540	.757	.937	.862		.833	.564	.810	.726	.875	.553	.782	.337	.532
	SMG (R)	.269	.378	.527	.713	.497	.277	.962	.951	.365	.396	.939	.758	.833		.925	.758	.937	.933	.835	.576	.729	.001
DAN	FEF (L)	.381	.701	.926	.913	.665	.864	.379	.604	.956	.948	.778	.850	.564	.925		.511	.985	.718	.949	.874	.946	.877
	FEF (R)	.660	.825	.873	.945	.999	.954	.171	.381	.791	.882	.256	.223	.810	.758	.511		.545	.095	.879	.961	.766	.809
	IPS (L)	.335	.153	.783	.447	.456	.897	.737	.915	.924	.925	.919	.974	.726	.937	.985	.545		.640	.877	.407	.963	.349
	IPS (R)	.469	.242	.837	.367	.333	.695	.298	.498	.866	.777	.672	.919	.875	.933	.718	.095	.640		.809	.400	.816	.246
FPN	LPFC (L)	.063	.348	.838	.227	.308	.812	.706	.509	.998	.950	.986	.989	.553	.835	.949	.879	.877	.809		.827	.644	.970
	PPC (L)	.483	.458	.317	.184	.460	.596	.469	.978	.946	.774	.993	.836	.782	.576	.874	.961	.407	.400	.827		.756	.961
	LPFC (R)	.076	.240	.646	.731	.444	.688	.732	.237	.954	.984	.298	.798	.337	.729	.946	.766	.963	.816	.644	.756		.906
	PPC (R)	.650	.601	.235	.321	.283	.180	.638	.988	.900	.708	.952	.716	.532	.001	.877	.809	.349	.246	.970	.961	.906	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 49.
Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > healthy control group during tongue movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.943	.932	.404	.155	.146	.590	.028	.003	.001	.002	.030	.021	.069	.386	.464	.108	.434	.181	.027	.271	.033
	LP (L)	.943		.896	.761	.079	.793	.265	.816	.059	.426	.611	.581	.105	.535	.184	.933	.046	.612	.892	.067	.698	.505
	LP (R)	.932	.896		.616	.820	.571	.463	.783	.526	.357	.633	.742	.596	.212	.797	.386	.587	.393	.325	.081	.877	.200
	PCC	.404	.761	.616		.325	.458	.270	.968	.213	.542	.961	.909	.531	.441	>.999	.884	.372	.310	.135	.130	.929	.104
SMN	Lat (L)	.155	.079	.820	.325		.996	.946	.926	.728	.927	.900	.947	.140	.934	.967	.936	.099	.708	.600	.160	.560	.693
	Lat (R)	.146	.793	.571	.458	.996		.792	.501	.933	.075	.509	.671	.928	.193	.999	.116	.995	.395	.040	.638	.077	.193
	Sup	.590	.265	.463	.270	.946	.792		.504	.976	.789	.553	.699	.870	.663	.668	.043	.830	.573	.024	.008	.388	.257
SN	ACC	.028	.816	.783	.968	.926	.501	.504		.777	.603	.062	.025	.948	.861	.934	.450	.987	.566	.020	.778	.181	.679
	AINS (L)	.003	.059	.526	.213	.728	.933	.976	.777		.960	.979	.922	.990	.993	.994	.923	.997	.987	.735	.470	.701	.976
	AINS (R)	.001	.426	.357	.542	.927	.075	.789	.603	.960		1.000	.989	.970	.907	.962	.322	.997	.713	.418	.734	.692	.955
	RPFC (L)	.002	.611	.633	.961	.900	.509	.553	.062	.979	1.000		.027	.994	.997	.583	.164	.878	.520	.035	.810	.196	.882
	RPFC (R)	.030	.581	.742	.909	.947	.671	.699	.025	.922	.989	.027		.996	.993	.451	.248	.975	.681	.050	.876	.213	.982
	SMG (L)	.021	.105	.596	.531	.140	.928	.870	.948	.990	.970	.994	.996		.968	.769	.686	.844	.948	.530	.057	.753	.941
	SMG (R)	.069	.535	.212	.441	.934	.193	.663	.861	.993	.907	.997	.993	.968		.983	.285	.960	.402	.161	.512	.692	.697
DAN	FEF (L)	.386	.184	.797	>.999	.967	.999	.668	.934	.994	.962	.583	.451	.769	.983		.830	.974	.940	.211	.489	.644	.694
	FEF (R)	.464	.933	.386	.884	.936	.116	.043	.450	.923	.322	.164	.248	.686	.285	.830		.958	.260	.379	.974	.588	.326
	IPS (L)	.108	.046	.587	.372	.099	.995	.830	.987	.997	.997	.878	.975	.844	.960	.974	.958		.950	.343	.001	.615	.400
	IPS (R)	.434	.612	.393	.310	.708	.395	.573	.566	.987	.713	.520	.681	.948	.402	.940	.260	.950		.182	.171	.531	.025
FPN	LPFC (L)	.181	.892	.325	.135	.600	.040	.024	.020	.735	.418	.035	.050	.530	.161	.211	.379	.343	.182		.991	.311	.333
	PPC (L)	.027	.067	.081	.130	.160	.638	.008	.778	.470	.734	.810	.876	.057	.512	.489	.974	.001	.171	.991		.853	.407
	LPFC (R)	.271	.698	.877	.929	.560	.077	.388	.181	.701	.692	.196	.213	.753	.692	.644	.588	.615	.531	.311	.853		.750
	PPC (R)	.033	.505	.200	.104	.693	.193	.257	.679	.976	.955	.882	.982	.941	.697	.694	.326	.400	.025	.333	.407	.750	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 50.
Summary of p-values of one-tailed t-tests of the healthy control group > uniform tumor growth pattern group during left hand movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.096	.006	.325	.695	.606	.313	.410	.861	.820	.778	.582	.929	.780	.655	.235	.777	.574	.579	.149	.615	.427
	LP (L)	.096		.227	.316	.917	.570	.007	.523	.651	.672	.393	.634	.597	.477	.491	.312	.740	.350	.638	.447	.752	.544
	LP (R)	.006	.227		.481	.765	.345	.103	.383	.887	.877	.779	.774	.863	.701	.763	.131	.857	.678	.863	.430	.934	.773
	PCC	.325	.316	.481		.984	.539	.108	.759	.769	.514	.384	.437	.551	.487	.550	.286	.764	.544	.902	.930	.899	.901
SMN	Lat (L)	.695	.917	.765	.984		.046	.131	.407	.643	.128	.348	.069	.502	.191	.056	.229	.327	.091	.991	.908	.921	.994
	Lat (R)	.606	.570	.345	.539	.046		.687	.017	.881	.618	.257	.035	.328	.563	.177	.183	.066	.174	.665	.441	.491	.542
	Sup	.313	.007	.103	.108	.131	.687		.297	.647	.961	.553	.153	.524	.811	.334	.775	.118	.423	.685	.647	.537	.838
SN	ACC	.410	.523	.383	.759	.407	.017	.297		.288	.152	.978	.789	.428	.209	.075	.382	.181	.048	.945	.262	.839	.871
	AINS (L)	.861	.651	.887	.769	.643	.881	.647	.288		.410	.233	.561	.165	.025	.354	.737	.088	.103	.010	.186	.404	.134
	AINS (R)	.820	.672	.877	.514	.128	.618	.961	.152	.410		.460	.615	.142	.278	.429	.804	.112	.359	.318	.322	.552	.662
	RPFC (L)	.778	.393	.779	.384	.348	.257	.553	.978	.233	.460		.728	.228	.047	.210	.847	.158	.001	.884	.631	.677	.716
	RPFC (R)	.582	.634	.774	.437	.069	.035	.153	.789	.561	.615	.728		.318	.321	.287	.875	.238	.142	.911	.670	.941	.857
	SMG (L)	.929	.597	.863	.551	.502	.328	.524	.428	.165	.142	.228	.318		.084	.731	.654	.273	.099	.642	.871	.992	.952
	SMG (R)	.780	.477	.701	.487	.191	.563	.811	.209	.025	.278	.047	.321	.084		.197	.568	.092	.212	.120	.353	.270	.529
DAN	FEF (L)	.655	.491	.763	.550	.056	.177	.334	.075	.354	.429	.210	.287	.731	.197		.543	.031	.240	.148	.336	.621	.658
	FEF (R)	.235	.312	.131	.286	.229	.183	.775	.382	.737	.804	.847	.875	.654	.568	.543		.461	.491	.679	.080	.809	.940
	IPS (L)	.777	.740	.857	.764	.327	.066	.118	.181	.088	.112	.158	.238	.273	.092	.031	.461		.029	.896	.894	.823	.895
	IPS (R)	.574	.350	.678	.544	.091	.174	.423	.048	.103	.359	.001	.142	.099	.212	.240	.491	.029		.489	.750	.491	.715
FPN	LPFC (L)	.579	.638	.863	.902	.991	.665	.685	.945	.010	.318	.884	.911	.642	.120	.148	.679	.896	.489		.459	.997	.210
	PPC (L)	.149	.447	.430	.930	.908	.441	.647	.262	.186	.322	.631	.670	.871	.353	.336	.080	.894	.750	.459		.420	.167
	LPFC (R)	.615	.752	.934	.899	.921	.491	.537	.839	.404	.552	.677	.941	.992	.270	.621	.809	.823	.491	.997	.420		.007
	PPC (R)	.427	.544	.773	.901	.994	.542	.838	.871	.134	.662	.716	.857	.952	.529	.658	.940	.895	.715	.210	.167	.007	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 51.
Summary of p-values of one-tailed t-tests of the healthy control group > uniform tumor growth pattern group during right hand movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.040	.935	.892	.981	.952	.862	.653	.856	.727	.791	.577	.770	.540	.962	.993	.990	.958	.034	.236	.693	.332
	LP (L)	.040		.361	.372	.945	.997	.996	.872	.494	.297	.459	.410	.705	.424	.948	.976	.987	.953	.044	.076	.114	.279
	LP (R)	.935	.361		.512	.833	.830	.864	.874	.903	.735	.969	.688	.826	.684	.178	.645	.752	.953	.394	.503	.318	.684
	PCC	.892	.372	.512		.994	.995	.647	.878	.960	.831	.979	.842	.870	.646	.376	.528	.992	.984	.258	.231	.217	.109
SMN	Lat (L)	.981	.945	.833	.994		.004	.236	.811	.862	.353	.960	.479	.899	.220	.113	.142	.171	.326	.786	.614	.929	.844
	Lat (R)	.952	.997	.830	.995	.004		.231	.673	.627	.533	.742	.191	.475	.466	.135	.027	.039	.284	.536	.304	.724	.831
	Sup	.862	.996	.864	.647	.236	.231		.370	.075	.034	.450	.012	.369	.002	.718	.764	.525	.430	.682	.540	.541	.065
SN	ACC	.653	.872	.874	.878	.811	.673	.370		.174	.034	.820	.292	.316	.004	.390	.258	.854	.679	.489	.185	.587	.347
	AINS (L)	.856	.494	.903	.960	.862	.627	.075	.174		.041	.343	.202	.072	.035	.346	.215	.582	.434	.456	.207	.914	.264
	AINS (R)	.727	.297	.735	.831	.353	.533	.034	.034	.041		.308	.105	.192	.149	.544	.336	.379	.354	.260	.016	.534	.063
	RPFC (L)	.791	.459	.969	.979	.960	.742	.450	.820	.343	.308		.718	.045	.173	.701	.369	.923	.707	.809	.237	.761	.535
	RPFC (R)	.577	.410	.688	.842	.479	.191	.012	.292	.202	.105	.718		.342	.258	.248	.284	.599	.400	.653	.260	.753	.153
	SMG (L)	.770	.705	.826	.870	.899	.475	.369	.316	.072	.192	.045	.342		.062	.595	.465	.759	.381	.699	.267	.717	.457
	SMG (R)	.540	.424	.684	.646	.220	.466	.002	.004	.035	.149	.173	.258	.062		.404	.192	.227	.195	.238	.008	.256	.300
DAN	FEF (L)	.962	.948	.178	.376	.113	.135	.718	.390	.346	.544	.701	.248	.595	.404		.187	.271	.362	.644	.403	.470	.294
	FEF (R)	.993	.976	.645	.528	.142	.027	.764	.258	.215	.336	.369	.284	.465	.192	.187		.150	.195	.947	.908	.297	.384
	IPS (L)	.990	.987	.752	.992	.171	.039	.525	.854	.582	.379	.923	.599	.759	.227	.271	.150		.255	.845	.782	.706	.690
	IPS (R)	.958	.953	.953	.984	.326	.284	.430	.679	.434	.354	.707	.400	.381	.195	.362	.195	.255		.784	.099	.793	.579
FPN	LPFC (L)	.034	.044	.394	.258	.786	.536	.682	.489	.456	.260	.809	.653	.699	.238	.644	.947	.845	.784		.514	.921	.654
	PPC (L)	.236	.076	.503	.231	.614	.304	.540	.185	.207	.016	.237	.260	.267	.008	.403	.908	.782	.099	.514		.490	.136
	LPFC (R)	.693	.114	.318	.217	.929	.724	.541	.587	.914	.534	.761	.753	.717	.256	.470	.297	.706	.793	.921	.490		.279
	PPC (R)	.332	.279	.684	.109	.844	.831	.065	.347	.264	.063	.535	.153	.457	.300	.294	.384	.690	.579	.654	.136	.279	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 52.
Summary of p-values of one-tailed t-tests of the healthy control group > uniform tumor growth pattern group during left foot movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.069	.169	.056	.937	.801	.516	.962	.929	.865	.824	.679	.938	.973	.943	.983	.942	.373	.686	.450	.719	.426
	LP (L)	.069		.142	.333	.900	.828	.559	.471	.912	.781	.615	.758	.955	.843	.840	.148	.962	.663	.206	.398	.105	.253
	LP (R)	.169	.142		.154	.884	.651	.307	.072	.712	.657	.303	.590	.749	.779	.833	.021	.958	.559	.070	.069	.256	.373
	PCC	.056	.333	.154		.699	.693	.675	.158	.811	.591	.655	.743	.773	.863	.968	.108	.973	.900	.410	.913	.466	.880
SMN	Lat (L)	.937	.900	.884	.699		.311	.251	.203	.045	.164	.458	.568	.118	.041	.028	.638	.542	.794	.781	.735	.902	.667
	Lat (R)	.801	.828	.651	.693	.311		.675	.192	.121	.276	.338	.442	.066	.581	.260	.581	.187	.843	.794	.698	.845	.631
	Sup	.516	.559	.307	.675	.251	.675		.712	.298	.538	.500	.512	.311	.503	.877	.997	.595	.658	.974	.750	.825	.658
SN	ACC	.962	.471	.072	.158	.203	.192	.712		.189	.107	.836	.650	.262	.005	.958	.778	.550	.153	.678	.207	.534	.197
	AINS (L)	.929	.912	.712	.811	.045	.121	.298	.189		.343	.284	.403	.062	.002	.361	.417	.105	.023	.841	.956	.953	.721
	AINS (R)	.865	.781	.657	.591	.164	.276	.538	.107	.343		.433	.622	.037	.153	.082	.502	.309	.420	.914	.905	.981	.998
	RPFC (L)	.824	.615	.303	.655	.458	.338	.500	.836	.284	.433		.632	.684	.171	.146	.565	.445	.568	.671	.331	.538	.335
	RPFC (R)	.679	.758	.590	.743	.568	.442	.512	.650	.403	.622	.632		.977	.301	.260	.482	.391	.795	.851	.526	.608	.433
	SMG (L)	.938	.955	.749	.773	.118	.066	.311	.262	.062	.037	.684	.977		.043	.587	.619	.294	.201	.911	.942	.996	.572
	SMG (R)	.973	.843	.779	.863	.041	.581	.503	.005	.002	.153	.171	.301	.043		.110	.262	.309	.377	.233	.098	.214	.350
DAN	FEF (L)	.943	.840	.833	.968	.028	.260	.877	.958	.361	.082	.146	.260	.587	.110		.738	.045	.893	.726	.760	.765	.626
	FEF (R)	.983	.148	.021	.108	.638	.581	.997	.778	.417	.502	.565	.482	.619	.262	.738		.815	.974	.760	.196	.486	.461
	IPS (L)	.942	.962	.958	.973	.542	.187	.595	.550	.105	.309	.445	.391	.294	.309	.045	.815		.728	.939	.915	.950	.910
	IPS (R)	.373	.663	.559	.900	.794	.843	.658	.153	.023	.420	.568	.795	.201	.377	.893	.974	.728		.695	.713	.810	.658
FPN	LPFC (L)	.686	.206	.070	.410	.781	.794	.974	.678	.841	.914	.671	.851	.911	.233	.726	.760	.939	.695		.131	.239	.016
	PPC (L)	.450	.398	.069	.913	.735	.698	.750	.207	.956	.905	.331	.526	.942	.098	.760	.196	.915	.713	.131		.019	.040
	LPFC (R)	.719	.105	.256	.466	.902	.845	.825	.534	.953	.981	.538	.608	.996	.214	.765	.486	.950	.810	.239	.019		.191
	PPC (R)	.426	.253	.373	.880	.667	.631	.658	.197	.721	.998	.335	.433	.572	.350	.626	.461	.910	.658	.016	.040	.191	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 53.
Summary of p-values of one-tailed t-tests of the healthy control group > uniform tumor growth pattern group during right foot movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.051	.096	.101	.923	.961	.779	.326	.914	.909	.402	.919	.966	.944	.634	.227	.967	.941	.400	.456	.272	.288
	LP (L)	.051		.106	.494	.864	.893	.664	.296	.951	.927	.242	.990	.976	.912	.721	.398	.952	.967	.434	.435	.253	.321
	LP (R)	.096	.106		.232	.936	.900	.795	.761	.990	.939	.406	.978	.953	.941	.851	.517	.977	.940	.524	.500	.404	.423
	PCC	.101	.494	.232		.788	.794	.625	.205	.955	.932	.335	.950	.946	.885	.727	.276	.986	.915	.601	.650	.183	.441
SMN	Lat (L)	.923	.864	.936	.788		.214	.409	.275	.090	.273	.428	.234	.088	.101	.709	.678	.230	.326	.887	.841	.921	.934
	Lat (R)	.961	.893	.900	.794	.214		.385	.173	.031	.168	.789	.230	.053	.207	.656	.632	.153	.117	.920	.798	.967	.967
	Sup	.779	.664	.795	.625	.409	.385		.458	.107	.289	.593	.300	.142	.092	.928	.727	.332	.959	.831	.756	.931	.950
SN	ACC	.326	.296	.761	.205	.275	.173	.458		.347	.231	.979	.957	.748	.848	.380	.523	.987	.788	.935	.919	.822	.972
	AINS (L)	.914	.951	.990	.955	.090	.031	.107	.347		.334	.506	.226	.380	.179	.113	.274	.197	.082	.606	.436	.806	.666
	AINS (R)	.909	.927	.939	.932	.273	.168	.289	.231	.334		.331	.114	.014	.057	.246	.276	.123	.105	.615	.488	.808	.713
	RPFC (L)	.402	.242	.406	.335	.428	.789	.593	.979	.506	.331		.910	.710	.575	.330	.961	.563	.916	.998	.981	.770	.804
	RPFC (R)	.919	.990	.978	.950	.234	.230	.300	.957	.226	.114	.910		.098	.066	.564	.946	.102	.261	.642	.535	.999	.844
	SMG (L)	.966	.976	.953	.946	.088	.053	.142	.748	.380	.014	.710	.098		.068	.467	.589	.130	.108	.522	.617	.811	.804
	SMG (R)	.944	.912	.941	.885	.101	.207	.092	.848	.179	.057	.575	.066	.068		.233	.633	.038	.018	.484	.472	.967	.868
DAN	FEF (L)	.634	.721	.851	.727	.709	.656	.928	.380	.113	.246	.330	.564	.467	.233		.762	.451	.713	.889	.926	.926	.967
	FEF (R)	.227	.398	.517	.276	.678	.632	.727	.523	.274	.276	.961	.946	.589	.633	.762		.706	.653	.592	.288	.773	.598
	IPS (L)	.967	.952	.977	.986	.230	.153	.332	.987	.197	.123	.563	.102	.130	.038	.451	.706		.413	.644	.690	.933	.901
	IPS (R)	.941	.967	.940	.915	.326	.117	.959	.788	.082	.105	.916	.261	.108	.018	.713	.653	.413		.673	.593	.967	.900
FPN	LPFC (L)	.400	.434	.524	.601	.887	.920	.831	.935	.606	.615	.998	.642	.522	.484	.889	.592	.644	.673		.079	.902	.743
	PPC (L)	.456	.435	.500	.650	.841	.798	.756	.919	.436	.488	.981	.535	.617	.472	.926	.288	.690	.593	.079		.782	.745
	LPFC (R)	.272	.253	.404	.183	.921	.967	.931	.822	.806	.808	.770	.999	.811	.967	.926	.773	.933	.967	.902	.782		.325
	PPC (R)	.288	.321	.423	.441	.934	.967	.950	.972	.666	.713	.804	.844	.804	.868	.967	.598	.901	.900	.743	.745	.325	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 54.
Summary of p-values of one-tailed t-tests of the healthy control group > uniform tumor growth pattern group during tongue movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LP (L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LP (R)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PCC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SMN	Lat (L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Lat (R)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Sup	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SN	ACC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	AINS (L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	AINS (R)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	RPFC (L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	RPFC (R)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	SMG (L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	SMG (R)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAN	FEF (L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	FEF (R)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IPS (L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IPS (R)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FPN	LPFC (L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PPC (L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LPFC (R)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PPC (R)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 55.
Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern group > healthy control group during left hand movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.904	.994	.675	.305	.394	.687	.590	.139	.180	.222	.418	.071	.220	.345	.765	.223	.426	.421	.851	.385	.573
	LP (L)	.904		.773	.684	.083	.430	.993	.477	.349	.328	.607	.366	.403	.523	.509	.688	.260	.650	.362	.553	.248	.456
	LP (R)	.994	.773		.519	.235	.655	.897	.617	.113	.123	.221	.226	.137	.299	.237	.869	.143	.322	.137	.570	.066	.227
	PCC	.675	.684	.519		.016	.461	.892	.241	.231	.486	.616	.563	.449	.513	.450	.714	.236	.456	.098	.070	.101	.099
SMN	Lat (L)	.305	.083	.235	.016		.954	.869	.593	.357	.872	.652	.931	.498	.809	.944	.771	.673	.909	.009	.092	.079	.006
	Lat (R)	.394	.430	.655	.461	.954		.313	.983	.119	.382	.743	.965	.672	.437	.823	.817	.934	.826	.335	.559	.509	.458
	Sup	.687	.993	.897	.892	.869	.313		.703	.353	.039	.447	.847	.476	.189	.666	.225	.882	.577	.315	.353	.463	.162
SN	ACC	.590	.477	.617	.241	.593	.983	.703		.712	.848	.022	.211	.572	.791	.925	.618	.819	.952	.055	.738	.161	.129
	AINS (L)	.139	.349	.113	.231	.357	.119	.353	.712		.590	.767	.439	.835	.975	.646	.263	.912	.897	.990	.814	.596	.866
	AINS (R)	.180	.328	.123	.486	.872	.382	.039	.848	.590		.540	.385	.858	.722	.571	.196	.888	.641	.682	.678	.448	.338
	RPFC (L)	.222	.607	.221	.616	.652	.743	.447	.022	.767	.540		.272	.772	.953	.790	.153	.842	.999	.116	.369	.323	.284
	RPFC (R)	.418	.366	.226	.563	.931	.965	.847	.211	.439	.385	.272		.682	.679	.713	.125	.762	.858	.089	.330	.059	.143
	SMG (L)	.071	.403	.137	.449	.498	.672	.476	.572	.835	.858	.772	.682		.916	.269	.346	.727	.901	.358	.129	.008	.048
	SMG (R)	.220	.523	.299	.513	.809	.437	.189	.791	.975	.722	.953	.679	.916		.803	.432	.908	.788	.880	.647	.730	.471
DAN	FEF (L)	.345	.509	.237	.450	.944	.823	.666	.925	.646	.571	.790	.713	.269	.803		.457	.969	.760	.852	.664	.379	.342
	FEF (R)	.765	.688	.869	.714	.771	.817	.225	.618	.263	.196	.153	.125	.346	.432	.457		.539	.509	.321	.920	.191	.060
	IPS (L)	.223	.260	.143	.236	.673	.934	.882	.819	.912	.888	.842	.762	.727	.908	.969	.539		.971	.104	.106	.177	.105
	IPS (R)	.426	.650	.322	.456	.909	.826	.577	.952	.897	.641	.999	.858	.901	.788	.760	.509	.971		.511	.250	.509	.285
FPN	LPFC (L)	.421	.362	.137	.098	.009	.335	.315	.055	.990	.682	.116	.089	.358	.880	.852	.321	.104	.511		.541	.003	.790
	PPC (L)	.851	.553	.570	.070	.092	.559	.353	.738	.814	.678	.369	.330	.129	.647	.664	.920	.106	.250	.541		.580	.833
	LPFC (R)	.385	.248	.066	.101	.079	.509	.463	.161	.596	.448	.323	.059	.008	.730	.379	.191	.177	.509	.003	.580		.993
	PPC (R)	.573	.456	.227	.099	.006	.458	.162	.129	.866	.338	.284	.143	.048	.471	.342	.060	.105	.285	.790	.833	.993	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 56.
Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern group > healthy control group during right hand movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.960	.065	.108	.019	.048	.138	.347	.144	.273	.209	.423	.230	.460	.038	.007	.010	.042	.966	.764	.307	.668
	LP (L)	.960		.639	.628	.055	.003	.004	.128	.506	.703	.541	.590	.295	.576	.052	.024	.013	.047	.956	.924	.886	.721
	LP (R)	.065	.639		.488	.167	.170	.136	.126	.097	.265	.031	.312	.174	.316	.822	.355	.248	.047	.606	.497	.682	.316
	PCC	.108	.628	.488		.006	.005	.353	.122	.040	.169	.021	.158	.130	.354	.624	.472	.008	.016	.742	.769	.783	.891
SMN	Lat (L)	.019	.055	.167	.006		.996	.764	.189	.138	.647	.040	.521	.101	.780	.887	.858	.829	.674	.214	.386	.071	.156
	Lat (R)	.048	.003	.170	.005	.996		.769	.327	.373	.467	.258	.809	.525	.534	.865	.973	.961	.716	.464	.696	.276	.169
	Sup	.138	.004	.136	.353	.764	.769		.630	.925	.966	.550	.988	.631	.998	.282	.236	.475	.570	.318	.460	.459	.935
SN	ACC	.347	.128	.126	.122	.189	.327	.630		.826	.966	.180	.708	.684	.996	.610	.742	.146	.321	.511	.815	.413	.653
	AINS (L)	.144	.506	.097	.040	.138	.373	.925	.826		.959	.657	.798	.928	.965	.654	.785	.418	.566	.544	.793	.086	.736
	AINS (R)	.273	.703	.265	.169	.647	.467	.966	.966	.959		.692	.895	.808	.851	.456	.664	.621	.646	.740	.984	.466	.937
	RPFC (L)	.209	.541	.031	.021	.040	.258	.550	.180	.657	.692		.282	.955	.827	.299	.631	.077	.293	.191	.763	.239	.465
	RPFC (R)	.423	.590	.312	.158	.521	.809	.988	.708	.798	.895	.282		.658	.742	.752	.716	.401	.600	.347	.740	.247	.847
	SMG (L)	.230	.295	.174	.130	.101	.525	.631	.684	.928	.808	.955	.658		.938	.405	.535	.241	.619	.301	.733	.283	.543
	SMG (R)	.460	.576	.316	.354	.780	.534	.998	.996	.965	.851	.827	.742	.938		.596	.808	.773	.805	.762	.992	.744	.700
DAN	FEF (L)	.038	.052	.822	.624	.887	.865	.282	.610	.654	.456	.299	.752	.405	.596		.813	.729	.638	.356	.597	.530	.706
	FEF (R)	.007	.024	.355	.472	.858	.973	.236	.742	.785	.664	.631	.716	.535	.808	.813		.850	.805	.053	.092	.703	.616
	IPS (L)	.010	.013	.248	.008	.829	.961	.475	.146	.418	.621	.077	.401	.241	.773	.729	.850		.745	.155	.218	.294	.310
	IPS (R)	.042	.047	.047	.016	.674	.716	.570	.321	.566	.646	.293	.600	.619	.805	.638	.805	.745		.216	.901	.207	.421
FPN	LPFC (L)	.966	.956	.606	.742	.214	.464	.318	.511	.544	.740	.191	.347	.301	.762	.356	.053	.155	.216		.486	.079	.346
	PPC (L)	.764	.924	.497	.769	.386	.696	.460	.815	.793	.984	.763	.740	.733	.992	.597	.092	.218	.901	.486		.510	.864
	LPFC (R)	.307	.886	.682	.783	.071	.276	.459	.413	.086	.466	.239	.247	.283	.744	.530	.703	.294	.207	.079	.510		.721
	PPC (R)	.668	.721	.316	.891	.156	.169	.935	.653	.736	.937	.465	.847	.543	.700	.706	.616	.310	.421	.346	.864	.721	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 57.
Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern group > healthy control group during left foot movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.931	.831	.944	.063	.199	.484	.038	.071	.135	.176	.321	.062	.027	.057	.017	.058	.627	.314	.550	.281	.574
	LP (L)	.931		.858	.667	.100	.172	.441	.529	.088	.219	.385	.242	.045	.157	.160	.852	.038	.337	.794	.602	.895	.747
	LP (R)	.831	.858		.846	.116	.349	.693	.928	.288	.343	.697	.410	.251	.221	.167	.979	.042	.441	.930	.931	.744	.627
	PCC	.944	.667	.846		.301	.307	.325	.842	.189	.409	.345	.257	.227	.137	.032	.892	.027	.100	.590	.087	.534	.120
SMN	Lat (L)	.063	.100	.116	.301		.689	.749	.797	.955	.836	.542	.432	.882	.959	.972	.362	.458	.206	.219	.265	.098	.333
	Lat (R)	.199	.172	.349	.307	.689		.325	.808	.879	.724	.662	.558	.934	.419	.740	.419	.813	.157	.206	.302	.155	.369
	Sup	.484	.441	.693	.325	.749	.325		.288	.702	.462	.500	.488	.689	.497	.123	.003	.405	.342	.026	.250	.175	.342
SN	ACC	.038	.529	.928	.842	.797	.808	.288		.811	.893	.164	.350	.738	.995	.042	.222	.450	.847	.322	.793	.466	.803
	AINS (L)	.071	.088	.288	.189	.955	.879	.702	.811		.657	.716	.597	.938	.998	.639	.583	.895	.977	.159	.044	.047	.279
	AINS (R)	.135	.219	.343	.409	.836	.724	.462	.893	.657		.567	.378	.963	.847	.918	.498	.691	.580	.086	.095	.019	.002
	RPFC (L)	.176	.385	.697	.345	.542	.662	.500	.164	.716	.567		.368	.316	.829	.854	.435	.555	.432	.329	.669	.462	.665
	RPFC (R)	.321	.242	.410	.257	.432	.558	.488	.350	.597	.378	.368		.023	.699	.740	.518	.609	.205	.149	.474	.392	.567
	SMG (L)	.062	.045	.251	.227	.882	.934	.689	.738	.938	.963	.316	.023		.957	.413	.381	.706	.799	.089	.058	.004	.428
	SMG (R)	.027	.157	.221	.137	.959	.419	.497	.995	.998	.847	.829	.699	.957		.890	.738	.691	.623	.767	.902	.786	.650
DAN	FEF (L)	.057	.160	.167	.032	.972	.740	.123	.042	.639	.918	.854	.740	.413	.890		.262	.955	.107	.274	.240	.235	.374
	FEF (R)	.017	.852	.979	.892	.362	.419	.003	.222	.583	.498	.435	.518	.381	.738	.262		.185	.026	.240	.804	.514	.539
	IPS (L)	.058	.038	.042	.027	.458	.813	.405	.450	.895	.691	.555	.609	.706	.691	.955	.185		.272	.061	.085	.050	.090
	IPS (R)	.627	.337	.441	.100	.206	.157	.342	.847	.977	.580	.432	.205	.799	.623	.107	.026	.272		.305	.287	.190	.342
FPN	LPFC (L)	.314	.794	.930	.590	.219	.206	.026	.322	.159	.086	.329	.149	.089	.767	.274	.240	.061	.305		.869	.761	.984
	PPC (L)	.550	.602	.931	.087	.265	.302	.250	.793	.044	.095	.669	.474	.058	.902	.240	.804	.085	.287	.869		.981	.960
	LPFC (R)	.281	.895	.744	.534	.098	.155	.175	.466	.047	.019	.462	.392	.004	.786	.235	.514	.050	.190	.761	.981		.809
	PPC (R)	.574	.747	.627	.120	.333	.369	.342	.803	.279	.002	.665	.567	.428	.650	.374	.539	.090	.342	.984	.960	.809	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 58.
Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern group > healthy control group during right foot movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.949	.904	.899	.077	.039	.221	.674	.086	.091	.598	.081	.034	.056	.366	.773	.033	.059	.600	.544	.728	.712
	LP (L)	.949		.894	.506	.136	.107	.336	.704	.049	.073	.758	.010	.024	.088	.279	.602	.048	.033	.566	.565	.747	.679
	LP (R)	.904	.894		.768	.064	.100	.205	.239	.010	.061	.594	.022	.047	.059	.149	.483	.023	.060	.476	.500	.596	.577
	PCC	.899	.506	.768		.212	.206	.375	.795	.045	.068	.665	.050	.054	.115	.273	.724	.014	.085	.399	.350	.817	.559
SMN	Lat (L)	.077	.136	.064	.212		.786	.591	.725	.910	.727	.572	.766	.912	.899	.291	.322	.770	.674	.113	.159	.079	.066
	Lat (R)	.039	.107	.100	.206	.786		.615	.827	.969	.832	.211	.770	.947	.793	.344	.368	.847	.883	.080	.202	.033	.033
	Sup	.221	.336	.205	.375	.591	.615		.542	.893	.711	.407	.700	.858	.908	.072	.273	.668	.041	.169	.244	.069	.050
SN	ACC	.674	.704	.239	.795	.725	.827	.542		.653	.769	.021	.043	.252	.152	.620	.477	.013	.212	.065	.081	.178	.028
	AINS (L)	.086	.049	.010	.045	.910	.969	.893	.653		.666	.494	.774	.620	.821	.887	.726	.803	.918	.394	.564	.194	.334
	AINS (R)	.091	.073	.061	.068	.727	.832	.711	.769	.666		.669	.886	.986	.943	.754	.724	.877	.895	.385	.512	.192	.287
	RPFC (L)	.598	.758	.594	.665	.572	.211	.407	.021	.494	.669		.090	.290	.425	.670	.039	.437	.084	.002	.019	.230	.196
	RPFC (R)	.081	.010	.022	.050	.766	.770	.700	.043	.774	.886	.090		.902	.934	.436	.054	.898	.739	.358	.465	.001	.156
	SMG (L)	.034	.024	.047	.054	.912	.947	.858	.252	.620	.986	.290	.902		.932	.533	.411	.870	.892	.478	.383	.189	.196
	SMG (R)	.056	.088	.059	.115	.899	.793	.908	.152	.821	.943	.425	.934	.932		.767	.367	.962	.982	.516	.528	.033	.132
DAN	FEF (L)	.366	.279	.149	.273	.291	.344	.072	.620	.887	.754	.670	.436	.533	.767		.238	.549	.287	.111	.074	.074	.033
	FEF (R)	.773	.602	.483	.724	.322	.368	.273	.477	.726	.724	.039	.054	.411	.367	.238		.294	.347	.408	.712	.227	.402
	IPS (L)	.033	.048	.023	.014	.770	.847	.668	.013	.803	.877	.437	.898	.870	.962	.549	.294		.587	.356	.310	.067	.099
	IPS (R)	.059	.033	.060	.085	.674	.883	.041	.212	.918	.895	.084	.739	.892	.982	.287	.347	.587		.327	.407	.033	.100
FPN	LPFC (L)	.600	.566	.476	.399	.113	.080	.169	.065	.394	.385	.002	.358	.478	.516	.111	.408	.356	.327		.921	.098	.257
	PPC (L)	.544	.565	.500	.350	.159	.202	.244	.081	.564	.512	.019	.465	.383	.528	.074	.712	.310	.407	.921		.218	.255
	LPFC (R)	.728	.747	.596	.817	.079	.033	.069	.178	.194	.192	.230	.001	.189	.033	.074	.227	.067	.033	.098	.218		.675
	PPC (R)	.712	.679	.577	.559	.066	.033	.050	.028	.334	.287	.196	.156	.196	.132	.033	.402	.099	.100	.257	.255	.675	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 59.
Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern group > healthy control group during tongue movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LP (L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LP (R)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PCC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SMN	Lat (L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Lat (R)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Sup	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SN	ACC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	AINS (L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	AINS (R)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	RPFC (L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	RPFC (R)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	SMG (L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	SMG (R)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DAN	FEF (L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	FEF (R)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IPS (L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IPS (R)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FPN	LPFC (L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PPC (L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LPFC (R)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	PPC (R)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 60.
Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern group > diffuse tumor growth pattern group during left hand movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.321	.281	.826	.621	.758	.359	.259	.657	.695	.812	.832	.293	.733	.160	.638	.681	.843	.826	.768	.377	.540
	LP (L)	.321		.343	.753	.992	.955	.999	.553	.496	.729	.915	.640	.968	.983	.650	.548	.963	.998	.219	.885	.306	.791
	LP (R)	.281	.343		.630	.392	.981	.973	.679	.183	.678	.592	.083	.550	.910	.100	.606	.483	.942	.130	.910	.074	.725
	PCC	.826	.753	.630		.558	.950	.998	.469	.515	.945	.805	.468	.673	.907	.681	.819	.509	.881	.194	.449	.215	.677
SMN	Lat (L)	.621	.992	.392	.558		.614	.847	.028	.333	.075	.466	.441	.857	.767	.670	.662	.481	.703	.366	.435	.029	.291
	Lat (R)	.758	.955	.981	.950	.614		.243	.605	.032	.378	.198	.650	.680	.502	.333	.590	.849	.620	.898	.967	.529	.843
	Sup	.359	.999	.973	.998	.847	.243		.490	.131	.023	.214	.470	.818	.261	.728	.297	.975	.810	.820	.919	.756	.553
SN	ACC	.259	.553	.679	.469	.028	.605	.490		.305	.340	.074	.505	.250	.709	.899	.427	.299	.873	.200	.267	.144	.078
	AINS (L)	.657	.496	.183	.515	.333	.032	.131	.305		.425	.389	.534	.590	.767	.187	.319	.313	.353	.197	.315	.006	.085
	AINS (R)	.695	.729	.678	.945	.075	.378	.023	.340	.425		.090	.178	.309	.460	.116	.342	.200	.175	.241	.431	.075	.092
	RPFC (L)	.812	.915	.592	.805	.466	.198	.214	.074	.389	.090		.297	.519	.237	.960	.479	.621	.567	.702	.585	.584	.030
	RPFC (R)	.832	.640	.083	.468	.441	.650	.470	.505	.534	.178	.297		.252	.498	.845	.592	.190	.386	.110	.046	.058	.013
	SMG (L)	.293	.968	.550	.673	.857	.680	.818	.250	.590	.309	.519	.252		.595	.575	.384	.403	.794	.249	.404	.011	.135
	SMG (R)	.733	.983	.910	.907	.767	.502	.261	.709	.767	.460	.237	.498	.595		.356	.652	.450	.089	.526	.635	.637	.634
DAN	FEF (L)	.160	.650	.100	.681	.670	.333	.728	.899	.187	.116	.960	.845	.575	.356		.453	.866	.650	.873	.477	.297	.077
	FEF (R)	.638	.548	.606	.819	.662	.590	.297	.427	.319	.342	.479	.592	.384	.652	.453		.514	.489	.813	.515	.679	.070
	IPS (L)	.681	.963	.483	.509	.481	.849	.975	.299	.313	.200	.621	.190	.403	.450	.866	.514		.827	.227	.527	.031	.091
	IPS (R)	.843	.998	.942	.881	.703	.620	.810	.873	.353	.175	.567	.386	.794	.089	.650	.489	.827		.558	.852	.361	.434
FPN	LPFC (L)	.826	.219	.130	.194	.366	.898	.820	.200	.197	.241	.702	.110	.249	.526	.873	.813	.227	.558		.405	.129	.226
	PPC (L)	.768	.885	.910	.449	.435	.967	.919	.267	.315	.431	.585	.046	.404	.635	.477	.515	.527	.852	.405		.499	.831
	LPFC (R)	.377	.306	.074	.215	.029	.529	.756	.144	.006	.075	.584	.058	.011	.637	.297	.679	.031	.361	.129	.499		.170
	PPC (R)	.540	.791	.725	.677	.291	.843	.553	.078	.085	.092	.030	.013	.135	.634	.077	.070	.091	.434	.226	.831	.170	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 61.
Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern group > diffuse tumor growth pattern group during right hand movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.542	.046	.288	.425	.556	.147	.320	.360	.591	.394	.442	.477	.671	.151	.004	.322	.134	.738	.662	.247	.344
	LP (L)	.542		.574	.394	.446	.107	.219	.088	.616	.301	.359	.725	.288	.584	.050	.305	.404	.270	.730	.960	.490	.381
	LP (R)	.046	.574		.051	.052	.169	.370	.030	.112	.313	.028	.080	.285	.624	.263	.066	.879	.429	.479	.781	.069	.463
	PCC	.288	.394	.051		.104	.050	.662	.036	.136	.226	.008	.046	.350	.912	.221	.186	.559	.176	.862	.885	.091	.383
SMN	Lat (L)	.425	.446	.052	.104		.367	.600	.027	.299	.189	.050	.256	.225	.772	.309	.594	.397	.036	.511	.741	.058	.168
	Lat (R)	.556	.107	.169	.050	.367		.325	.203	.420	.565	.163	.921	.612	.828	.131	.590	.578	.297	.828	.903	.286	.404
	Sup	.147	.219	.370	.662	.600	.325		.361	.712	.305	.419	.340	.302	.822	.269	.651	.374	.558	.473	.309	.379	.918
SN	ACC	.320	.088	.030	.036	.027	.203	.361		.315	.568	.115	.687	.088	.320	.433	.517	.156	.114	.668	.631	.522	.696
	AINS (L)	.360	.616	.112	.136	.299	.420	.712	.315		.551	.168	.724	.810	.600	.529	.811	.544	.229	.527	.559	.497	.706
	AINS (R)	.591	.301	.313	.226	.189	.565	.305	.568	.551		.132	.548	.345	.384	.204	.811	.175	.165	.571	.217	.622	.645
	RPFC (L)	.394	.359	.028	.008	.050	.163	.419	.115	.168	.132		.420	.050	.150	.418	.572	.040	.099	.873	.745	.767	.868
	RPFC (R)	.442	.725	.080	.046	.256	.921	.340	.687	.724	.548	.420		.539	.252	.763	.584	.555	.492	.500	.619	.724	.661
	SMG (L)	.477	.288	.285	.350	.225	.612	.302	.088	.810	.345	.050	.539		.621	.354	.622	.086	.164	.731	.843	.522	.982
	SMG (R)	.671	.584	.624	.912	.772	.828	.822	.320	.600	.384	.150	.252	.621		.405	.620	.696	.828	.950	.950	.958	.918
DAN	FEF (L)	.151	.050	.263	.221	.309	.131	.269	.433	.529	.204	.418	.763	.354	.405		.443	.418	.114	.506	.400	.368	.389
	FEF (R)	.004	.305	.066	.186	.594	.590	.651	.517	.811	.811	.572	.584	.622	.620	.443		.666	.458	.217	.159	.438	.446
	IPS (L)	.322	.404	.879	.559	.397	.578	.374	.156	.544	.175	.040	.555	.086	.696	.418	.666		.568	.647	.913	.505	.995
	IPS (R)	.134	.270	.429	.176	.036	.297	.558	.114	.229	.165	.099	.492	.164	.828	.114	.458	.568		.358	.767	.186	.900
FPN	LPFC (L)	.738	.730	.479	.862	.511	.828	.473	.668	.527	.571	.873	.500	.731	.950	.506	.217	.647	.358		.180	.109	.273
	PPC (L)	.662	.960	.781	.885	.741	.903	.309	.631	.559	.217	.745	.619	.843	.950	.400	.159	.913	.767	.180		.059	.575
	LPFC (R)	.247	.490	.069	.091	.058	.286	.379	.522	.497	.622	.767	.724	.522	.958	.368	.438	.505	.186	.109	.059		.179
	PPC (R)	.344	.381	.463	.383	.168	.404	.918	.696	.706	.645	.868	.661	.982	.918	.389	.446	.995	.900	.273	.575	.179	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 62.
Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern group > diffuse tumor growth pattern group during left foot movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.473	.412	.587	.477	.087	.202	.264	.621	.609	.558	.499	.793	.650	.325	.153	.800	.399	.617	.423	.054	.214
	LP (L)	.473		.240	.237	.518	.462	.260	.374	.690	.625	.518	.179	.804	.748	.114	.169	.375	.282	.314	.119	.041	.138
	LP (R)	.412	.240		.982	.319	.814	.674	.671	.676	.669	.618	.589	.610	.467	.141	.370	.430	.600	.544	.440	.192	.318
	PCC	.587	.237	.982		.514	.900	.548	.506	.663	.625	.513	.613	.572	.892	.095	.321	.313	.437	.358	.150	.111	.672
SMN	Lat (L)	.477	.518	.319	.514		.059	.064	.079	.881	.742	.563	.286	.711	.765	.290	.275	.517	.150	.584	.760	.138	.341
	Lat (R)	.087	.462	.814	.900	.059		.065	.096	.475	.347	.152	.786	.100	.569	.099	.237	.179	.390	.161	.607	.137	.860
	Sup	.202	.260	.674	.548	.064	.065		.354	.170	.310	.251	.326	.152	.249	.670	.178	.182	.200	.299	.500	.397	.422
SN	ACC	.264	.374	.671	.506	.079	.096	.354		.152	.597	.035	.333	.063	.300	.195	.062	.364	.802	.048	.469	.436	.910
	AINS (L)	.621	.690	.676	.663	.881	.475	.170	.152		.481	.724	.333	.726	.768	.186	.308	.652	.426	.541	.534	.412	.202
	AINS (R)	.609	.625	.669	.625	.742	.347	.310	.597	.481		.793	.423	.692	.698	.695	.408	.558	.280	.823	.834	.740	.783
	RPFC (L)	.558	.518	.618	.513	.563	.152	.251	.035	.724	.793		.111	.323	.503	.545	.241	.144	.365	.492	.871	.523	.690
	RPFC (R)	.499	.179	.589	.613	.286	.786	.326	.333	.333	.423	.111		.001	.675	.422	.517	.200	.687	.045	.006	.480	.838
	SMG (L)	.793	.804	.610	.572	.711	.100	.152	.063	.726	.692	.323	.001		.447	.088	.298	.131	.109	.446	.755	.609	.749
	SMG (R)	.650	.748	.467	.892	.765	.569	.249	.300	.768	.698	.503	.675	.447		.310	.384	.353	.346	.637	.843	.916	.893
DAN	FEF (L)	.325	.114	.141	.095	.290	.099	.670	.195	.186	.695	.545	.422	.088	.310		.302	.658	.236	.244	.334	.620	.211
	FEF (R)	.153	.169	.370	.321	.275	.237	.178	.062	.308	.408	.241	.517	.298	.384	.302		.188	.565	.196	.481	.291	.069
	IPS (L)	.800	.375	.430	.313	.517	.179	.182	.364	.652	.558	.144	.200	.131	.353	.658	.188		.124	.667	.747	.599	.545
	IPS (R)	.399	.282	.600	.437	.150	.390	.200	.802	.426	.280	.365	.687	.109	.346	.236	.565	.124		.057	.172	.127	.818
FPN	LPFC (L)	.617	.314	.544	.358	.584	.161	.299	.048	.541	.823	.492	.045	.446	.637	.244	.196	.667	.057		.293	.345	.308
	PPC (L)	.423	.119	.440	.150	.760	.607	.500	.469	.534	.834	.871	.006	.755	.843	.334	.481	.747	.172	.293		.368	.199
	LPFC (R)	.054	.041	.192	.111	.138	.137	.397	.436	.412	.740	.523	.480	.609	.916	.620	.291	.599	.127	.345	.368		.180
	PPC (R)	.214	.138	.318	.672	.341	.860	.422	.910	.202	.783	.690	.838	.749	.893	.211	.069	.545	.818	.308	.199	.180	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 63.
Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern group > diffuse tumor growth pattern group during right foot movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.198	.357	.237	.184	.675	.352	.869	.289	.375	.906	.944	.568	.831	.150	.772	.246	.493	.286	.180	.601	.307
	LP (L)	.198		.123	.126	.509	.313	.744	.459	.653	.482	.961	.713	.962	.818	.075	.103	.936	.773	.421	.800	.118	.340
	LP (R)	.357	.123		.183	.512	.259	.367	.044	.703	.566	.820	.305	.895	.629	.031	.155	.688	.416	.039	.317	.035	.267
	PCC	.237	.126	.183		.591	.563	.766	.224	.638	.678	.985	.861	.765	.755	.203	.367	.842	.789	.291	.440	.110	.347
SMN	Lat (L)	.184	.509	.512	.591		.128	.160	.336	.676	.172	.388	.364	.592	.636	.250	.042	.316	.298	.255	.393	.014	.243
	Lat (R)	.675	.313	.259	.563	.128		.069	.416	.572	.533	.222	.172	.436	.683	.138	.092	.218	.301	.007	.266	.048	.342
	Sup	.352	.744	.367	.766	.160	.069		.312	.584	.311	.325	.183	.924	.284	.239	.437	.350	.138	.102	.532	.215	.188
SN	ACC	.869	.459	.044	.224	.336	.416	.312		.444	.655	.260	.642	.101	.087	.352	.498	.034	.283	.252	.007	.907	.199
	AINS (L)	.289	.653	.703	.638	.676	.572	.584	.444		.638	.449	.580	.465	.716	.605	.583	.527	.452	.306	.679	.209	.847
	AINS (R)	.375	.482	.566	.678	.172	.533	.311	.655	.638		.697	.617	.793	.899	.461	.543	.562	.439	.130	.925	.518	.913
	RPFC (L)	.906	.961	.820	.985	.388	.222	.325	.260	.449	.697		.241	.338	.301	.438	.436	.054	.191	.355	.884	.891	.559
	RPFC (R)	.944	.713	.305	.861	.364	.172	.183	.642	.580	.617	.241		.506	.479	.518	.287	.162	.139	.015	.326	.975	.563
	SMG (L)	.568	.962	.895	.765	.592	.436	.924	.101	.465	.793	.338	.506		.492	.771	.243	.706	.456	.766	.813	.559	.747
	SMG (R)	.831	.818	.629	.755	.636	.683	.284	.087	.716	.899	.301	.479	.492		.208	.188	.564	.411	.399	.717	.057	.988
DAN	FEF (L)	.150	.075	.031	.203	.250	.138	.239	.352	.605	.461	.438	.518	.771	.208		.229	.167	.355	.088	.063	.135	.069
	FEF (R)	.772	.103	.155	.367	.042	.092	.437	.498	.583	.543	.436	.287	.243	.188	.229		.078	.221	.028	.042	.024	.114
	IPS (L)	.246	.936	.688	.842	.316	.218	.350	.034	.527	.562	.054	.162	.706	.564	.167	.078		.298	.353	.694	.149	.675
	IPS (R)	.493	.773	.416	.789	.298	.301	.138	.283	.452	.439	.191	.139	.456	.411	.355	.221	.298		.125	.418	.278	.450
FPN	LPFC (L)	.286	.421	.039	.291	.255	.007	.102	.252	.306	.130	.355	.015	.766	.399	.088	.028	.353	.125		.230	.031	.009
	PPC (L)	.180	.800	.317	.440	.393	.266	.532	.007	.679	.925	.884	.326	.813	.717	.063	.042	.694	.418	.230		.011	.079
	LPFC (R)	.601	.118	.035	.110	.014	.048	.215	.907	.209	.518	.891	.975	.559	.057	.135	.024	.149	.278	.031	.011		.019
	PPC (R)	.307	.340	.267	.347	.243	.342	.188	.199	.847	.913	.559	.563	.747	.988	.069	.114	.675	.450	.009	.079	.019	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 64.
Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern group > diffuse tumor growth pattern group during tongue movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.441	.462	.582	.666	.830	.326	.731	.794	.867	.748	.920	.930	.799	.638	.642	.926	.720	.429	.018	.093	.135
	LP (L)	.441		.142	.046	.708	.465	.036	.359	.860	.684	.312	.162	.521	.746	.643	.392	.844	.509	.079	.110	.051	.365
	LP (R)	.462	.142		.167	.512	.757	.230	.513	.821	.811	.349	.452	.379	.906	.425	.605	.731	.819	.117	.101	.066	.610
	PCC	.582	.046	.167		.704	.716	.234	.380	.798	.640	.218	.203	.290	.854	.199	.508	.776	.694	.054	.157	.134	.652
SMN	Lat (L)	.666	.708	.512	.704		.090	.293	.057	.212	.038	.126	.115	.899	.177	.269	.818	.799	.371	.608	.851	.715	.620
	Lat (R)	.830	.465	.757	.716	.090		.722	.145	.012	.176	.330	.429	.358	.451	.086	.812	.151	.570	.980	.565	.981	.897
	Sup	.326	.036	.230	.234	.293	.722		.600	.552	.666	.407	.429	.340	.837	.537	.751	.701	.953	.421	.149	.298	.769
SN	ACC	.731	.359	.513	.380	.057	.145	.600		.030	.149	.490	.916	.122	.065	.390	.991	.247	.487	.793	.273	.907	.487
	AINS (L)	.794	.860	.821	.798	.212	.012	.552	.030		.053	.117	.280	.690	.058	.167	.795	.383	.322	.743	.819	.888	.313
	AINS (R)	.867	.684	.811	.640	.038	.176	.666	.149	.053		.095	.201	.314	.041	.002	.927	.046	.203	.969	.671	.998	.811
	RPFC (L)	.748	.312	.349	.218	.126	.330	.407	.490	.117	.095		.675	.288	.141	.352	.986	.419	.474	.894	.466	.881	.614
	RPFC (R)	.920	.162	.452	.203	.115	.429	.429	.916	.280	.201	.675		.160	.400	.393	.988	.127	.263	.837	.248	.909	.776
	SMG (L)	.930	.521	.379	.290	.899	.358	.340	.122	.690	.314	.288	.160		.440	.057	.425	.353	.217	.297	.630	.504	.635
	SMG (R)	.799	.746	.906	.854	.177	.451	.837	.065	.058	.041	.141	.400	.440		.005	.606	.060	.177	.978	.769	.919	.958
DAN	FEF (L)	.638	.643	.425	.199	.269	.086	.537	.390	.167	.002	.352	.393	.057	.005		.606	.049	.103	.439	.370	.334	.218
	FEF (R)	.642	.392	.605	.508	.818	.812	.751	.991	.795	.927	.986	.988	.425	.606	.606		.142	.594	.814	.353	.812	.729
	IPS (L)	.926	.844	.731	.776	.799	.151	.701	.247	.383	.046	.419	.127	.353	.060	.049	.142		.112	.640	.986	.717	.740
	IPS (R)	.720	.509	.819	.694	.371	.570	.953	.487	.322	.203	.474	.263	.217	.177	.103	.594	.112		.775	.676	.750	.983
FPN	LPFC (L)	.429	.079	.117	.054	.608	.980	.421	.793	.743	.969	.894	.837	.297	.978	.439	.814	.640	.775		.028	.208	.321
	PPC (L)	.018	.110	.101	.157	.851	.565	.149	.273	.819	.671	.466	.248	.630	.769	.370	.353	.986	.676	.028		.015	.373
	LPFC (R)	.093	.051	.066	.134	.715	.981	.298	.907	.888	.998	.881	.909	.504	.919	.334	.812	.717	.750	.208	.015		.195
	PPC (R)	.135	.365	.610	.652	.620	.897	.769	.487	.313	.811	.614	.776	.635	.958	.218	.729	.740	.983	.321	.373	.195	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 65.
Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > uniform tumor growth pattern group during left hand movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.679	.719	.174	.379	.242	.641	.741	.343	.305	.188	.168	.707	.267	.840	.362	.319	.157	.174	.232	.623	.460
	LP (L)	.679		.657	.247	.008	.045	.001	.447	.504	.271	.085	.360	.032	.017	.350	.452	.037	.002	.781	.115	.694	.209
	LP (R)	.719	.657		.370	.608	.019	.027	.321	.817	.322	.408	.917	.450	.090	.900	.394	.517	.058	.870	.090	.926	.275
	PCC	.174	.247	.370		.442	.050	.002	.531	.485	.055	.195	.532	.327	.093	.319	.181	.491	.119	.806	.551	.785	.323
SMN	Lat (L)	.379	.008	.608	.442		.386	.153	.972	.667	.925	.534	.559	.143	.233	.330	.338	.519	.297	.634	.565	.971	.709
	Lat (R)	.242	.045	.019	.050	.386		.757	.395	.968	.622	.802	.350	.320	.498	.667	.410	.151	.380	.102	.033	.471	.157
	Sup	.641	.001	.027	.002	.153	.757		.510	.869	.977	.786	.530	.182	.739	.272	.703	.025	.190	.180	.081	.244	.447
SN	ACC	.741	.447	.321	.531	.972	.395	.510		.695	.660	.926	.495	.750	.291	.101	.573	.701	.127	.800	.733	.856	.922
	AINS (L)	.343	.504	.817	.485	.667	.968	.869	.695		.575	.611	.466	.410	.233	.813	.681	.687	.647	.803	.685	.994	.915
	AINS (R)	.305	.271	.322	.055	.925	.622	.977	.660	.575		.910	.822	.691	.540	.884	.658	.800	.825	.759	.569	.925	.908
	RPFC (L)	.188	.085	.408	.195	.534	.802	.786	.926	.611	.910		.703	.481	.763	.040	.521	.379	.433	.298	.415	.416	.970
	RPFC (R)	.168	.360	.917	.532	.559	.350	.530	.495	.466	.822	.703		.748	.502	.155	.408	.810	.614	.890	.954	.942	.987
	SMG (L)	.707	.032	.450	.327	.143	.320	.182	.750	.410	.691	.481	.748		.405	.425	.616	.597	.206	.751	.596	.989	.865
	SMG (R)	.267	.017	.090	.093	.233	.498	.739	.291	.233	.540	.763	.502	.405		.644	.348	.550	.911	.474	.365	.363	.366
DAN	FEF (L)	.840	.350	.900	.319	.330	.667	.272	.101	.813	.884	.040	.155	.425	.644		.547	.134	.350	.127	.523	.703	.923
	FEF (R)	.362	.452	.394	.181	.338	.410	.703	.573	.681	.658	.521	.408	.616	.348	.547		.486	.511	.187	.485	.321	.930
	IPS (L)	.319	.037	.517	.491	.519	.151	.025	.701	.687	.800	.379	.810	.597	.550	.134	.486		.173	.773	.473	.969	.909
	IPS (R)	.157	.002	.058	.119	.297	.380	.190	.127	.647	.825	.433	.614	.206	.911	.350	.511	.173		.442	.148	.639	.566
FPN	LPFC (L)	.174	.781	.870	.806	.634	.102	.180	.800	.803	.759	.298	.890	.751	.474	.127	.187	.773	.442		.595	.871	.774
	PPC (L)	.232	.115	.090	.551	.565	.033	.081	.733	.685	.569	.415	.954	.596	.365	.523	.485	.473	.148	.595		.501	.169
	LPFC (R)	.623	.694	.926	.785	.971	.471	.244	.856	.994	.925	.416	.942	.989	.363	.703	.321	.969	.639	.871	.501		.830
	PPC (R)	.460	.209	.275	.323	.709	.157	.447	.922	.915	.908	.970	.987	.865	.366	.923	.930	.909	.566	.774	.169	.830	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 66.
Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > uniform tumor growth pattern group during right hand movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.458	.954	.712	.575	.444	.853	.680	.640	.409	.606	.558	.523	.329	.849	.996	.678	.866	.262	.338	.753	.656
	LP (L)	.458		.426	.606	.554	.893	.781	.912	.384	.699	.641	.275	.712	.416	.950	.695	.596	.730	.270	.040	.510	.619
	LP (R)	.954	.426		.949	.948	.831	.630	.970	.888	.687	.972	.920	.715	.376	.737	.934	.121	.571	.521	.219	.931	.537
	PCC	.712	.606	.949		.896	.950	.338	.964	.864	.774	.992	.954	.650	.088	.779	.814	.441	.824	.138	.115	.909	.617
SMN	Lat (L)	.575	.554	.948	.896		.633	.400	.973	.701	.811	.950	.744	.775	.228	.691	.406	.603	.964	.489	.259	.942	.832
	Lat (R)	.444	.893	.831	.950	.633		.675	.797	.580	.435	.837	.079	.388	.172	.869	.410	.422	.703	.172	.097	.714	.596
	Sup	.853	.781	.630	.338	.400	.675		.639	.288	.695	.581	.660	.698	.178	.731	.349	.626	.442	.527	.691	.621	.082
SN	ACC	.680	.912	.970	.964	.973	.797	.639		.685	.432	.885	.313	.912	.680	.567	.483	.844	.886	.332	.369	.478	.304
	AINS (L)	.640	.384	.888	.864	.701	.580	.288	.685		.449	.832	.276	.190	.400	.471	.189	.456	.771	.473	.441	.503	.294
	AINS (R)	.409	.699	.687	.774	.811	.435	.695	.432	.449		.868	.452	.655	.616	.796	.189	.825	.835	.429	.783	.378	.355
	RPFC (L)	.606	.641	.972	.992	.950	.837	.581	.885	.832	.868		.580	.950	.850	.582	.428	.960	.901	.127	.255	.233	.132
	RPFC (R)	.558	.275	.920	.954	.744	.079	.660	.313	.276	.452	.580		.461	.748	.237	.416	.445	.508	.500	.381	.276	.339
	SMG (L)	.523	.712	.715	.650	.775	.388	.698	.912	.190	.655	.950	.461		.379	.646	.378	.914	.836	.269	.157	.478	.018
	SMG (R)	.329	.416	.376	.088	.228	.172	.178	.680	.400	.616	.850	.748	.379		.595	.380	.304	.172	.050	.050	.042	.082
DAN	FEF (L)	.849	.950	.737	.779	.691	.869	.731	.567	.471	.796	.582	.237	.646	.595		.557	.582	.886	.494	.600	.632	.611
	FEF (R)	.996	.695	.934	.814	.406	.410	.349	.483	.189	.189	.428	.416	.378	.380	.557		.334	.542	.783	.841	.562	.554
	IPS (L)	.678	.596	.121	.441	.603	.422	.626	.844	.456	.825	.960	.445	.914	.304	.582	.334		.432	.353	.087	.495	.005
	IPS (R)	.866	.730	.571	.824	.964	.703	.442	.886	.771	.835	.901	.508	.836	.172	.886	.542	.432		.642	.233	.814	.100
FPN	LPFC (L)	.262	.270	.521	.138	.489	.172	.527	.332	.473	.429	.127	.500	.269	.050	.494	.783	.353	.642		.820	.891	.727
	PPC (L)	.338	.040	.219	.115	.259	.097	.691	.369	.441	.783	.255	.381	.157	.050	.600	.841	.087	.233	.820		.941	.425
	LPFC (R)	.753	.510	.931	.909	.942	.714	.621	.478	.503	.378	.233	.276	.478	.042	.632	.562	.495	.814	.891	.941		.821
	PPC (R)	.656	.619	.537	.617	.832	.596	.082	.304	.294	.355	.132	.339	.018	.082	.611	.554	.005	.100	.727	.425	.821	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 67.
Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > uniform tumor growth pattern group during left foot movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.527	.588	.413	.523	.913	.798	.736	.379	.391	.442	.501	.207	.350	.675	.847	.200	.601	.383	.577	.946	.786
	LP (L)	.527		.760	.763	.482	.538	.740	.626	.310	.375	.482	.821	.196	.252	.886	.831	.625	.718	.686	.881	.959	.862
	LP (R)	.588	.760		.018	.681	.186	.326	.329	.324	.331	.382	.411	.390	.533	.859	.630	.570	.400	.456	.560	.808	.682
	PCC	.413	.763	.018		.486	.100	.452	.494	.337	.375	.487	.387	.428	.108	.905	.679	.687	.563	.642	.850	.889	.328
SMN	Lat (L)	.523	.482	.681	.486		.941	.936	.921	.119	.258	.437	.714	.289	.235	.710	.725	.483	.850	.416	.240	.862	.659
	Lat (R)	.913	.538	.186	.100	.941		.935	.904	.525	.653	.848	.214	.900	.431	.901	.763	.821	.610	.839	.393	.863	.140
	Sup	.798	.740	.326	.452	.936	.935		.646	.830	.690	.749	.674	.848	.751	.330	.822	.818	.800	.701	.500	.603	.578
SN	ACC	.736	.626	.329	.494	.921	.904	.646		.848	.403	.965	.667	.937	.700	.805	.938	.636	.198	.952	.531	.564	.090
	AINS (L)	.379	.310	.324	.337	.119	.525	.830	.848		.519	.276	.667	.274	.232	.814	.692	.348	.574	.459	.466	.588	.798
	AINS (R)	.391	.375	.331	.375	.258	.653	.690	.403	.519		.207	.577	.308	.302	.305	.592	.442	.720	.177	.166	.260	.217
	RPFC (L)	.442	.482	.382	.487	.437	.848	.749	.965	.276	.207		.889	.677	.497	.455	.759	.856	.635	.508	.129	.477	.310
	RPFC (R)	.501	.821	.411	.387	.714	.214	.674	.667	.667	.577	.889		.999	.325	.578	.483	.800	.313	.955	.994	.520	.162
	SMG (L)	.207	.196	.390	.428	.289	.900	.848	.937	.274	.308	.677	.999		.553	.912	.702	.869	.891	.554	.245	.391	.251
	SMG (R)	.350	.252	.533	.108	.235	.431	.751	.700	.232	.302	.497	.325	.553		.690	.616	.647	.654	.363	.157	.084	.107
DAN	FEF (L)	.675	.886	.859	.905	.710	.901	.330	.805	.814	.305	.455	.578	.912	.690		.698	.342	.764	.756	.666	.380	.789
	FEF (R)	.847	.831	.630	.679	.725	.763	.822	.938	.692	.592	.759	.483	.702	.616	.698		.812	.435	.804	.519	.709	.931
	IPS (L)	.200	.625	.570	.687	.483	.821	.818	.636	.348	.442	.856	.800	.869	.647	.342	.812		.876	.333	.253	.401	.455
	IPS (R)	.601	.718	.400	.563	.850	.610	.800	.198	.574	.720	.635	.313	.891	.654	.764	.435	.876		.943	.828	.873	.182
FPN	LPFC (L)	.383	.686	.456	.642	.416	.839	.701	.952	.459	.177	.508	.955	.554	.363	.756	.804	.333	.943		.707	.655	.692
	PPC (L)	.577	.881	.560	.850	.240	.393	.500	.531	.466	.166	.129	.994	.245	.157	.666	.519	.253	.828	.707		.632	.801
	LPFC (R)	.946	.959	.808	.889	.862	.863	.603	.564	.588	.260	.477	.520	.391	.084	.380	.709	.401	.873	.655	.632		.820
	PPC (R)	.786	.862	.682	.328	.659	.140	.578	.090	.798	.217	.310	.162	.251	.107	.789	.931	.455	.182	.692	.801	.820	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 68.
Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > uniform tumor growth pattern group during right foot movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.802	.643	.763	.816	.325	.648	.131	.711	.625	.094	.056	.432	.169	.850	.228	.754	.507	.714	.820	.399	.693
	LP (L)	.802		.877	.874	.491	.687	.256	.541	.347	.518	.039	.287	.038	.182	.925	.897	.064	.227	.579	.200	.882	.660
	LP (R)	.643	.877		.817	.488	.741	.633	.956	.297	.434	.180	.695	.105	.371	.969	.845	.312	.584	.961	.683	.965	.733
	PCC	.763	.874	.817		.409	.437	.234	.776	.362	.322	.015	.139	.235	.245	.797	.633	.158	.211	.709	.560	.890	.653
SMN	Lat (L)	.816	.491	.488	.409		.872	.840	.664	.324	.828	.612	.636	.408	.364	.750	.958	.684	.702	.745	.607	.986	.757
	Lat (R)	.325	.687	.741	.437	.872		.931	.584	.428	.467	.778	.828	.564	.317	.862	.908	.782	.699	.993	.734	.952	.658
	Sup	.648	.256	.633	.234	.840	.931		.688	.416	.689	.675	.817	.076	.716	.761	.563	.650	.862	.898	.468	.785	.812
SN	ACC	.131	.541	.956	.776	.664	.584	.688		.556	.345	.740	.358	.899	.913	.648	.502	.966	.717	.748	.993	.093	.801
	AINS (L)	.711	.347	.297	.362	.324	.428	.416	.556		.362	.551	.420	.535	.284	.395	.417	.473	.548	.694	.321	.791	.153
	AINS (R)	.625	.518	.434	.322	.828	.467	.689	.345	.362		.303	.383	.207	.101	.539	.457	.438	.561	.870	.075	.482	.087
	RPFC (L)	.094	.039	.180	.015	.612	.778	.675	.740	.551	.303		.759	.662	.699	.562	.564	.946	.809	.645	.116	.109	.441
	RPFC (R)	.056	.287	.695	.139	.636	.828	.817	.358	.420	.383	.759		.494	.521	.482	.713	.838	.861	.985	.674	.025	.437
	SMG (L)	.432	.038	.105	.235	.408	.564	.076	.899	.535	.207	.662	.494		.508	.229	.757	.294	.544	.234	.187	.441	.253
	SMG (R)	.169	.182	.371	.245	.364	.317	.716	.913	.284	.101	.699	.521	.508		.792	.812	.436	.589	.601	.283	.943	.012
DAN	FEF (L)	.850	.925	.969	.797	.750	.862	.761	.648	.395	.539	.562	.482	.229	.792		.771	.833	.645	.912	.937	.865	.931
	FEF (R)	.228	.897	.845	.633	.958	.908	.563	.502	.417	.457	.564	.713	.757	.812	.771		.922	.779	.972	.958	.976	.886
	IPS (L)	.754	.064	.312	.158	.684	.782	.650	.966	.473	.438	.946	.838	.294	.436	.833	.922		.702	.647	.306	.851	.325
	IPS (R)	.507	.227	.584	.211	.702	.699	.862	.717	.548	.561	.809	.861	.544	.589	.645	.779	.702		.875	.582	.722	.550
FPN	LPFC (L)	.714	.579	.961	.709	.745	.993	.898	.748	.694	.870	.645	.985	.234	.601	.912	.972	.647	.875		.770	.969	.991
	PPC (L)	.820	.200	.683	.560	.607	.734	.468	.993	.321	.075	.116	.674	.187	.283	.937	.958	.306	.582	.770		.989	.921
	LPFC (R)	.399	.882	.965	.890	.986	.952	.785	.093	.791	.482	.109	.025	.441	.943	.865	.976	.851	.722	.969	.989		.981
	PPC (R)	.693	.660	.733	.653	.757	.658	.812	.801	.153	.087	.441	.437	.253	.012	.931	.886	.325	.550	.991	.921	.981	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 69.
Summary of p-values of one-tailed t-tests of thediffuse tumor growth pattern group > uniform tumor growth pattern group during tongue movement for left hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.559	.538	.418	.334	.170	.674	.269	.206	.133	.252	.080	.070	.201	.362	.358	.074	.280	.571	.982	.907	.865
	LP (L)	.559		.858	.954	.292	.535	.964	.641	.140	.316	.688	.838	.479	.254	.357	.608	.156	.491	.921	.890	.949	.635
	LP (R)	.538	.858		.833	.488	.243	.770	.487	.179	.189	.651	.548	.621	.094	.575	.395	.269	.181	.883	.899	.934	.390
	PCC	.418	.954	.833		.296	.284	.766	.620	.202	.360	.782	.797	.710	.146	.801	.492	.224	.306	.946	.843	.866	.348
SMN	Lat (L)	.334	.292	.488	.296		.910	.707	.943	.788	.962	.874	.885	.101	.823	.731	.182	.201	.629	.392	.149	.285	.380
	Lat (R)	.170	.535	.243	.284	.910		.278	.855	.988	.824	.670	.571	.642	.549	.914	.188	.849	.430	.020	.435	.019	.103
	Sup	.674	.964	.770	.766	.707	.278		.400	.448	.334	.593	.571	.660	.163	.463	.249	.299	.047	.579	.851	.702	.231
SN	ACC	.269	.641	.487	.620	.943	.855	.400		.970	.851	.510	.084	.878	.935	.610	.009	.753	.513	.207	.727	.093	.513
	AINS (L)	.206	.140	.179	.202	.788	.988	.448	.970		.947	.883	.720	.310	.942	.833	.205	.617	.678	.257	.181	.112	.687
	AINS (R)	.133	.316	.189	.360	.962	.824	.334	.851	.947		.905	.799	.686	.959	.998	.073	.954	.797	.031	.329	.002	.189
	RPFC (L)	.252	.688	.651	.782	.874	.670	.593	.510	.883	.905		.325	.712	.859	.648	.014	.581	.526	.106	.534	.119	.386
	RPFC (R)	.080	.838	.548	.797	.885	.571	.571	.084	.720	.799	.325		.840	.600	.607	.012	.873	.737	.163	.752	.091	.224
	SMG (L)	.070	.479	.621	.710	.101	.642	.660	.878	.310	.686	.712	.840		.560	.943	.575	.647	.783	.703	.370	.496	.365
	SMG (R)	.201	.254	.094	.146	.823	.549	.163	.935	.942	.959	.859	.600	.560		.995	.394	.940	.823	.022	.231	.081	.042
DAN	FEF (L)	.362	.357	.575	.801	.731	.914	.463	.610	.833	.998	.648	.607	.943	.995		.394	.951	.897	.561	.630	.666	.782
	FEF (R)	.358	.608	.395	.492	.182	.188	.249	.009	.205	.073	.014	.012	.575	.394	.394		.858	.406	.186	.647	.188	.271
	IPS (L)	.074	.156	.269	.224	.201	.849	.299	.753	.617	.954	.581	.873	.647	.940	.951	.858		.888	.360	.014	.283	.260
	IPS (R)	.280	.491	.181	.306	.629	.430	.047	.513	.678	.797	.526	.737	.783	.823	.897	.406	.888		.225	.324	.250	.017
FPN	LPFC (L)	.571	.921	.883	.946	.392	.020	.579	.207	.257	.031	.106	.163	.703	.022	.561	.186	.360	.225		.972	.792	.679
	PPC (L)	.982	.890	.899	.843	.149	.435	.851	.727	.181	.329	.534	.752	.370	.231	.630	.647	.014	.324	.972		.985	.627
	LPFC (R)	.907	.949	.934	.866	.285	.019	.702	.093	.112	.002	.119	.091	.496	.081	.666	.188	.283	.250	.792	.985		.805
	PPC (R)	.865	.635	.390	.348	.380	.103	.231	.513	.687	.189	.386	.224	.365	.042	.782	.271	.260	.017	.679	.627	.805	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 70.
Summary of p-values of one-tailed t-tests of the healthy control group > diffuse tumor growth pattern group during left hand movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.125	.119	.642	.263	.565	.299	.095	.917	.949	.064	.601	.885	.847	.743	.988	.908	.880	.965	.644	.981	.116
	LP (L)	.125		.521	.766	.502	.891	.790	.165	.493	.963	.621	.510	.898	.710	.876	.781	.830	.794	.820	.935	.838	.881
	LP (R)	.119	.521		.808	.163	.572	.547	.041	.064	.357	.470	.135	.695	.593	.415	.611	.829	.575	.630	.969	.482	.653
	PCC	.642	.766	.808		.355	.252	.487	.010	.036	.406	.070	.004	.671	.777	.561	.248	.758	.348	.537	.992	.611	.892
SMN	Lat (L)	.263	.502	.163	.355		<.001	.321	.205	.038	.012	.770	.382	.152	.042	.082	.243	.403	.191	.973	.950	.642	.255
	Lat (R)	.565	.891	.572	.252	<.001		.047	.200	.003	.009	.443	.368	.064	.284	.386	.064	.006	.469	.963	.954	.837	.908
	Sup	.299	.790	.547	.487	.321	.047		.483	.185	.267	.224	.055	.137	.284	.645	.139	.619	.915	.913	.934	.716	.993
SN	ACC	.095	.165	.041	.010	.205	.200	.483		<.001	<.001	.673	.433	.430	.463	.175	.135	.625	.447	.785	.186	.533	.010
	AINS (L)	.917	.493	.064	.036	.038	.003	.185	<.001		.013	.063	.002	.002	.004	.039	.073	.073	.020	.210	.191	.151	.002
	AINS (R)	.949	.963	.357	.406	.012	.009	.267	<.001	.013		.015	.002	.013	.011	.171	.149	.018	.026	.231	.584	.352	.487
	RPFC (L)	.064	.621	.470	.070	.770	.443	.224	.673	.063	.015		.218	.242	.404	.066	.051	.661	.293	.930	.967	.889	.535
	RPFC (R)	.601	.510	.135	.004	.382	.368	.055	.433	.002	.002	.218		.188	.183	.027	.024	.024	.023	.864	.733	.801	.204
	SMG (L)	.885	.898	.695	.671	.152	.064	.137	.430	.002	.013	.242	.188		.031	.043	.003	.035	.005	.765	.999	.881	.878
	SMG (R)	.847	.710	.593	.777	.042	.284	.284	.463	.004	.011	.404	.183	.031		.363	.058	.107	.096	.459	.901	.281	.973
DAN	FEF (L)	.743	.876	.415	.561	.082	.386	.645	.175	.039	.171	.066	.027	.043	.363		.031	.009	.176	.906	.988	.510	.860
	FEF (R)	.988	.781	.611	.248	.243	.064	.139	.135	.073	.149	.051	.024	.003	.058	.031		.003	.009	.307	.123	.211	.631
	IPS (L)	.908	.830	.829	.758	.403	.006	.619	.625	.073	.018	.661	.024	.035	.107	.009	.003		.002	.584	.998	.434	.890
	IPS (R)	.880	.794	.575	.348	.191	.469	.915	.447	.020	.026	.293	.023	.005	.096	.176	.009	.002		.251	.928	.056	.946
FPN	LPFC (L)	.965	.820	.630	.537	.973	.963	.913	.785	.210	.231	.930	.864	.765	.459	.906	.307	.584	.251		.297	.525	.669
	PPC (L)	.644	.935	.969	.992	.950	.954	.934	.186	.191	.584	.967	.733	.999	.901	.988	.123	.998	.928	.297		.365	.699
	LPFC (R)	.981	.838	.482	.611	.642	.837	.716	.533	.151	.352	.889	.801	.881	.281	.510	.211	.434	.056	.525	.365		.006
	PPC (R)	.116	.881	.653	.892	.255	.908	.993	.010	.002	.487	.535	.204	.878	.973	.860	.631	.890	.946	.669	.699	.006	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 71.
Summary of p-values of one-tailed t-tests of the healthy control group > diffuse tumor growth pattern group during right hand movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.093	.009	.224	.995	.998	.908	.893	>.999	>.999	.998	.998	.996	.999	.924	.956	>.999	>.999	.899	.095	.964	.086
	LP (L)	.093		.009	.472	.686	.842	.591	.502	.694	.972	.730	.926	.971	.907	.866	.384	.913	.921	.605	.191	.873	.112
	LP (R)	.009	.009		.454	.526	.792	.423	.260	.721	.984	.935	.809	.925	.848	.760	.517	.710	.734	.807	.189	.813	.214
	PCC	.224	.472	.454		.990	.999	.574	.981	.986	>.999	.924	.925	.999	.993	.880	.754	.992	.935	.810	.881	.969	.653
SMN	Lat (L)	.995	.686	.526	.990		<.001	.886	.614	.144	.002	.758	.461	.003	<.001	.138	.358	.353	.061	.324	.652	.932	.797
	Lat (R)	.998	.842	.792	.999	<.001		.486	.393	.012	.001	.717	.415	<.001	<.001	.081	.294	.003	.012	.449	.544	.673	.785
	Sup	.908	.591	.423	.574	.886	.486		.833	.403	.184	.096	.095	.112	.020	.211	.088	.597	.553	.863	.990	.974	.985
SN	ACC	.893	.502	.260	.981	.614	.393	.833		.111	.008	.980	.850	.195	.049	.093	.155	.530	.183	.899	.812	.980	.548
	AINS (L)	>.999	.694	.721	.986	.144	.012	.403	.111		.030	.015	.141	<.001	.008	.004	.050	.007	<.001	.109	.464	.745	.532
	AINS (R)	>.999	.972	.984	>.999	.002	.001	.184	.008	.030		.135	.045	<.001	<.001	.010	.092	<.001	<.001	.299	.353	.553	.253
	RPFC (L)	.998	.730	.935	.924	.758	.717	.096	.980	.015	.135		.811	.075	.005	.010	.002	.046	.001	.793	.810	.983	.476
	RPFC (R)	.998	.926	.809	.925	.461	.415	.095	.850	.141	.045	.811		.056	.045	.017	.020	.010	.001	.222	.549	.504	.365
	SMG (L)	.996	.971	.925	.999	.003	<.001	.112	.195	<.001	<.001	.075	.056		<.001	.001	.053	<.001	<.001	.544	.869	.760	.925
	SMG (R)	.999	.907	.848	.993	<.001	<.001	.020	.049	.008	<.001	.005	.045	<.001		.001	.003	<.001	<.001	.592	.763	.758	.992
DAN	FEF (L)	.924	.866	.760	.880	.138	.081	.211	.093	.004	.010	.010	.017	.001	.001		.006	.001	.002	.203	.830	.518	.949
	FEF (R)	.956	.384	.517	.754	.358	.294	.088	.155	.050	.092	.002	.020	.053	.003	.006		.006	.034	.208	.294	.765	.899
	IPS (L)	>.999	.913	.710	.992	.353	.003	.597	.530	.007	<.001	.046	.010	<.001	<.001	.001	.006		.005	.300	.994	.906	.992
	IPS (R)	>.999	.921	.734	.935	.061	.012	.553	.183	<.001	<.001	.001	.001	<.001	<.001	.002	.034	.005		.278	.935	.213	.997
FPN	LPFC (L)	.899	.605	.807	.810	.324	.449	.863	.899	.109	.299	.793	.222	.544	.592	.203	.208	.300	.278		.063	.352	.239
	PPC (L)	.095	.191	.189	.881	.652	.544	.990	.812	.464	.353	.810	.549	.869	.763	.830	.294	.994	.935	.063		.535	.101
	LPFC (R)	.964	.873	.813	.969	.932	.673	.974	.980	.745	.553	.983	.504	.760	.758	.518	.765	.906	.213	.352	.535		.003
	PPC (R)	.086	.112	.214	.653	.797	.785	.985	.548	.532	.253	.476	.365	.925	.992	.949	.899	.992	.997	.239	.101	.003	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 72.
Summary of p-values of one-tailed t-tests of the healthy control group > diffuse tumor growth pattern group during left foot movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.708	.191	.900	.480	.586	.315	.436	.141	.280	.852	.920	.461	.519	.611	.929	.615	.862	.417	.136	.527	.440
	LP (L)	.708		.740	.986	.457	.312	.546	.081	.082	.085	.125	.288	.395	.545	.601	.772	.606	.757	.051	.068	.198	.260
	LP (R)	.191	.740		.663	.058	.639	.702	.578	.254	.302	.587	.676	.571	.563	.846	.997	.904	.765	.158	.219	.363	.449
	PCC	.900	.986	.663		.027	.073	.041	.127	.312	.255	.040	.366	.213	.546	.259	.617	.089	.468	.556	.556	.516	.911
SMN	Lat (L)	.480	.457	.058	.027		.010	.425	.082	.716	.240	.242	.291	.233	.006	.251	.187	.380	.302	.799	.646	.320	.039
	Lat (R)	.586	.312	.639	.073	.010		.223	.070	.243	.244	.179	.614	.048	.316	.167	.198	.118	.877	.168	.048	.507	.073
	Sup	.315	.546	.702	.041	.425	.223		.244	.611	.099	.086	.004	.053	.031	.260	.029	.631	.374	.521	.791	.363	.593
SN	ACC	.436	.081	.578	.127	.082	.070	.244		.032	.100	.777	.963	.145	.079	.248	.494	.014	.082	.413	.164	.577	.177
	AINS (L)	.141	.082	.254	.312	.716	.243	.611	.032		.456	.066	.435	.226	.008	.128	.037	.116	.095	.116	.104	.173	.010
	AINS (R)	.280	.085	.302	.255	.240	.244	.099	.100	.456		.010	.184	.470	.079	.011	.131	.097	.051	.116	.415	.134	.064
	RPFC (L)	.852	.125	.587	.040	.242	.179	.086	.777	.066	.010		.859	.142	.121	.007	.085	.022	.019	.360	.159	.633	.113
	RPFC (R)	.920	.288	.676	.366	.291	.614	.004	.963	.435	.184	.859		.136	.211	.001	.054	.013	.093	.482	.168	.904	.257
	SMG (L)	.461	.395	.571	.213	.233	.048	.053	.145	.226	.470	.142	.136		.112	.030	.028	.074	.017	.761	.957	.495	.042
	SMG (R)	.519	.545	.563	.546	.006	.316	.031	.079	.008	.079	.121	.211	.112		.002	.064	.059	.041	.594	.538	.490	.134
DAN	FEF (L)	.611	.601	.846	.259	.251	.167	.260	.248	.128	.011	.007	.001	.030	.002		.002	.019	.003	.730	.972	.232	.414
	FEF (R)	.929	.772	.997	.617	.187	.198	.029	.494	.037	.131	.085	.054	.028	.064	.002		<.001	<.001	.092	.244	.278	.376
	IPS (L)	.615	.606	.904	.089	.380	.118	.631	.014	.116	.097	.022	.013	.074	.059	.019	<.001		.009	.833	.960	.241	.454
	IPS (R)	.862	.757	.765	.468	.302	.877	.374	.082	.095	.051	.019	.093	.017	.041	.003	<.001	.009		.506	.430	.076	.367
FPN	LPFC (L)	.417	.051	.158	.556	.799	.168	.521	.413	.116	.116	.360	.482	.761	.594	.730	.092	.833	.506		.078	.457	.279
	PPC (L)	.136	.068	.219	.556	.646	.048	.791	.164	.104	.415	.159	.168	.957	.538	.972	.244	.960	.430	.078		.113	.076
	LPFC (R)	.527	.198	.363	.516	.320	.507	.363	.577	.173	.134	.633	.904	.495	.490	.232	.278	.241	.076	.457	.113		.154
	PPC (R)	.440	.260	.449	.911	.039	.073	.593	.177	.010	.064	.113	.257	.042	.134	.414	.376	.454	.367	.279	.076	.154	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 73.
Summary of p-values of one-tailed t-tests of the healthy control group > diffuse tumor growth pattern group during right foot movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.185	.018	.001	.770	.608	.142	.487	.869	.886	.076	.917	.659	.563	.626	.584	.212	.508	.569	.105	.845	.232
	LP (L)	.185		.086	.343	.185	.092	.159	.175	.173	.720	.011	.358	.316	.272	.134	.614	.025	.069	.184	.284	.505	.413
	LP (R)	.018	.086		.060	.021	.018	.019	.019	.053	.403	.032	.235	.030	.211	.032	.170	.006	.126	.177	.428	.665	.761
	PCC	.001	.343	.060		.264	.325	.237	.470	.071	.846	.344	.635	.712	.870	.536	.770	.275	.643	.294	.428	.798	.853
SMN	Lat (L)	.770	.185	.021	.264		<.001	.056	.109	.242	.047	.656	.009	.062	.041	.098	.006	.243	.012	.460	.353	.028	.018
	Lat (R)	.608	.092	.018	.325	<.001		.158	.599	.073	.086	.300	.205	.065	.203	.395	.031	.075	.115	.106	.031	.051	.047
	Sup	.142	.159	.019	.237	.056	.158		.699	.487	.754	.692	.392	.198	.335	.509	.015	.089	.362	.321	.402	.713	.692
SN	ACC	.487	.175	.019	.470	.109	.599	.699		.252	.300	.839	.978	.689	.369	.338	.024	.293	.367	.098	.039	.261	.034
	AINS (L)	.869	.173	.053	.071	.242	.073	.487	.252		.691	.856	.821	.418	.056	.120	<.001	.045	.056	.190	.128	.252	.082
	AINS (R)	.886	.720	.403	.846	.047	.086	.754	.300	.691		.816	.480	.348	.152	.264	.146	.441	.349	.028	.055	.041	.025
	RPFC (L)	.076	.011	.032	.344	.656	.300	.692	.839	.856	.816		.986	.799	.235	.267	.311	.504	.362	.188	.045	.358	.041
	RPFC (R)	.917	.358	.235	.635	.009	.205	.392	.978	.821	.480	.986		.568	.260	.053	.120	.230	.182	.236	.035	.445	.077
	SMG (L)	.659	.316	.030	.712	.062	.065	.198	.689	.418	.348	.799	.568		.189	.350	.009	.270	.124	.461	.477	.271	.195
	SMG (R)	.563	.272	.211	.870	.041	.203	.335	.369	.056	.152	.235	.260	.189		.118	.062	.150	.203	.195	.643	.126	.829
DAN	FEF (L)	.626	.134	.032	.536	.098	.395	.509	.338	.120	.264	.267	.053	.350	.118		.057	.001	.020	.079	.076	.118	.502
	FEF (R)	.584	.614	.170	.770	.006	.031	.015	.024	<.001	.146	.311	.120	.009	.062	.057		<.001	.011	.239	.021	.375	.301
	IPS (L)	.212	.025	.006	.275	.243	.075	.089	.293	.045	.441	.504	.230	.270	.150	.001	<.001		.018	.292	.525	.049	.305
	IPS (R)	.508	.069	.126	.643	.012	.115	.362	.367	.056	.349	.362	.182	.124	.203	.020	.011	.018		.123	.187	.016	.506
FPN	LPFC (L)	.569	.184	.177	.294	.460	.106	.321	.098	.190	.028	.188	.236	.461	.195	.079	.239	.292	.123		.014	.069	.093
	PPC (L)	.105	.284	.428	.428	.353	.031	.402	.039	.128	.055	.045	.035	.477	.643	.076	.021	.525	.187	.014		.199	.243
	LPFC (R)	.845	.505	.665	.798	.028	.051	.713	.261	.252	.041	.358	.445	.271	.126	.118	.375	.049	.016	.069	.199		.103
	PPC (R)	.232	.413	.761	.853	.018	.047	.692	.034	.082	.025	.041	.077	.195	.829	.502	.301	.305	.506	.093	.243	.103	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 74.
Summary of p-values of one-tailed t-tests of the healthy control group > diffuse tumor growth pattern group during tongue movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.971	.976	.484	.912	.363	.069	.138	.056	.023	.040	.016	.688	.326	.054	.005	.049	.008	.182	.645	<.001	.666
	LP (L)	.971		.936	.425	.978	.880	.471	.142	.405	.355	.061	.137	.231	.425	.599	.572	.431	.526	.282	.193	.075	.169
	LP (R)	.976	.936		.710	.939	.456	.604	.430	.757	.369	.037	.101	.255	.174	.224	.921	.416	.487	.300	.317	.023	.189
	PCC	.484	.425	.710		.880	.885	.705	.015	.526	.389	.014	.222	.031	.279	.298	.855	.574	.443	.448	.288	.239	.185
SMN	Lat (L)	.912	.978	.939	.880		.982	.452	.577	.553	.877	.200	.474	.858	.401	.912	.313	.269	.608	.608	.545	.508	.320
	Lat (R)	.363	.880	.456	.885	.982		.769	.765	.888	.333	.640	.754	.951	.260	.961	.611	.841	.771	.829	.594	.680	.571
	Sup	.069	.471	.604	.705	.452	.769		.380	.718	.456	.310	.630	.594	.747	.487	.907	.198	.193	.655	.296	.744	.231
SN	ACC	.138	.142	.430	.015	.577	.765	.380		>.999	.994	.109	.551	.900	.973	.872	.853	.390	.922	.028	.008	.578	.836
	AINS (L)	.056	.405	.757	.526	.553	.888	.718	>.999		.958	.974	.989	.952	.976	.976	.991	.929	.997	.680	.601	.997	.999
	AINS (R)	.023	.355	.369	.389	.877	.333	.456	.994	.958		.621	.929	.912	.950	.788	.638	.809	.894	.131	.032	.853	.883
	RPFC (L)	.040	.061	.037	.014	.200	.640	.310	.109	.974	.621		.729	.580	.554	.783	.991	.438	.941	.025	.085	.469	.775
	RPFC (R)	.016	.137	.101	.222	.474	.754	.630	.551	.989	.929	.729		.802	.962	.946	.993	.874	.957	.060	.070	.522	.653
	SMG (L)	.688	.231	.255	.031	.858	.951	.594	.900	.952	.912	.580	.802		.965	.950	.953	.786	.946	.264	.017	.489	.027
	SMG (R)	.326	.425	.174	.279	.401	.260	.747	.973	.976	.950	.554	.962	.965		.823	.659	.900	.931	.157	.007	.813	.089
DAN	FEF (L)	.054	.599	.224	.298	.912	.961	.487	.872	.976	.788	.783	.946	.950	.823		.826	.983	.998	.612	.258	.898	.009
	FEF (R)	.005	.572	.921	.855	.313	.611	.907	.853	.991	.638	.991	.993	.953	.659	.826		.973	.971	.952	.506	.985	.388
	IPS (L)	.049	.431	.416	.574	.269	.841	.198	.390	.929	.809	.438	.874	.786	.900	.983	.973		.934	.596	.070	.724	.050
	IPS (R)	.008	.526	.487	.443	.608	.771	.193	.922	.997	.894	.941	.957	.946	.931	.998	.971	.934		.612	.130	.936	.143
FPN	LPFC (L)	.182	.282	.300	.448	.608	.829	.655	.028	.680	.131	.025	.060	.264	.157	.612	.952	.596	.612		.890	.343	.476
	PPC (L)	.645	.193	.317	.288	.545	.594	.296	.008	.601	.032	.085	.070	.017	.007	.258	.506	.070	.130	.890		.323	.386
	LPFC (R)	<.001	.075	.023	.239	.508	.680	.744	.578	.997	.853	.469	.522	.489	.813	.898	.985	.724	.936	.343	.323		.738
	PPC (R)	.666	.169	.189	.185	.320	.571	.231	.836	.999	.883	.775	.653	.027	.089	.009	.388	.050	.143	.476	.386	.738	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 75.
Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > healthy control group during left hand movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.875	.881	.358	.737	.435	.701	.905	.083	.051	.936	.399	.115	.153	.257	.012	.092	.120	.035	.356	.019	.884
	LP (L)	.875		.479	.234	.498	.109	.210	.835	.507	.037	.379	.490	.102	.290	.124	.219	.170	.206	.180	.065	.162	.119
	LP (R)	.881	.479		.192	.837	.428	.453	.959	.936	.643	.530	.865	.305	.407	.585	.389	.171	.425	.370	.031	.518	.347
	PCC	.358	.234	.192		.645	.748	.513	.990	.964	.594	.930	.996	.329	.223	.439	.752	.242	.652	.463	.008	.389	.108
SMN	Lat (L)	.737	.498	.837	.645		>.999	.679	.795	.962	.988	.230	.618	.848	.958	.918	.757	.597	.809	.027	.050	.358	.745
	Lat (R)	.435	.109	.428	.748	>.999		.953	.800	.997	.991	.557	.632	.936	.716	.614	.936	.994	.531	.037	.046	.163	.092
	Sup	.701	.210	.453	.513	.679	.953		.517	.815	.733	.776	.945	.863	.716	.355	.861	.381	.085	.087	.066	.284	.007
SN	ACC	.905	.835	.959	.990	.795	.800	.517		>.999	>.999	.327	.567	.570	.537	.825	.865	.375	.553	.215	.814	.467	.990
	AINS (L)	.083	.507	.936	.964	.962	.997	.815	>.999		.987	.937	.998	.998	.996	.961	.927	.927	.980	.790	.809	.849	.998
	AINS (R)	.051	.037	.643	.594	.988	.991	.733	>.999	.987		.985	.998	.987	.989	.829	.851	.982	.974	.769	.416	.648	.513
	RPFC (L)	.936	.379	.530	.930	.230	.557	.776	.327	.937	.985		.782	.758	.596	.934	.949	.339	.707	.070	.033	.111	.465
	RPFC (R)	.399	.490	.865	.996	.618	.632	.945	.567	.998	.998	.782		.812	.817	.973	.976	.976	.977	.136	.267	.199	.796
	SMG (L)	.115	.102	.305	.329	.848	.936	.863	.570	.998	.987	.758	.812		.969	.957	.997	.965	.995	.235	.001	.119	.122
	SMG (R)	.153	.290	.407	.223	.958	.716	.716	.537	.996	.989	.596	.817	.969		.637	.942	.893	.904	.541	.099	.719	.027
DAN	FEF (L)	.257	.124	.585	.439	.918	.614	.355	.825	.961	.829	.934	.973	.957	.637		.969	.991	.824	.094	.012	.490	.140
	FEF (R)	.012	.219	.389	.752	.757	.936	.861	.865	.927	.851	.949	.976	.997	.942	.969		.997	.991	.693	.877	.789	.369
	IPS (L)	.092	.170	.171	.242	.597	.994	.381	.375	.927	.982	.339	.976	.965	.893	.991	.997		.998	.416	.002	.566	.110
	IPS (R)	.120	.206	.425	.652	.809	.531	.085	.553	.980	.974	.707	.977	.995	.904	.824	.991	.998		.749	.072	.944	.054
FPN	LPFC (L)	.035	.180	.370	.463	.027	.037	.087	.215	.790	.769	.070	.136	.235	.541	.094	.693	.416	.749		.703	.475	.331
	PPC (L)	.356	.065	.031	.008	.050	.046	.066	.814	.809	.416	.033	.267	.001	.099	.012	.877	.002	.072	.703		.635	.301
	LPFC (R)	.019	.162	.518	.389	.358	.163	.284	.467	.849	.648	.111	.199	.119	.719	.490	.789	.566	.944	.475	.635		.994
	PPC (R)	.884	.119	.347	.108	.745	.092	.007	.990	.998	.513	.465	.796	.122	.027	.140	.369	.110	.054	.331	.301	.994	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 76.
Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > healthy control group during right hand movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.907	.991	.776	.005	.002	.092	.107	<.001	<.001	.002	.002	.004	.001	.076	.044	<.001	<.001	.101	.905	.036	.914
	LP (L)	.907		.991	.528	.314	.158	.409	.498	.306	.028	.270	.074	.029	.093	.134	.616	.087	.079	.395	.809	.127	.888
	LP (R)	.991	.991		.546	.474	.208	.577	.740	.279	.016	.065	.191	.075	.152	.240	.483	.290	.266	.193	.811	.187	.786
	PCC	.776	.528	.546		.010	.001	.426	.019	.014	<.001	.076	.075	.001	.007	.120	.246	.008	.065	.190	.119	.031	.347
SMN	Lat (L)	.005	.314	.474	.010		>.999	.114	.386	.856	.998	.242	.539	.997	>.999	.862	.642	.647	.939	.676	.348	.068	.203
	Lat (R)	.002	.158	.208	.001	>.999		.514	.607	.988	.999	.283	.585	>.999	>.999	.919	.706	.997	.988	.551	.456	.327	.215
	Sup	.092	.409	.577	.426	.114	.514		.167	.597	.816	.904	.905	.888	.980	.789	.912	.403	.447	.137	.010	.026	.015
SN	ACC	.107	.498	.740	.019	.386	.607	.167		.889	.992	.020	.150	.805	.951	.907	.845	.470	.817	.101	.188	.020	.452
	AINS (L)	<.001	.306	.279	.014	.856	.988	.597	.889		.970	.985	.859	>.999	.992	.996	.950	.993	>.999	.891	.536	.255	.468
	AINS (R)	<.001	.028	.016	<.001	.998	.999	.816	.992	.970		.865	.955	>.999	>.999	.990	.908	>.999	>.999	.701	.647	.447	.747
	RPFC (L)	.002	.270	.065	.076	.242	.283	.904	.020	.985	.865		.189	.925	.995	.990	.998	.954	.999	.207	.190	.017	.524
	RPFC (R)	.002	.074	.191	.075	.539	.585	.905	.150	.859	.955	.189		.944	.955	.983	.980	.990	.999	.778	.451	.496	.635
	SMG (L)	.004	.029	.075	.001	.997	>.999	.888	.805	>.999	>.999	.925	.944		>.999	.999	.947	>.999	>.999	.456	.131	.240	.075
	SMG (R)	.001	.093	.152	.007	>.999	>.999	.980	.951	.992	>.999	.995	.955	>.999		.999	.997	>.999	>.999	.408	.237	.242	.008
DAN	FEF (L)	.076	.134	.240	.120	.862	.919	.789	.907	.996	.990	.990	.983	.999	.999		.994	.999	.998	.797	.170	.482	.051
	FEF (R)	.044	.616	.483	.246	.642	.706	.912	.845	.950	.908	.998	.980	.947	.997	.994		.994	.966	.792	.706	.235	.101
	IPS (L)	<.001	.087	.290	.008	.647	.997	.403	.470	.993	>.999	.954	.990	>.999	>.999	.999	.994		.995	.700	.006	.094	.008
	IPS (R)	<.001	.079	.266	.065	.939	.988	.447	.817	>.999	>.999	.999	.999	>.999	>.999	.998	.966	.995		.722	.065	.787	.003
FPN	LPFC (L)	.101	.395	.193	.190	.676	.551	.137	.101	.891	.701	.207	.778	.456	.408	.797	.792	.700	.722		.937	.648	.761
	PPC (L)	.905	.809	.811	.119	.348	.456	.010	.188	.536	.647	.190	.451	.131	.237	.170	.706	.006	.065	.937		.465	.899
	LPFC (R)	.036	.127	.187	.031	.068	.327	.026	.020	.255	.447	.017	.496	.240	.242	.482	.235	.094	.787	.648	.465		.997
	PPC (R)	.914	.888	.786	.347	.203	.215	.015	.452	.468	.747	.524	.635	.075	.008	.051	.101	.008	.003	.761	.899	.997	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 77.
Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > healthy control group during left foot movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.292	.809	.100	.520	.414	.685	.564	.859	.720	.148	.080	.539	.481	.389	.071	.385	.138	.583	.864	.473	.560
	LP (L)	.292		.260	.014	.543	.688	.454	.919	.918	.915	.875	.712	.605	.455	.399	.228	.394	.243	.949	.932	.802	.740
	LP (R)	.809	.260		.337	.942	.361	.298	.422	.746	.698	.413	.324	.429	.437	.154	.003	.096	.235	.842	.781	.637	.551
	PCC	.100	.014	.337		.973	.927	.959	.873	.688	.745	.960	.634	.787	.454	.741	.383	.911	.532	.444	.444	.484	.089
SMN	Lat (L)	.520	.543	.942	.973		.990	.575	.918	.284	.760	.758	.709	.767	.994	.749	.813	.620	.698	.201	.354	.680	.961
	Lat (R)	.414	.688	.361	.927	.990		.777	.930	.757	.756	.821	.386	.952	.684	.833	.802	.882	.123	.832	.952	.493	.927
	Sup	.685	.454	.298	.959	.575	.777		.756	.389	.901	.914	.996	.947	.969	.740	.971	.369	.626	.479	.209	.637	.407
SN	ACC	.564	.919	.422	.873	.918	.930	.756		.968	.900	.223	.037	.855	.921	.752	.506	.986	.918	.587	.836	.423	.823
	AINS (L)	.859	.918	.746	.688	.284	.757	.389	.968		.544	.934	.565	.774	.992	.872	.963	.884	.905	.884	.896	.827	.990
	AINS (R)	.720	.915	.698	.745	.760	.756	.901	.900	.544		.990	.816	.530	.921	.989	.869	.903	.949	.884	.585	.866	.936
	RPFC (L)	.148	.875	.413	.960	.758	.821	.914	.223	.934	.990		.141	.858	.879	.993	.915	.978	.981	.640	.841	.367	.887
	RPFC (R)	.080	.712	.324	.634	.709	.386	.996	.037	.565	.816	.141		.864	.789	.999	.946	.987	.907	.518	.832	.096	.743
	SMG (L)	.539	.605	.429	.787	.767	.952	.947	.855	.774	.530	.858	.864		.888	.970	.972	.926	.983	.239	.043	.505	.958
	SMG (R)	.481	.455	.437	.454	.994	.684	.969	.921	.992	.921	.879	.789	.888		.998	.936	.941	.959	.406	.462	.510	.866
DAN	FEF (L)	.389	.399	.154	.741	.749	.833	.740	.752	.872	.989	.993	.999	.970	.998		.998	.981	.997	.270	.028	.768	.586
	FEF (R)	.071	.228	.003	.383	.813	.802	.971	.506	.963	.869	.915	.946	.972	.936	.998		>.999	>.999	.908	.756	.722	.624
	IPS (L)	.385	.394	.096	.911	.620	.882	.369	.986	.884	.903	.978	.987	.926	.941	.981	>.999		.991	.167	.040	.759	.546
	IPS (R)	.138	.243	.235	.532	.698	.123	.626	.918	.905	.949	.981	.907	.983	.959	.997	>.999	.991		.494	.570	.924	.633
FPN	LPFC (L)	.583	.949	.842	.444	.201	.832	.479	.587	.884	.884	.640	.518	.239	.406	.270	.908	.167	.494		.922	.543	.721
	PPC (L)	.864	.932	.781	.444	.354	.952	.209	.836	.896	.585	.841	.832	.043	.462	.028	.756	.040	.570	.922		.887	.924
	LPFC (R)	.473	.802	.637	.484	.680	.493	.637	.423	.827	.866	.367	.096	.505	.510	.768	.722	.759	.924	.543	.887		.846
	PPC (R)	.560	.740	.551	.089	.961	.927	.407	.823	.990	.936	.887	.743	.958	.866	.586	.624	.546	.633	.721	.924	.846	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 78.
Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > healthy control group during right foot movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.815	.982	.999	.230	.392	.858	.513	.131	.114	.924	.083	.341	.437	.374	.416	.788	.492	.431	.895	.155	.768
	LP (L)	.815		.914	.657	.815	.908	.841	.825	.827	.280	.989	.642	.684	.728	.866	.386	.975	.931	.816	.716	.495	.587
	LP (R)	.982	.914		.940	.979	.982	.981	.981	.947	.597	.968	.765	.970	.789	.968	.830	.994	.874	.823	.572	.335	.239
	PCC	.999	.657	.940		.736	.675	.763	.530	.929	.154	.656	.365	.288	.130	.464	.230	.725	.357	.706	.572	.202	.147
SMN	Lat (L)	.230	.815	.979	.736		>.999	.944	.891	.758	.953	.344	.991	.938	.959	.902	.994	.757	.988	.540	.647	.972	.982
	Lat (R)	.392	.908	.982	.675	>.999		.842	.401	.927	.914	.700	.795	.935	.797	.605	.969	.925	.885	.894	.969	.949	.953
	Sup	.858	.841	.981	.763	.944	.842		.301	.513	.246	.308	.608	.802	.665	.491	.985	.911	.638	.679	.598	.287	.308
SN	ACC	.513	.825	.981	.530	.891	.401	.301		.748	.700	.161	.022	.311	.631	.662	.976	.707	.633	.902	.961	.739	.966
	AINS (L)	.131	.827	.947	.929	.758	.927	.513	.748		.309	.144	.179	.582	.944	.880	>.999	.955	.944	.810	.872	.748	.918
	AINS (R)	.114	.280	.597	.154	.953	.914	.246	.700	.309		.184	.520	.652	.848	.736	.854	.559	.651	.972	.945	.959	.975
	RPFC (L)	.924	.989	.968	.656	.344	.700	.308	.161	.144	.184		.014	.201	.765	.733	.689	.496	.638	.812	.955	.642	.959
	RPFC (R)	.083	.642	.765	.365	.991	.795	.608	.022	.179	.520	.014		.432	.740	.947	.880	.770	.818	.764	.965	.555	.923
	SMG (L)	.341	.684	.970	.288	.938	.935	.802	.311	.582	.652	.201	.432		.811	.650	.991	.730	.876	.539	.523	.729	.805
	SMG (R)	.437	.728	.789	.130	.959	.797	.665	.631	.944	.848	.765	.740	.811		.882	.938	.850	.797	.805	.357	.874	.171
DAN	FEF (L)	.374	.866	.968	.464	.902	.605	.491	.662	.880	.736	.733	.947	.650	.882		.943	.999	.980	.921	.924	.882	.498
	FEF (R)	.416	.386	.830	.230	.994	.969	.985	.976	>.999	.854	.689	.880	.991	.938	.943		>.999	.989	.761	.979	.625	.699
	IPS (L)	.788	.975	.994	.725	.757	.925	.911	.707	.955	.559	.496	.770	.730	.850	.999	>.999		.982	.708	.475	.951	.695
	IPS (R)	.492	.931	.874	.357	.988	.885	.638	.633	.944	.651	.638	.818	.876	.797	.980	.989	.982		.877	.813	.984	.494
FPN	LPFC (L)	.431	.816	.823	.706	.540	.894	.679	.902	.810	.972	.812	.764	.539	.805	.921	.761	.708	.877		.986	.931	.907
	PPC (L)	.895	.716	.572	.572	.647	.969	.598	.961	.872	.945	.955	.965	.523	.357	.924	.979	.475	.813	.986		.801	.757
	LPFC (R)	.155	.495	.335	.202	.972	.949	.287	.739	.748	.959	.642	.555	.729	.874	.882	.625	.951	.984	.931	.801		.897
	PPC (R)	.768	.587	.239	.147	.982	.953	.308	.966	.918	.975	.959	.923	.805	.171	.498	.699	.695	.494	.907	.757	.897	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 79.
Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > healthy control group during tongue movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.029	.024	.516	.088	.637	.931	.862	.944	.977	.960	.984	.312	.674	.946	.995	.951	.992	.818	.355	>.999	.334
	LP (L)	.029		.064	.575	.022	.120	.529	.858	.595	.645	.939	.863	.769	.575	.401	.428	.569	.474	.718	.807	.925	.831
	LP (R)	.024	.064		.290	.061	.544	.396	.570	.243	.631	.963	.899	.745	.826	.776	.079	.584	.513	.700	.683	.977	.811
	PCC	.516	.575	.290		.120	.115	.295	.985	.474	.611	.986	.778	.969	.721	.702	.145	.426	.557	.552	.712	.761	.815
SMN	Lat (L)	.088	.022	.061	.120		.018	.548	.423	.447	.123	.800	.526	.142	.599	.088	.687	.731	.392	.392	.455	.492	.680
	Lat (R)	.637	.120	.544	.115	.018		.231	.235	.112	.667	.360	.246	.049	.740	.039	.389	.159	.229	.171	.406	.320	.429
	Sup	.931	.529	.396	.295	.548	.231		.620	.282	.544	.690	.370	.406	.253	.513	.093	.802	.807	.345	.704	.256	.769
SN	ACC	.862	.858	.570	.985	.423	.235	.620		<.001	.006	.891	.449	.100	.027	.128	.147	.610	.078	.972	.992	.422	.164
	AINS (L)	.944	.595	.243	.474	.447	.112	.282	<.001		.042	.026	.011	.048	.024	.024	.009	.071	.003	.320	.399	.003	.001
	AINS (R)	.977	.645	.631	.611	.123	.667	.544	.006	.042		.379	.071	.088	.050	.212	.362	.191	.106	.869	.968	.147	.117
	RPFC (L)	.960	.939	.963	.986	.800	.360	.690	.891	.026	.379		.271	.420	.446	.217	.009	.562	.059	.975	.915	.531	.225
	RPFC (R)	.984	.863	.899	.778	.526	.246	.370	.449	.011	.071	.271		.198	.038	.054	.007	.126	.043	.940	.930	.478	.347
	SMG (L)	.312	.769	.745	.969	.142	.049	.406	.100	.048	.088	.420	.198		.035	.050	.047	.214	.054	.736	.983	.511	.973
	SMG (R)	.674	.575	.826	.721	.599	.740	.253	.027	.024	.050	.446	.038	.035		.177	.341	.100	.069	.843	.993	.187	.911
DAN	FEF (L)	.946	.401	.776	.702	.088	.039	.513	.128	.024	.212	.217	.054	.050	.177		.174	.017	.002	.388	.742	.102	.991
	FEF (R)	.995	.428	.079	.145	.687	.389	.093	.147	.009	.362	.009	.007	.047	.341	.174		.027	.029	.048	.494	.015	.612
	IPS (L)	.951	.569	.584	.426	.731	.159	.802	.610	.071	.191	.562	.126	.214	.100	.017	.027		.066	.404	.930	.276	.950
	IPS (R)	.992	.474	.513	.557	.392	.229	.807	.078	.003	.106	.059	.043	.054	.069	.002	.029	.066		.388	.870	.064	.857
FPN	LPFC (L)	.818	.718	.700	.552	.392	.171	.345	.972	.320	.869	.975	.940	.736	.843	.388	.048	.404	.388		.110	.657	.524
	PPC (L)	.355	.807	.683	.712	.455	.406	.704	.992	.399	.968	.915	.930	.983	.993	.742	.494	.930	.870	.110		.677	.614
	LPFC (R)	>.999	.925	.977	.761	.492	.320	.256	.422	.003	.147	.531	.478	.511	.187	.102	.015	.276	.064	.657	.677		.262
	PPC (R)	.334	.831	.811	.815	.680	.429	.769	.164	.001	.117	.225	.347	.973	.911	.991	.612	.950	.857	.524	.614	.262	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 80.
Summary of p-values of one-tailed t-tests of the healthy control group > uniform tumor growth pattern group during left hand movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.036	.311	.479	.945	.985	.987	.206	.772	.864	.808	.892	.740	.431	.510	.368	.911	.943	.855	.059	.819	.013
	LP (L)	.036		.330	.208	.903	.999	.964	.001	.257	.900	.304	.670	.940	.853	.692	.759	.954	.971	.742	.357	.747	.162
	LP (R)	.311	.330		.513	.295	.518	.187	.024	.012	.266	.057	.155	.304	.657	.556	.603	.349	.564	.447	.765	.508	.463
	PCC	.479	.208	.513		.956	.995	.990	.062	.166	.812	.338	.878	.994	.531	.516	.398	.989	.999	.772	.451	.912	.139
SMN	Lat (L)	.945	.903	.295	.956		.116	.294	.315	.426	.182	.103	.308	.385	.302	.440	.014	.395	.543	.884	.978	.926	.780
	Lat (R)	.985	.999	.518	.995	.116		.452	.704	.083	.140	.402	.214	.194	.220	.498	.024	.336	.591	.938	.992	.847	.930
	Sup	.987	.964	.187	.990	.294	.452		.966	.261	.250	.684	.332	.316	.337	.582	.140	.499	.606	.959	.983	.929	.791
SN	ACC	.206	.001	.024	.062	.315	.704	.966		.005	.115	.727	.968	.385	.244	.755	.614	.959	.934	.954	.860	.977	.373
	AINS (L)	.772	.257	.012	.166	.426	.083	.261	.005		.466	<.001	.041	.027	.001	.342	.499	.250	.134	.169	.344	.134	.065
	AINS (R)	.864	.900	.266	.812	.182	.140	.250	.115	.466		.013	.020	.085	.022	.322	.345	.363	.138	.691	.929	.698	.523
	RPFC (L)	.808	.304	.057	.338	.103	.402	.684	.727	<.001	.013		.555	.003	.032	.385	.846	.323	.285	.973	.940	.994	.697
	RPFC (R)	.892	.670	.155	.878	.308	.214	.332	.968	.041	.020	.555		.102	.102	.654	.740	.111	.002	.850	.827	.565	.587
	SMG (L)	.740	.940	.304	.994	.385	.194	.316	.385	.027	.085	.003	.102		.038	.072	.529	.181	.107	.019	.699	.949	.909
	SMG (R)	.431	.853	.657	.531	.302	.220	.337	.244	.001	.022	.032	.102	.038		.318	.487	.455	.667	.671	.928	.943	.945
DAN	FEF (L)	.510	.692	.556	.516	.440	.498	.582	.755	.342	.322	.385	.654	.072	.318		.046	.242	.459	.728	.894	.966	.850
	FEF (R)	.368	.759	.603	.398	.014	.024	.140	.614	.499	.345	.846	.740	.529	.487	.046		.172	.314	.708	.984	.994	.999
	IPS (L)	.911	.954	.349	.989	.395	.336	.499	.959	.250	.363	.323	.111	.181	.455	.242	.172		.013	.673	.996	.795	.987
	IPS (R)	.943	.971	.564	.999	.543	.591	.606	.934	.134	.138	.285	.002	.107	.667	.459	.314	.013		.583	.973	.300	.994
FPN	LPFC (L)	.855	.742	.447	.772	.884	.938	.959	.954	.169	.691	.973	.850	.019	.671	.728	.708	.673	.583		.378	.945	.411
	PPC (L)	.059	.357	.765	.451	.978	.992	.983	.860	.344	.929	.940	.827	.699	.928	.894	.984	.996	.973	.378		.837	.027
	LPFC (R)	.819	.747	.508	.912	.926	.847	.929	.977	.134	.698	.994	.565	.949	.943	.966	.994	.795	.300	.945	.837		.251
	PPC (R)	.013	.162	.463	.139	.780	.930	.791	.373	.065	.523	.697	.587	.909	.945	.850	.999	.987	.994	.411	.027	.251	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 81.
Summary of p-values of one-tailed t-tests of the healthy control group > uniform tumor growth pattern group during right hand movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.945	.491	.722	.666	.795	.655	.909	.925	.964	.651	.875	.598	.851	.262	.789	.578	.757	.693	.112	.522	.059
	LP (L)	.945		.498	.537	.854	.961	.705	.280	.653	.973	.673	.982	.362	.689	.387	.226	.546	.684	.742	.281	.818	.638
	LP (R)	.491	.498		.229	.614	.776	.455	.027	.719	.720	.070	.222	.321	.512	.437	.454	.416	.491	.641	.299	.590	.711
	PCC	.722	.537	.229		.668	.766	.680	.235	.550	.841	.361	.725	.298	.574	.279	.510	.285	.493	.584	.404	.826	.127
SMN	Lat (L)	.666	.854	.614	.668		.010	.252	.142	.118	.004	.312	.344	.300	.153	.287	.005	.304	.172	.399	.945	.913	.964
	Lat (R)	.795	.961	.776	.766	.010		.158	.200	.161	.018	.235	.240	.182	.047	.351	.021	.088	.056	.430	.844	.930	.951
	Sup	.655	.705	.455	.680	.252	.158		.155	.026	.003	.054	.233	.622	.097	.509	.003	.095	.105	.304	.940	.926	.926
SN	ACC	.909	.280	.027	.235	.142	.200	.155		.011	.005	.100	.358	.039	.011	.096	.086	.013	.229	.342	.732	.635	.620
	AINS (L)	.925	.653	.719	.550	.118	.161	.026	.011		.346	.016	.127	.071	.023	.013	.021	.036	.108	.208	.384	.862	.636
	AINS (R)	.964	.973	.720	.841	.004	.018	.003	.005	.346		.035	.005	.060	.002	.008	.085	.002	.012	.394	.299	.705	.529
	RPFC (L)	.651	.673	.070	.361	.312	.235	.054	.100	.016	.035		.957	.126	.273	.024	.086	.082	.570	.618	.877	.941	.626
	RPFC (R)	.875	.982	.222	.725	.344	.240	.233	.358	.127	.005	.957		.309	.131	.415	.216	.126	.272	.877	.911	.748	.623
	SMG (L)	.598	.362	.321	.298	.300	.182	.622	.039	.071	.060	.126	.309		.004	.209	.396	.020	.068	.066	.666	.364	.472
	SMG (R)	.851	.689	.512	.574	.153	.047	.097	.011	.023	.002	.273	.131	.004		.139	.090	.081	.240	.457	.863	.668	.844
DAN	FEF (L)	.262	.387	.437	.279	.287	.351	.509	.096	.013	.008	.024	.415	.209	.139		.038	.057	.550	.193	.931	.890	.932
	FEF (R)	.789	.226	.454	.510	.005	.021	.003	.086	.021	.085	.086	.216	.396	.090	.038		.003	.016	.492	.997	.976	.993
	IPS (L)	.578	.546	.416	.285	.304	.088	.095	.013	.036	.002	.082	.126	.020	.081	.057	.003		.058	.296	.989	.935	.967
	IPS (R)	.757	.684	.491	.493	.172	.056	.105	.229	.108	.012	.570	.272	.068	.240	.550	.016	.058		.568	.979	.876	.977
FPN	LPFC (L)	.693	.742	.641	.584	.399	.430	.304	.342	.208	.394	.618	.877	.066	.457	.193	.492	.296	.568		.111	.870	.923
	PPC (L)	.112	.281	.299	.404	.945	.844	.940	.732	.384	.299	.877	.911	.666	.863	.931	.997	.989	.979	.111		.471	.185
	LPFC (R)	.522	.818	.590	.826	.913	.930	.926	.635	.862	.705	.941	.748	.364	.668	.890	.976	.935	.876	.870	.471		.444
	PPC (R)	.059	.638	.711	.127	.964	.951	.926	.620	.636	.529	.626	.623	.472	.844	.932	.993	.967	.977	.923	.185	.444	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 82.
Summary of p-values of one-tailed t-tests of the healthy control group > uniform tumor growth pattern group during left foot movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.147	.582	.502	.992	.999	.987	.898	.846	.984	.696	.969	.476	.819	.990	.633	.935	.985	.980	.669	.909	.307
	LP (L)	.147		.348	.847	.721	.880	.910	.493	.864	.960	.545	.946	.507	.694	.891	.554	.822	.974	.905	.793	.957	.549
	LP (R)	.582	.348		.819	.667	.897	.244	.104	.717	.673	.323	.552	.502	.507	.560	.783	.494	.543	.615	.210	.532	.296
	PCC	.502	.847	.819		.892	.879	.847	.564	.825	.872	.710	.796	.834	.924	.752	.871	.737	.944	.637	.893	.752	.368
SMN	Lat (L)	.992	.721	.667	.892		.616	.470	.042	.078	.046	.092	.222	.002	.182	.142	.304	.074	.260	.564	.918	.912	.991
	Lat (R)	.999	.880	.897	.879	.616		.503	.094	.366	.471	.306	.323	.046	.968	.193	.139	.208	.549	.949	.958	.995	>.999
	Sup	.987	.910	.244	.847	.470	.503		.119	.283	.341	.082	.223	.163	.587	.546	.164	.257	.308	.579	.667	.955	.922
SN	ACC	.898	.493	.104	.564	.042	.094	.119		.274	.684	.588	.383	.020	.114	.133	.577	.016	.104	.470	.830	.905	.988
	AINS (L)	.846	.864	.717	.825	.078	.366	.283	.274		.453	.294	.133	.186	.090	.423	.454	.113	.367	.221	.242	.199	.998
	AINS (R)	.984	.960	.673	.872	.046	.471	.341	.684	.453		.621	.079	.053	.099	.468	.156	.022	.088	.339	.437	.824	.976
	RPFC (L)	.696	.545	.323	.710	.092	.306	.082	.588	.294	.621		.648	.429	.560	.169	.256	.333	.582	.675	.681	.961	.960
	RPFC (R)	.969	.946	.552	.796	.222	.323	.223	.383	.133	.079	.648		.045	.015	.445	.360	.073	.174	.550	.882	.853	.582
	SMG (L)	.476	.507	.502	.834	.002	.046	.163	.020	.186	.053	.429	.045		.004	.316	.758	.110	.042	.231	.573	.540	.988
	SMG (R)	.819	.694	.507	.924	.182	.968	.587	.114	.090	.099	.560	.015	.004		.473	.629	.241	.874	.222	.186	.104	.928
DAN	FEF (L)	.990	.891	.560	.752	.142	.193	.546	.133	.423	.468	.169	.445	.316	.473		.049	.123	.255	.643	.881	.852	.704
	FEF (R)	.633	.554	.783	.871	.304	.139	.164	.577	.454	.156	.256	.360	.758	.629	.049		.315	.276	.568	.927	.907	.847
	IPS (L)	.935	.822	.494	.737	.074	.208	.257	.016	.113	.022	.333	.073	.110	.241	.123	.315		.083	.437	.968	.768	.974
	IPS (R)	.985	.974	.543	.944	.260	.549	.308	.104	.367	.088	.582	.174	.042	.874	.255	.276	.083		.387	.719	.465	.878
FPN	LPFC (L)	.980	.905	.615	.637	.564	.949	.579	.470	.221	.339	.675	.550	.231	.222	.643	.568	.437	.387		.460	.950	.652
	PPC (L)	.669	.793	.210	.893	.918	.958	.667	.830	.242	.437	.681	.882	.573	.186	.881	.927	.968	.719	.460		.715	.090
	LPFC (R)	.909	.957	.532	.752	.912	.995	.955	.905	.199	.824	.961	.853	.540	.104	.852	.907	.768	.465	.950	.715		.168
	PPC (R)	.307	.549	.296	.368	.991	>.999	.922	.988	.998	.976	.960	.582	.988	.928	.704	.847	.974	.878	.652	.090	.168	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 83.
Summary of p-values of one-tailed t-tests of the healthy control group > uniform tumor growth pattern group during right foot movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.026	.023	.664	.931	.852	.865	.752	.938	.886	.752	.829	.774	.877	.970	.552	.908	.874	.678	.125	.832	.059
	LP (L)	.026		.010	.578	.912	.952	.851	.520	.852	.811	.971	.936	.826	.883	.932	.756	.894	.793	.420	.207	.700	.125
	LP (R)	.023	.010		.657	.912	.956	.830	.398	.815	.535	.680	.821	.670	.887	.953	.646	.785	.883	.436	.251	.676	.195
	PCC	.664	.578	.657		.414	.363	.771	.331	.230	.536	.897	.712	.364	.855	.867	.464	.449	.404	.400	.736	.864	.416
SMN	Lat (L)	.931	.912	.912	.414		.013	.361	.525	.187	.135	.638	.262	.242	.150	.224	.220	.469	.164	.927	.936	.594	.928
	Lat (R)	.852	.952	.956	.363	.013		.201	.452	.118	.071	.696	.148	.154	.152	.106	.306	.467	.175	.987	.973	.703	.945
	Sup	.865	.851	.830	.771	.361	.201		.336	.324	.072	.487	.080	.066	.050	.903	.448	.439	.556	.955	.968	.913	.996
SN	ACC	.752	.520	.398	.331	.525	.452	.336		.193	.048	.587	.541	.382	.351	.485	.987	.574	.246	.984	.985	.904	.973
	AINS (L)	.938	.852	.815	.230	.187	.118	.324	.193		.098	.097	.165	.001	.028	.370	.565	.129	.033	.550	.900	.689	.990
	AINS (R)	.886	.811	.535	.536	.135	.071	.072	.048	.098		.149	.001	.032	.019	.036	.060	.136	.272	.324	.921	.803	.863
	RPFC (L)	.752	.971	.680	.897	.638	.696	.487	.587	.097	.149		.908	.045	.240	.552	.782	.784	.515	.981	.983	.998	.931
	RPFC (R)	.829	.936	.821	.712	.262	.148	.080	.541	.165	.001	.908		.059	<.001	.293	.404	.156	.083	.988	.991	.993	.956
	SMG (L)	.774	.826	.670	.364	.242	.154	.066	.382	.001	.032	.045	.059		.035	.058	.142	.125	.007	.040	.823	.102	.919
	SMG (R)	.877	.883	.887	.855	.150	.152	.050	.351	.028	.019	.240	<.001	.035		.109	.493	.388	.011	.930	.983	.760	.998
DAN	FEF (L)	.970	.932	.953	.867	.224	.106	.903	.485	.370	.036	.552	.293	.058	.109		.259	.343	.796	.574	.954	.681	.831
	FEF (R)	.552	.756	.646	.464	.220	.306	.448	.987	.565	.060	.782	.404	.142	.493	.259		.405	.414	.838	.896	.968	.965
	IPS (L)	.908	.894	.785	.449	.469	.467	.439	.574	.129	.136	.784	.156	.125	.388	.343	.405		.132	.684	.994	.548	.998
	IPS (R)	.874	.793	.883	.404	.164	.175	.556	.246	.033	.272	.515	.083	.007	.011	.796	.414	.132		.530	.855	.272	.948
FPN	LPFC (L)	.678	.420	.436	.400	.927	.987	.955	.984	.550	.324	.981	.988	.040	.930	.574	.838	.684	.530		.784	.626	.677
	PPC (L)	.125	.207	.251	.736	.936	.973	.968	.985	.900	.921	.983	.991	.823	.983	.954	.896	.994	.855	.784		.296	.138
	LPFC (R)	.832	.700	.676	.864	.594	.703	.913	.904	.689	.803	.998	.993	.102	.760	.681	.968	.548	.272	.626	.296		.324
	PPC (R)	.059	.125	.195	.416	.928	.945	.996	.973	.990	.863	.931	.956	.919	.998	.831	.965	.998	.948	.677	.138	.324	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 84.
Summary of p-values of one-tailed t-tests of the healthy control group > uniform tumor growth pattern group during tongue movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.256	.539	.780	.882	.643	.570	.477	.956	.903	.630	.944	.830	.953	.762	.905	.645	.854	.719	.172	.760	.564
	LP (L)	.256		.523	.793	.027	.012	.469	.066	.100	.549	.159	.411	.755	.546	.624	.815	.099	.430	.328	.435	.654	.576
	LP (R)	.539	.523		.902	.029	.334	.511	.030	.117	.278	.072	.317	.644	.369	.066	.372	.079	.306	.283	.598	.541	.902
	PCC	.780	.793	.902		.061	.141	.598	.183	.152	.296	.478	.349	.813	.985	.677	.560	.229	.494	.581	.834	.768	.998
SMN	Lat (L)	.882	.027	.029	.061		.040	.332	.539	.806	.193	.343	.191	.291	.179	.545	.912	.166	.325	.668	.651	.485	.788
	Lat (R)	.643	.012	.334	.141	.040		.157	.394	.341	.280	.079	.544	.082	.937	.182	.856	.025	.684	.139	.591	.339	.999
	Sup	.570	.469	.511	.598	.332	.157		.720	.878	.574	.766	.754	.185	.427	.487	.632	.418	.502	.920	.900	.825	.997
SN	ACC	.477	.066	.030	.183	.539	.394	.720		.222	.301	.909	.989	.860	.439	.287	.846	.699	.603	.729	.043	.968	.494
	AINS (L)	.956	.100	.117	.152	.806	.341	.878	.222		.154	.038	.041	.503	.178	.736	.642	.167	.175	.186	.187	.305	.239
	AINS (R)	.903	.549	.278	.296	.193	.280	.574	.301	.154		.065	.009	.293	.012	.197	.389	.010	.005	.685	.279	.263	.364
	RPFC (L)	.630	.159	.072	.478	.343	.079	.766	.909	.038	.065		.800	.409	.209	.608	.828	.278	.112	.637	.335	.967	.478
	RPFC (R)	.944	.411	.317	.349	.191	.544	.754	.989	.041	.009	.800		.140	.137	.517	.674	.161	.160	.571	.643	.928	.710
	SMG (L)	.830	.755	.644	.813	.291	.082	.185	.860	.503	.293	.409	.140		.313	.811	.868	.214	.371	.477	.844	.272	.948
	SMG (R)	.953	.546	.369	.985	.179	.937	.427	.439	.178	.012	.209	.137	.313		.724	.570	.353	.521	.322	.779	.199	.917
DAN	FEF (L)	.762	.624	.066	.677	.545	.182	.487	.287	.736	.197	.608	.517	.811	.724		.454	.266	.219	.987	.976	.775	.893
	FEF (R)	.905	.815	.372	.560	.912	.856	.632	.846	.642	.389	.828	.674	.868	.570	.454		.852	.671	.928	.939	.973	.770
	IPS (L)	.645	.099	.079	.229	.166	.025	.418	.699	.167	.010	.278	.161	.214	.353	.266	.852		.174	.831	.962	.546	.851
	IPS (R)	.854	.430	.306	.494	.325	.684	.502	.603	.175	.005	.112	.160	.371	.521	.219	.671	.174		.174	.963	.175	.889
FPN	LPFC (L)	.719	.328	.283	.581	.668	.139	.920	.729	.186	.685	.637	.571	.477	.322	.987	.928	.831	.174		.139	.511	.097
	PPC (L)	.172	.435	.598	.834	.651	.591	.900	.043	.187	.279	.335	.643	.844	.779	.976	.939	.962	.963	.139		.364	.023
	LPFC (R)	.760	.654	.541	.768	.485	.339	.825	.968	.305	.263	.967	.928	.272	.199	.775	.973	.546	.175	.511	.364		.563
	PPC (R)	.564	.576	.902	.998	.788	.999	.997	.494	.239	.364	.478	.710	.948	.917	.893	.770	.851	.889	.097	.023	.563	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 85.
Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern group > healthy control group during left hand movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.964	.689	.521	.055	.015	.013	.794	.228	.136	.192	.108	.260	.569	.490	.632	.089	.057	.145	.941	.181	.987
	LP (L)	.964		.670	.792	.097	.001	.036	.999	.743	.100	.696	.330	.060	.147	.308	.241	.046	.029	.258	.643	.253	.838
	LP (R)	.689	.670		.487	.705	.482	.813	.976	.988	.734	.943	.845	.696	.343	.444	.397	.651	.436	.553	.235	.492	.537
	PCC	.521	.792	.487		.044	.005	.010	.938	.834	.188	.662	.122	.006	.469	.484	.602	.011	.001	.228	.549	.088	.861
SMN	Lat (L)	.055	.097	.705	.044		.884	.706	.685	.574	.818	.897	.692	.615	.698	.560	.986	.605	.457	.116	.022	.074	.220
	Lat (R)	.015	.001	.482	.005	.884		.548	.296	.917	.860	.598	.786	.806	.780	.502	.976	.664	.409	.062	.008	.153	.070
	Sup	.013	.036	.813	.010	.706	.548		.034	.739	.750	.316	.668	.684	.663	.418	.860	.501	.394	.041	.017	.071	.209
SN	ACC	.794	.999	.976	.938	.685	.296	.034		.995	.885	.273	.032	.615	.756	.245	.386	.041	.066	.046	.140	.023	.627
	AINS (L)	.228	.743	.988	.834	.574	.917	.739	.995		.534	>.999	.959	.973	.999	.658	.501	.750	.866	.831	.656	.866	.935
	AINS (R)	.136	.100	.734	.188	.818	.860	.750	.885	.534		.987	.980	.915	.978	.678	.655	.637	.862	.309	.071	.302	.477
	RPFC (L)	.192	.696	.943	.662	.897	.598	.316	.273	>.999	.987		.445	.997	.968	.615	.154	.677	.715	.027	.060	.006	.303
	RPFC (R)	.108	.330	.845	.122	.692	.786	.668	.032	.959	.980	.445		.898	.898	.346	.260	.889	.998	.150	.173	.435	.413
	SMG (L)	.260	.060	.696	.006	.615	.806	.684	.615	.973	.915	.997	.898		.962	.928	.471	.819	.893	.981	.301	.051	.091
	SMG (R)	.569	.147	.343	.469	.698	.780	.663	.756	.999	.978	.968	.898	.962		.682	.513	.545	.333	.329	.072	.057	.055
DAN	FEF (L)	.490	.308	.444	.484	.560	.502	.418	.245	.658	.678	.615	.346	.928	.682		.954	.758	.541	.272	.106	.034	.150
	FEF (R)	.632	.241	.397	.602	.986	.976	.860	.386	.501	.655	.154	.260	.471	.513	.954		.828	.686	.292	.016	.006	.001
	IPS (L)	.089	.046	.651	.011	.605	.664	.501	.041	.750	.637	.677	.889	.819	.545	.758	.828		.987	.327	.004	.205	.013
	IPS (R)	.057	.029	.436	.001	.457	.409	.394	.066	.866	.862	.715	.998	.893	.333	.541	.686	.987		.417	.027	.700	.006
FPN	LPFC (L)	.145	.258	.553	.228	.116	.062	.041	.046	.831	.309	.027	.150	.981	.329	.272	.292	.327	.417		.622	.055	.589
	PPC (L)	.941	.643	.235	.549	.022	.008	.017	.140	.656	.071	.060	.173	.301	.072	.106	.016	.004	.027	.622		.163	.973
	LPFC (R)	.181	.253	.492	.088	.074	.153	.071	.023	.866	.302	.006	.435	.051	.057	.034	.006	.205	.700	.055	.163		.749
	PPC (R)	.987	.838	.537	.861	.220	.070	.209	.627	.935	.477	.303	.413	.091	.055	.150	.001	.013	.006	.589	.973	.749	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 86.
Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern group > healthy control group during right hand movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.055	.509	.278	.334	.205	.345	.091	.075	.036	.349	.125	.402	.149	.738	.211	.422	.243	.307	.888	.478	.941
	LP (L)	.055		.502	.463	.146	.039	.295	.720	.347	.027	.327	.018	.638	.311	.613	.774	.454	.316	.258	.719	.182	.362
	LP (R)	.509	.502		.771	.386	.224	.545	.973	.281	.280	.930	.778	.679	.488	.563	.546	.584	.509	.359	.701	.410	.289
	PCC	.278	.463	.771		.332	.234	.320	.765	.450	.159	.639	.275	.702	.426	.721	.490	.715	.507	.416	.596	.174	.873
SMN	Lat (L)	.334	.146	.386	.332		.990	.748	.858	.882	.996	.688	.656	.700	.847	.713	.995	.696	.828	.601	.055	.087	.036
	Lat (R)	.205	.039	.224	.234	.990		.842	.800	.839	.982	.765	.760	.818	.953	.649	.979	.912	.944	.570	.156	.070	.049
	Sup	.345	.295	.545	.320	.748	.842		.845	.974	.997	.946	.767	.378	.903	.491	.997	.905	.895	.696	.060	.074	.074
SN	ACC	.091	.720	.973	.765	.858	.800	.845		.989	.995	.900	.642	.961	.989	.904	.914	.987	.771	.658	.268	.365	.380
	AINS (L)	.075	.347	.281	.450	.882	.839	.974	.989		.654	.984	.873	.929	.977	.987	.979	.964	.892	.792	.616	.138	.364
	AINS (R)	.036	.027	.280	.159	.996	.982	.997	.995	.654		.965	.995	.940	.998	.992	.915	.998	.988	.606	.701	.295	.471
	RPFC (L)	.349	.327	.930	.639	.688	.765	.946	.900	.984	.965		.043	.874	.727	.976	.914	.918	.430	.382	.123	.059	.374
	RPFC (R)	.125	.018	.778	.275	.656	.760	.767	.642	.873	.995	.043		.691	.869	.585	.784	.874	.728	.123	.089	.252	.377
	SMG (L)	.402	.638	.679	.702	.700	.818	.378	.961	.929	.940	.874	.691		.996	.791	.604	.980	.932	.934	.334	.636	.528
	SMG (R)	.149	.311	.488	.426	.847	.953	.903	.989	.977	.998	.727	.869	.996		.861	.910	.919	.760	.543	.137	.332	.156
DAN	FEF (L)	.738	.613	.563	.721	.713	.649	.491	.904	.987	.992	.976	.585	.791	.861		.962	.943	.450	.807	.069	.110	.068
	FEF (R)	.211	.774	.546	.490	.995	.979	.997	.914	.979	.915	.914	.784	.604	.910	.962		.997	.984	.508	.003	.024	.007
	IPS (L)	.422	.454	.584	.715	.696	.912	.905	.987	.964	.998	.918	.874	.980	.919	.943	.997		.942	.704	.011	.065	.033
	IPS (R)	.243	.316	.509	.507	.828	.944	.895	.771	.892	.988	.430	.728	.932	.760	.450	.984	.942		.432	.021	.124	.023
FPN	LPFC (L)	.307	.258	.359	.416	.601	.570	.696	.658	.792	.606	.382	.123	.934	.543	.807	.508	.704	.432		.889	.130	.077
	PPC (L)	.888	.719	.701	.596	.055	.156	.060	.268	.616	.701	.123	.089	.334	.137	.069	.003	.011	.021	.889		.529	.815
	LPFC (R)	.478	.182	.410	.174	.087	.070	.074	.365	.138	.295	.059	.252	.636	.332	.110	.024	.065	.124	.130	.529		.556
	PPC (R)	.941	.362	.289	.873	.036	.049	.074	.380	.364	.471	.374	.377	.528	.156	.068	.007	.033	.023	.077	.815	.556	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 87.
Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern group > healthy control group during left foot movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.853	.418	.498	.008	.001	.013	.102	.154	.016	.304	.031	.524	.181	.010	.367	.065	.015	.020	.331	.091	.693
	LP (L)	.853		.652	.153	.279	.120	.090	.507	.136	.040	.455	.054	.493	.306	.109	.446	.178	.026	.095	.207	.043	.451
	LP (R)	.418	.652		.181	.333	.103	.756	.896	.283	.327	.677	.448	.498	.493	.440	.217	.506	.457	.385	.790	.468	.704
	PCC	.498	.153	.181		.108	.121	.153	.436	.175	.128	.290	.204	.166	.076	.248	.129	.263	.056	.363	.107	.248	.632
SMN	Lat (L)	.008	.279	.333	.108		.384	.530	.958	.922	.954	.908	.778	.998	.818	.858	.696	.926	.740	.436	.082	.088	.009
	Lat (R)	.001	.120	.103	.121	.384		.497	.906	.634	.529	.694	.677	.954	.032	.807	.861	.792	.451	.051	.042	.005	<.001
	Sup	.013	.090	.756	.153	.530	.497		.881	.717	.659	.918	.777	.837	.413	.454	.836	.743	.692	.421	.333	.045	.078
SN	ACC	.102	.507	.896	.436	.958	.906	.881		.726	.316	.412	.617	.980	.886	.867	.423	.984	.896	.530	.170	.095	.012
	AINS (L)	.154	.136	.283	.175	.922	.634	.717	.726		.547	.706	.867	.814	.910	.577	.546	.887	.633	.779	.758	.801	.002
	AINS (R)	.016	.040	.327	.128	.954	.529	.659	.316	.547		.379	.921	.947	.901	.532	.844	.978	.912	.661	.563	.176	.024
	RPFC (L)	.304	.455	.677	.290	.908	.694	.918	.412	.706	.379		.352	.571	.440	.831	.744	.667	.418	.325	.319	.039	.040
	RPFC (R)	.031	.054	.448	.204	.778	.677	.777	.617	.867	.921	.352		.955	.985	.555	.640	.927	.826	.450	.118	.147	.418
	SMG (L)	.524	.493	.498	.166	.998	.954	.837	.980	.814	.947	.571	.955		.996	.684	.242	.890	.958	.769	.427	.460	.012
	SMG (R)	.181	.306	.493	.076	.818	.032	.413	.886	.910	.901	.440	.985	.996		.527	.371	.759	.126	.778	.814	.896	.072
DAN	FEF (L)	.010	.109	.440	.248	.858	.807	.454	.867	.577	.532	.831	.555	.684	.527		.951	.877	.745	.357	.119	.148	.296
	FEF (R)	.367	.446	.217	.129	.696	.861	.836	.423	.546	.844	.744	.640	.242	.371	.951		.685	.724	.432	.073	.093	.153
	IPS (L)	.065	.178	.506	.263	.926	.792	.743	.984	.887	.978	.667	.927	.890	.759	.877	.685		.917	.563	.032	.232	.026
	IPS (R)	.015	.026	.457	.056	.740	.451	.692	.896	.633	.912	.418	.826	.958	.126	.745	.724	.917		.613	.281	.535	.122
FPN	LPFC (L)	.020	.095	.385	.363	.436	.051	.421	.530	.779	.661	.325	.450	.769	.778	.357	.432	.563	.613		.540	.050	.348
	PPC (L)	.331	.207	.790	.107	.082	.042	.333	.170	.758	.563	.319	.118	.427	.814	.119	.073	.032	.281	.540		.285	.910
	LPFC (R)	.091	.043	.468	.248	.088	.005	.045	.095	.801	.176	.039	.147	.460	.896	.148	.093	.232	.535	.050	.285		.832
	PPC (R)	.693	.451	.704	.632	.009	<.001	.078	.012	.002	.024	.040	.418	.012	.072	.296	.153	.026	.122	.348	.910	.832	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 88.
Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern group > healthy control group during right foot movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.974	.977	.336	.069	.148	.135	.248	.062	.114	.248	.171	.226	.123	.030	.448	.092	.126	.322	.875	.168	.941
	LP (L)	.974		.990	.422	.088	.048	.149	.480	.148	.189	.029	.064	.174	.117	.068	.244	.106	.207	.580	.793	.300	.875
	LP (R)	.977	.990		.343	.088	.044	.170	.602	.185	.465	.320	.179	.330	.113	.047	.354	.215	.117	.564	.749	.324	.805
	PCC	.336	.422	.343		.586	.637	.229	.669	.770	.464	.103	.288	.636	.145	.133	.536	.551	.596	.600	.264	.136	.584
SMN	Lat (L)	.069	.088	.088	.586		.987	.639	.475	.813	.865	.362	.738	.758	.850	.776	.780	.531	.836	.073	.064	.406	.072
	Lat (R)	.148	.048	.044	.637	.987		.799	.548	.882	.929	.304	.852	.846	.848	.894	.694	.533	.825	.013	.027	.297	.055
	Sup	.135	.149	.170	.229	.639	.799		.664	.676	.928	.513	.920	.934	.950	.097	.552	.561	.444	.045	.032	.087	.004
SN	ACC	.248	.480	.602	.669	.475	.548	.664		.807	.952	.413	.459	.618	.649	.515	.013	.426	.754	.016	.015	.096	.027
	AINS (L)	.062	.148	.185	.770	.813	.882	.676	.807		.902	.903	.835	.999	.972	.630	.435	.871	.967	.450	.100	.311	.010
	AINS (R)	.114	.189	.465	.464	.865	.929	.928	.952	.902		.851	.999	.968	.981	.964	.940	.864	.728	.676	.079	.197	.137
	RPFC (L)	.248	.029	.320	.103	.362	.304	.513	.413	.903	.851		.092	.955	.760	.448	.218	.216	.485	.019	.017	.002	.069
	RPFC (R)	.171	.064	.179	.288	.738	.852	.920	.459	.835	.999	.092		.941	>.999	.707	.596	.844	.917	.012	.009	.007	.044
	SMG (L)	.226	.174	.330	.636	.758	.846	.934	.618	.999	.968	.955	.941		.965	.942	.858	.875	.993	.960	.177	.898	.081
	SMG (R)	.123	.117	.113	.145	.850	.848	.950	.649	.972	.981	.760	>.999	.965		.891	.507	.612	.989	.070	.017	.240	.002
DAN	FEF (L)	.030	.068	.047	.133	.776	.894	.097	.515	.630	.964	.448	.707	.942	.891		.741	.657	.204	.426	.046	.319	.169
	FEF (R)	.448	.244	.354	.536	.780	.694	.552	.013	.435	.940	.218	.596	.858	.507	.741		.595	.586	.162	.104	.032	.035
	IPS (L)	.092	.106	.215	.551	.531	.533	.561	.426	.871	.864	.216	.844	.875	.612	.657	.595		.868	.316	.006	.452	.002
	IPS (R)	.126	.207	.117	.596	.836	.825	.444	.754	.967	.728	.485	.917	.993	.989	.204	.586	.868		.470	.145	.728	.052
FPN	LPFC (L)	.322	.580	.564	.600	.073	.013	.045	.016	.450	.676	.019	.012	.960	.070	.426	.162	.316	.470		.216	.374	.323
	PPC (L)	.875	.793	.749	.264	.064	.027	.032	.015	.100	.079	.017	.009	.177	.017	.046	.104	.006	.145	.216		.704	.862
	LPFC (R)	.168	.300	.324	.136	.406	.297	.087	.096	.311	.197	.002	.007	.898	.240	.319	.032	.452	.728	.374	.704		.676
	PPC (R)	.941	.875	.805	.584	.072	.055	.004	.027	.010	.137	.069	.044	.081	.002	.169	.035	.002	.052	.323	.862	.676	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 89.
Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern group > healthy control group during tongue movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.744	.461	.220	.118	.357	.430	.523	.044	.097	.370	.056	.170	.047	.238	.095	.355	.146	.281	.828	.240	.436
	LP (L)	.744		.477	.207	.973	.988	.531	.934	.900	.451	.841	.589	.245	.454	.376	.185	.901	.570	.672	.565	.346	.424
	LP (R)	.461	.477		.098	.971	.666	.489	.970	.883	.722	.928	.683	.356	.631	.934	.628	.921	.694	.717	.402	.459	.098
	PCC	.220	.207	.098		.939	.859	.402	.817	.848	.704	.522	.651	.187	.015	.323	.440	.771	.506	.419	.166	.232	.002
SMN	Lat (L)	.118	.973	.971	.939		.960	.668	.461	.194	.807	.657	.809	.709	.821	.455	.088	.834	.675	.332	.349	.515	.212
	Lat (R)	.357	.988	.666	.859	.960		.843	.606	.659	.720	.921	.456	.918	.063	.818	.144	.975	.316	.861	.409	.661	.001
	Sup	.430	.531	.489	.402	.668	.843		.280	.122	.426	.234	.246	.815	.573	.513	.368	.582	.498	.080	.100	.175	.003
SN	ACC	.523	.934	.970	.817	.461	.606	.280		.778	.699	.091	.011	.140	.561	.713	.154	.301	.397	.271	.957	.032	.506
	AINS (L)	.044	.900	.883	.848	.194	.659	.122	.778		.846	.962	.959	.497	.822	.264	.358	.833	.825	.814	.813	.695	.761
	AINS (R)	.097	.451	.722	.704	.807	.720	.426	.699	.846		.935	.991	.707	.988	.803	.611	.990	.995	.315	.721	.737	.636
	RPFC (L)	.370	.841	.928	.522	.657	.921	.234	.091	.962	.935		.200	.591	.791	.392	.172	.722	.888	.363	.665	.033	.522
	RPFC (R)	.056	.589	.683	.651	.809	.456	.246	.011	.959	.991	.200		.860	.863	.483	.326	.839	.840	.429	.357	.072	.290
	SMG (L)	.170	.245	.356	.187	.709	.918	.815	.140	.497	.707	.591	.860		.687	.189	.132	.786	.629	.523	.156	.728	.052
	SMG (R)	.047	.454	.631	.015	.821	.063	.573	.561	.822	.988	.791	.863	.687		.276	.430	.647	.479	.678	.221	.801	.083
DAN	FEF (L)	.238	.376	.934	.323	.455	.818	.513	.713	.264	.803	.392	.483	.189	.276		.546	.734	.781	.013	.024	.225	.107
	FEF (R)	.095	.185	.628	.440	.088	.144	.368	.154	.358	.611	.172	.326	.132	.430	.546		.148	.329	.072	.061	.027	.230
	IPS (L)	.355	.901	.921	.771	.834	.975	.582	.301	.833	.990	.722	.839	.786	.647	.734	.148		.826	.169	.038	.454	.149
	IPS (R)	.146	.570	.694	.506	.675	.316	.498	.397	.825	.995	.888	.840	.629	.479	.781	.329	.826		.826	.037	.825	.111
FPN	LPFC (L)	.281	.672	.717	.419	.332	.861	.080	.271	.814	.315	.363	.429	.523	.678	.013	.072	.169	.826		.861	.489	.903
	PPC (L)	.828	.565	.402	.166	.349	.409	.100	.957	.813	.721	.665	.357	.156	.221	.024	.061	.038	.037	.861		.636	.977
	LPFC (R)	.240	.346	.459	.232	.515	.661	.175	.032	.695	.737	.033	.072	.728	.801	.225	.027	.454	.825	.489	.636		.437
	PPC (R)	.436	.424	.098	.002	.212	.001	.003	.506	.761	.636	.522	.290	.052	.083	.107	.230	.149	.111	.903	.977	.437	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 90.
Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern group > diffuse tumor growth pattern group during left hand movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.826	.807	.125	.080	.066	.026	.231	.576	.366	.096	.246	.522	.954	.442	.849	.335	.148	.415	.770	.746	.594
	LP (L)	.826		.742	.802	.002	.006	.212	.320	.219	.274	.427	.175	.340	.371	.119	.624	.077	.088	.575	.803	.495	.810
	LP (R)	.807	.742		.923	.135	.097	.643	.504	.514	.259	.480	.110	.795	.675	.492	.835	.530	.261	.560	.385	.063	.410
	PCC	.125	.802	.923		.012	.003	.155	.080	.268	.221	.217	.019	.618	.911	.458	.481	.452	.039	.361	.862	.180	.790
SMN	Lat (L)	.080	.002	.135	.012		.117	.344	.777	.047	.186	.981	.898	.831	.362	.307	.974	.456	.195	.282	.157	.292	.587
	Lat (R)	.066	.006	.097	.003	.117		.257	.584	.121	.278	.809	.806	.787	.734	.726	.901	.325	.345	.203	.134	.285	.738
	Sup	.026	.212	.643	.155	.344	.257		.030	.757	.767	.136	.133	.625	.957	.624	.466	.568	.976	.071	.489	.150	.928
SN	ACC	.231	.320	.504	.080	.777	.584	.030		.582	.059	.315	.719	.656	.725	.189	.193	.241	.367	.166	.171	.740	.436
	AINS (L)	.576	.219	.514	.268	.047	.121	.757	.582		.246	.849	.604	.140	.345	.184	.573	.179	.472	.371	.456	.654	.523
	AINS (R)	.366	.274	.259	.221	.186	.278	.767	.059	.246		.355	.309	.531	.486	.501	.737	.441	.685	.467	.560	.583	.765
	RPFC (L)	.096	.427	.480	.217	.981	.809	.136	.315	.849	.355		.533	.743	.619	.162	.123	.486	.407	.126	.138	.229	.302
	RPFC (R)	.246	.175	.110	.019	.898	.806	.133	.719	.604	.309	.533		.695	.411	.201	.155	.296	.648	.425	.308	.626	.248
	SMG (L)	.522	.340	.795	.618	.831	.787	.625	.656	.140	.531	.743	.695		.765	.344	.432	.665	.552	.935	.958	.295	.722
	SMG (R)	.954	.371	.675	.911	.362	.734	.957	.725	.345	.486	.619	.411	.765		.720	.513	.528	.311	.505	.745	.016	.716
DAN	FEF (L)	.442	.119	.492	.458	.307	.726	.624	.189	.184	.501	.162	.201	.344	.720		.654	.299	.780	.241	.286	.266	.821
	FEF (R)	.849	.624	.835	.481	.974	.901	.466	.193	.573	.737	.123	.155	.432	.513	.654		.377	.320	.761	.709	.254	.365
	IPS (L)	.335	.077	.530	.452	.456	.325	.568	.241	.179	.441	.486	.296	.665	.528	.299	.377		.739	.020	.414	.069	.348
	IPS (R)	.148	.088	.261	.039	.195	.345	.976	.367	.472	.685	.407	.648	.552	.311	.780	.320	.739		.133	.390	.074	.654
FPN	LPFC (L)	.415	.575	.560	.361	.282	.203	.071	.166	.371	.467	.126	.425	.935	.505	.241	.761	.020	.133		.307	.483	.505
	PPC (L)	.770	.803	.385	.862	.157	.134	.489	.171	.456	.560	.138	.308	.958	.745	.286	.709	.414	.390	.307		.365	.925
	LPFC (R)	.746	.495	.063	.180	.292	.285	.150	.740	.654	.583	.229	.626	.295	.016	.266	.254	.069	.074	.483	.365		.045
	PPC (R)	.594	.810	.410	.790	.587	.738	.928	.436	.523	.765	.302	.248	.722	.716	.821	.365	.348	.654	.505	.925	.045	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 91.
Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern group > diffuse tumor growth pattern group during right hand movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.583	.578	.238	.914	.681	.898	.674	.830	.804	.758	.897	.776	.838	.837	.976	.964	.939	.488	.530	.801	.639
	LP (L)	.583		.508	.085	.373	.366	.712	.649	.274	.437	.216	.262	.647	.550	.789	.804	.618	.478	.293	.735	.028	.535
	LP (R)	.578	.508		.634	.483	.716	.662	.709	.173	.599	.704	.750	.684	.664	.899	.937	.613	.653	.880	.727	.204	.396
	PCC	.238	.085	.634		.900	.973	.901	.914	.832	.864	.462	.543	.959	.826	.883	.751	.951	.825	.373	.492	.250	.824
SMN	Lat (L)	.914	.373	.483	.900		.311	.625	.794	.300	.311	.904	.447	.326	.086	.735	.940	.883	.356	.324	.333	.612	.099
	Lat (R)	.681	.366	.716	.973	.311		.479	.794	.420	.686	.971	.863	.400	.854	.736	.986	.672	.716	.846	.548	.486	.313
	Sup	.898	.712	.662	.901	.625	.479		.679	.870	.933	.520	.259	.486	.554	.292	.575	.794	.700	.848	.903	.771	.889
SN	ACC	.674	.649	.709	.914	.794	.794	.679		.761	.626	.948	.393	.771	.419	.520	.895	.864	.398	.861	.452	.968	.516
	AINS (L)	.830	.274	.173	.832	.300	.420	.870	.761		.166	.687	.386	.024	.149	.777	.895	.220	.134	.124	.368	.251	.091
	AINS (R)	.804	.437	.599	.864	.311	.686	.933	.626	.166		.877	.764	.172	.512	.947	.839	.607	.491	.207	.414	.415	.105
	RPFC (L)	.758	.216	.704	.462	.904	.971	.520	.948	.687	.877		.245	.701	.040	.338	.852	.422	.123	.737	.189	.776	.429
	RPFC (R)	.897	.262	.750	.543	.447	.863	.259	.393	.386	.764	.245		.353	.262	.098	.686	.431	.206	.265	.104	.735	.280
	SMG (L)	.776	.647	.684	.959	.326	.400	.486	.771	.024	.172	.701	.353		.266	.048	.607	.285	.266	.708	.582	.357	.720
	SMG (R)	.838	.550	.664	.826	.086	.854	.554	.419	.149	.512	.040	.262	.266		.302	.185	.027	.131	.446	.217	.165	.435
DAN	FEF (L)	.837	.789	.899	.883	.735	.736	.292	.520	.777	.947	.338	.098	.048	.302		.401	.602	.210	.770	.831	.252	.716
	FEF (R)	.976	.804	.937	.751	.940	.986	.575	.895	.895	.839	.852	.686	.607	.185	.401		.872	.704	.908	.456	.710	.856
	IPS (L)	.964	.618	.613	.951	.883	.672	.794	.864	.220	.607	.422	.431	.285	.027	.602	.872		.312	.512	.739	.420	.475
	IPS (R)	.939	.478	.653	.825	.356	.716	.700	.398	.134	.491	.123	.206	.266	.131	.210	.704	.312		.705	.480	.219	.899
FPN	LPFC (L)	.488	.293	.880	.373	.324	.846	.848	.861	.124	.207	.737	.265	.708	.446	.770	.908	.512	.705		.601	.159	.395
	PPC (L)	.530	.735	.727	.492	.333	.548	.903	.452	.368	.414	.189	.104	.582	.217	.831	.456	.739	.480	.601		.336	.382
	LPFC (R)	.801	.028	.204	.250	.612	.486	.771	.968	.251	.415	.776	.735	.357	.165	.252	.710	.420	.219	.159	.336		.201
	PPC (R)	.639	.535	.396	.824	.099	.313	.889	.516	.091	.105	.429	.280	.720	.435	.716	.856	.475	.899	.395	.382	.201	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 92.
Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern group > diffuse tumor growth pattern group during left foot movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.892	.576	.749	.152	.231	.011	.751	.232	.106	.842	.347	.459	.533	.062	.556	.070	.279	.240	.038	.130	.391
	LP (L)	.892		.885	.502	.715	.654	.228	.774	.206	.344	.424	.241	.466	.766	.070	.331	.119	.713	.486	.197	.096	.801
	LP (R)	.576	.885		.235	.482	.886	.691	.979	.229	.733	.482	.527	.420	.799	.551	.410	.595	.795	.306	.138	.205	.403
	PCC	.749	.502	.235		.153	.272	.170	.575	.198	.497	.056	.179	.234	.435	.212	.052	.107	.433	.625	.151	.075	.794
SMN	Lat (L)	.152	.715	.482	.153		.011	.111	.154	.609	.060	.112	.250	.792	.030	.447	.236	.126	.050	.778	.547	.486	.198
	Lat (R)	.231	.654	.886	.272	.011		.036	.103	.187	.080	.051	.687	.525	.380	.214	.300	.062	.413	.330	.229	.523	.311
	Sup	.011	.228	.691	.170	.111	.036		.008	.295	.040	.139	.156	.496	.078	.346	.279	.532	.106	.438	.734	.350	.395
SN	ACC	.751	.774	.979	.575	.154	.103	.008		.194	.097	.388	.586	.277	.210	.385	.521	.018	.091	.881	.443	.420	.288
	AINS (L)	.232	.206	.229	.198	.609	.187	.295	.194		.355	.104	.682	.424	.011	.364	.438	.033	.064	.665	.924	.736	.020
	AINS (R)	.106	.344	.733	.497	.060	.080	.040	.097	.355		.101	.579	.746	.174	.158	.938	.117	.090	.601	.968	.676	.592
	RPFC (L)	.842	.424	.482	.056	.112	.051	.139	.388	.104	.101		.317	.090	.043	.210	.670	.006	.005	.747	.243	.479	.016
	RPFC (R)	.347	.241	.527	.179	.250	.687	.156	.586	.682	.579	.317		.338	.610	.168	.849	.142	.671	.353	.159	.749	.834
	SMG (L)	.459	.466	.420	.234	.792	.525	.496	.277	.424	.746	.090	.338		.706	.766	.261	.232	.215	.873	.980	.830	.222
	SMG (R)	.533	.766	.799	.435	.030	.380	.078	.210	.011	.174	.043	.610	.706		.390	.670	.079	.021	.901	.990	.917	.516
DAN	FEF (L)	.062	.070	.551	.212	.447	.214	.346	.385	.364	.158	.210	.168	.766	.390		.182	.716	.349	.685	.693	.347	.683
	FEF (R)	.556	.331	.410	.052	.236	.300	.279	.521	.438	.938	.670	.849	.261	.670	.182		.151	.306	.280	.121	.674	.419
	IPS (L)	.070	.119	.595	.107	.126	.062	.532	.018	.033	.117	.006	.142	.232	.079	.716	.151		.210	.633	.739	.367	.428
	IPS (R)	.279	.713	.795	.433	.050	.413	.106	.091	.064	.090	.005	.671	.215	.021	.349	.306	.210		.588	.892	.834	.515
FPN	LPFC (L)	.240	.486	.306	.625	.778	.330	.438	.881	.665	.601	.747	.353	.873	.901	.685	.280	.633	.588		.371	.106	.499
	PPC (L)	.038	.197	.138	.151	.547	.229	.734	.443	.924	.968	.243	.159	.980	.990	.693	.121	.739	.892	.371		.191	.889
	LPFC (R)	.130	.096	.205	.075	.486	.523	.350	.420	.736	.676	.479	.749	.830	.917	.347	.674	.367	.834	.106	.191		.561
	PPC (R)	.391	.801	.403	.794	.198	.311	.395	.288	.020	.592	.016	.834	.222	.516	.683	.419	.428	.515	.499	.889	.561	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 93.
Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern group > diffuse tumor growth pattern group during right foot movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.651	.439	.073	.495	.716	.113	.421	.395	.243	.326	.525	.482	.168	.086	.656	.116	.237	.559	.056	.397	.658
	LP (L)	.651		.746	.085	.114	.083	.148	.110	.153	.433	.028	.080	.201	.279	.081	.650	.024	.126	.054	.108	.415	.702
	LP (R)	.439	.746		.171	.051	.050	.059	.080	.209	.576	.086	.132	.081	.337	.002	.859	.056	.107	.086	.315	.335	.834
	PCC	.073	.085	.171		.656	.902	.635	.291	.619	.922	.121	.241	.844	.698	.085	.705	.374	.650	.037	.018	.180	.847
SMN	Lat (L)	.495	.114	.051	.656		.000	.087	.136	.726	.361	.612	.448	.433	.121	.226	.036	.202	.062	.025	.289	.120	.015
	Lat (R)	.716	.083	.050	.902	.000		.523	.767	.669	.693	.375	.789	.380	.773	.553	.290	.060	.705	<.001	.008	.076	.043
	Sup	.113	.148	.059	.635	.087	.523		.594	.652	.881	.702	.882	.905	.977	.463	.193	.288	.583	.034	.367	.438	.229
SN	ACC	.421	.110	.080	.291	.136	.767	.594		.953	.987	.343	.754	.823	.305	.338	.032	.307	.719	.057	.003	.078	.015
	AINS (L)	.395	.153	.209	.619	.726	.669	.652	.953		.958	.944	.974	.906	.650	.560	.128	.798	.717	.118	.176	.282	.047
	AINS (R)	.243	.433	.576	.922	.361	.693	.881	.987	.958		.978	.990	.950	.556	.413	.888	.737	.632	.289	.435	.534	.317
	RPFC (L)	.326	.028	.086	.121	.612	.375	.702	.343	.944	.978		.558	.909	.295	.243	.233	.490	.612	.045	.001	.006	.049
	RPFC (R)	.525	.080	.132	.241	.448	.789	.882	.754	.974	.990	.558		.962	.668	.162	.326	.899	.851	.051	.038	.181	.166
	SMG (L)	.482	.201	.081	.844	.433	.380	.905	.823	.906	.950	.909	.962		.827	.968	.621	.434	.779	.492	.262	.510	.104
	SMG (R)	.168	.279	.337	.698	.121	.773	.977	.305	.650	.556	.295	.668	.827		.852	.529	.678	.912	.007	.205	.019	.198
DAN	FEF (L)	.086	.081	.002	.085	.226	.553	.463	.338	.560	.413	.243	.162	.968	.852		.600	.381	.094	.153	.113	.247	.128
	FEF (R)	.656	.650	.859	.705	.036	.290	.193	.032	.128	.888	.233	.326	.621	.529	.600		.031	.309	.160	.128	.183	.101
	IPS (L)	.116	.024	.056	.374	.202	.060	.288	.307	.798	.737	.490	.899	.434	.678	.381	.031		.522	.020	.236	.167	.055
	IPS (R)	.237	.126	.107	.650	.062	.705	.583	.719	.717	.632	.612	.851	.779	.912	.094	.309	.522		.017	.181	.129	.188
FPN	LPFC (L)	.559	.054	.086	.037	.025	<.001	.034	.057	.118	.289	.045	.051	.492	.007	.153	.160	.020	.017		.019	.022	.022
	PPC (L)	.056	.108	.315	.018	.289	.008	.367	.003	.176	.435	.001	.038	.262	.205	.113	.128	.236	.181	.019		.400	.187
	LPFC (R)	.397	.415	.335	.180	.120	.076	.438	.078	.282	.534	.006	.181	.510	.019	.247	.183	.167	.129	.022	.400		.433
	PPC (R)	.658	.702	.834	.847	.015	.043	.229	.015	.047	.317	.049	.166	.104	.198	.128	.101	.055	.188	.022	.187	.433	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 94.
Summary of p-values of one-tailed t-tests of the uniform tumor growth pattern group > diffuse tumor growth pattern group during tongue movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.225	.166	.415	.326	.742	.735	.567	.287	.861	.554	.905	.398	.566	.426	.248	.701	.945	.646	.231	.905	.106
	LP (L)	.225		.702	.635	.789	.874	.934	.971	.671	.626	.557	.769	.731	.868	.509	.762	.762	.516	.651	.867	.856	.544
	LP (R)	.166	.702		.190	.877	.730	.839	.921	.723	.613	.930	.755	.608	.865	.898	.593	.769	.400	.914	.642	.984	.085
	PCC	.415	.635	.190		.441	.345	.663	.910	.339	.404	.511	.575	.299	.337	.255	.222	.362	.235	.829	.615	.764	.250
SMN	Lat (L)	.326	.789	.877	.441		.842	.801	.259	.044	.656	.223	.438	.130	.730	.090	.041	.746	.766	.299	.687	.674	.863
	Lat (R)	.742	.874	.730	.345	.842		.862	.587	.345	.861	.713	.146	.291	.517	.738	.405	.714	.221	.686	.688	.656	.174
	Sup	.735	.934	.839	.663	.801	.862		.531	.488	.466	.348	.806	.322	.702	.464	.791	.879	.988	.578	.877	.841	.821
SN	ACC	.567	.971	.921	.910	.259	.587	.531		.053	.388	.536	.198	.281	.606	.361	.042	.724	.729	.916	.981	.341	.396
	AINS (L)	.287	.671	.723	.339	.044	.345	.488	.053		.465	.061	.128	.445	.877	.100	.017	.210	.310	.121	.580	.030	.338
	AINS (R)	.861	.626	.613	.404	.656	.861	.466	.388	.465		.446	.383	.472	.964	.769	.791	.937	.947	.752	.997	.251	.599
	RPFC (L)	.554	.557	.930	.511	.223	.713	.348	.536	.061	.446		.111	.486	.827	.292	.014	.580	.801	.670	.882	.034	.425
	RPFC (R)	.905	.769	.755	.575	.438	.146	.806	.198	.128	.383	.111		.186	.228	.344	.038	.377	.329	.710	.778	.047	.490
	SMG (L)	.398	.731	.608	.299	.130	.291	.322	.281	.445	.472	.486	.186		.222	.290	.142	.087	.239	.308	.852	.128	.593
	SMG (R)	.566	.868	.865	.337	.730	.517	.702	.606	.877	.964	.827	.228	.222		.572	.552	.442	.474	.687	.900	.343	.299
DAN	FEF (L)	.426	.509	.898	.255	.090	.738	.464	.361	.100	.769	.292	.344	.290	.572		.426	.677	.901	.316	.879	.469	.828
	FEF (R)	.248	.762	.593	.222	.041	.405	.791	.042	.017	.791	.014	.038	.142	.552	.426		.192	.632	.017	.509	.049	.575
	IPS (L)	.701	.762	.769	.362	.746	.714	.879	.724	.210	.937	.580	.377	.087	.442	.677	.192		.747	.348	.773	.470	.786
	IPS (R)	.945	.516	.400	.235	.766	.221	.988	.729	.310	.947	.801	.329	.239	.474	.901	.632	.747		.921	.851	.850	.662
FPN	LPFC (L)	.646	.651	.914	.829	.299	.686	.578	.916	.121	.752	.670	.710	.308	.687	.316	.017	.348	.921		.819	.742	.590
	PPC (L)	.231	.867	.642	.615	.687	.688	.877	.981	.580	.997	.882	.778	.852	.900	.879	.509	.773	.851	.819		.850	.584
	LPFC (R)	.905	.856	.984	.764	.674	.656	.841	.341	.030	.251	.034	.047	.128	.343	.469	.049	.470	.850	.742	.850		.493
	PPC (R)	.106	.544	.085	.250	.863	.174	.821	.396	.338	.599	.425	.490	.593	.299	.828	.575	.786	.662	.590	.584	.493	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 95.
Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > uniform tumor growth pattern group during left hand movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.174	.193	.875	.920	.934	.974	.769	.424	.634	.904	.754	.478	.046	.558	.151	.665	.852	.585	.230	.254	.406
	LP (L)	.174		.258	.198	.998	.994	.788	.680	.781	.726	.573	.825	.660	.629	.881	.376	.923	.912	.425	.197	.505	.190
	LP (R)	.193	.258		.077	.865	.903	.357	.496	.486	.741	.520	.890	.205	.325	.508	.165	.470	.739	.440	.615	.937	.590
	PCC	.875	.198	.077		.988	.997	.845	.920	.732	.779	.783	.981	.382	.089	.542	.519	.548	.961	.639	.138	.820	.210
SMN	Lat (L)	.920	.998	.865	.988		.883	.656	.223	.953	.814	.019	.102	.169	.638	.693	.026	.544	.805	.718	.843	.708	.413
	Lat (R)	.934	.994	.903	.997	.883		.743	.416	.879	.722	.191	.194	.213	.266	.274	.099	.675	.655	.797	.866	.715	.262
	Sup	.974	.788	.357	.845	.656	.743		.970	.243	.233	.864	.867	.375	.043	.376	.534	.432	.024	.929	.511	.850	.072
SN	ACC	.769	.680	.496	.920	.223	.416	.970		.418	.941	.685	.281	.344	.275	.811	.807	.759	.633	.834	.829	.260	.564
	AINS (L)	.424	.781	.486	.732	.953	.879	.243	.418		.754	.151	.396	.860	.655	.816	.427	.821	.528	.629	.544	.346	.477
	AINS (R)	.634	.726	.741	.779	.814	.722	.233	.941	.754		.645	.691	.469	.514	.499	.263	.559	.315	.533	.440	.417	.235
	RPFC (L)	.904	.573	.520	.783	.019	.191	.864	.685	.151	.645		.467	.257	.381	.838	.877	.514	.593	.874	.862	.771	.698
	RPFC (R)	.754	.825	.890	.981	.102	.194	.867	.281	.396	.691	.467		.305	.589	.799	.845	.704	.352	.575	.692	.374	.752
	SMG (L)	.478	.660	.205	.382	.169	.213	.375	.344	.860	.469	.257	.305		.235	.656	.568	.335	.448	.065	.042	.705	.278
	SMG (R)	.046	.629	.325	.089	.638	.266	.043	.275	.655	.514	.381	.589	.235		.280	.487	.472	.689	.495	.255	.984	.284
DAN	FEF (L)	.558	.881	.508	.542	.693	.274	.376	.811	.816	.499	.838	.799	.656	.280		.346	.701	.220	.759	.714	.734	.179
	FEF (R)	.151	.376	.165	.519	.026	.099	.534	.807	.427	.263	.877	.845	.568	.487	.346		.623	.680	.239	.291	.746	.635
	IPS (L)	.665	.923	.470	.548	.544	.675	.432	.759	.821	.559	.514	.704	.335	.472	.701	.623		.261	.980	.586	.931	.652
	IPS (R)	.852	.912	.739	.961	.805	.655	.024	.633	.528	.315	.593	.352	.448	.689	.220	.680	.261		.867	.610	.926	.346
FPN	LPFC (L)	.585	.425	.440	.639	.718	.797	.929	.834	.629	.533	.874	.575	.065	.495	.759	.239	.980	.867		.693	.517	.495
	PPC (L)	.230	.197	.615	.138	.843	.866	.511	.829	.544	.440	.862	.692	.042	.255	.714	.291	.586	.610	.693		.635	.075
	LPFC (R)	.254	.505	.937	.820	.708	.715	.850	.260	.346	.417	.771	.374	.705	.984	.734	.746	.931	.926	.517	.635		.955
	PPC (R)	.406	.190	.590	.210	.413	.262	.072	.564	.477	.235	.698	.752	.278	.284	.179	.635	.652	.346	.495	.075	.955	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 96.
Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > uniform tumor growth pattern group during right hand movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.417	.422	.762	.086	.319	.102	.326	.170	.196	.242	.103	.224	.162	.163	.024	.036	.061	.512	.470	.199	.361
	LP (L)	.417		.492	.915	.627	.634	.288	.351	.726	.563	.784	.738	.353	.450	.211	.196	.382	.522	.707	.265	.972	.465
	LP (R)	.422	.492		.366	.517	.284	.338	.291	.827	.401	.296	.250	.316	.336	.101	.063	.387	.347	.120	.273	.796	.604
	PCC	.762	.915	.366		.100	.027	.099	.086	.168	.136	.538	.457	.041	.174	.117	.249	.049	.175	.627	.508	.750	.176
SMN	Lat (L)	.086	.627	.517	.100		.689	.375	.206	.700	.689	.096	.553	.674	.914	.265	.060	.117	.644	.676	.667	.388	.901
	Lat (R)	.319	.634	.284	.027	.689		.521	.206	.580	.314	.029	.137	.600	.146	.264	.014	.328	.284	.154	.452	.514	.687
	Sup	.102	.288	.338	.099	.375	.521		.321	.130	.067	.480	.741	.514	.446	.708	.425	.206	.300	.152	.097	.229	.111
SN	ACC	.326	.351	.291	.086	.206	.206	.321		.239	.374	.052	.607	.229	.581	.480	.105	.136	.602	.139	.548	.032	.484
	AINS (L)	.170	.726	.827	.168	.700	.580	.130	.239		.834	.313	.614	.976	.851	.223	.105	.780	.866	.876	.632	.749	.909
	AINS (R)	.196	.563	.401	.136	.689	.314	.067	.374	.834		.123	.236	.828	.488	.053	.161	.393	.509	.793	.586	.585	.895
	RPFC (L)	.242	.784	.296	.538	.096	.029	.480	.052	.313	.123		.755	.299	.960	.662	.148	.578	.877	.263	.811	.224	.571
	RPFC (R)	.103	.738	.250	.457	.553	.137	.741	.607	.614	.236	.755		.647	.738	.902	.314	.569	.794	.735	.896	.265	.720
	SMG (L)	.224	.353	.316	.041	.674	.600	.514	.229	.976	.828	.299	.647		.734	.952	.393	.715	.734	.292	.418	.643	.280
	SMG (R)	.162	.450	.336	.174	.914	.146	.446	.581	.851	.488	.960	.738	.734		.698	.815	.973	.869	.554	.783	.835	.565
DAN	FEF (L)	.163	.211	.101	.117	.265	.264	.708	.480	.223	.053	.662	.902	.952	.698		.599	.398	.790	.230	.169	.748	.284
	FEF (R)	.024	.196	.063	.249	.060	.014	.425	.105	.105	.161	.148	.314	.393	.815	.599		.128	.296	.092	.544	.290	.144
	IPS (L)	.036	.382	.387	.049	.117	.328	.206	.136	.780	.393	.578	.569	.715	.973	.398	.128		.688	.488	.261	.580	.525
	IPS (R)	.061	.522	.347	.175	.644	.284	.300	.602	.866	.509	.877	.794	.734	.869	.790	.296	.688		.295	.520	.781	.101
FPN	LPFC (L)	.512	.707	.120	.627	.676	.154	.152	.139	.876	.793	.263	.735	.292	.554	.230	.092	.488	.295		.399	.841	.605
	PPC (L)	.470	.265	.273	.508	.667	.452	.097	.548	.632	.586	.811	.896	.418	.783	.169	.544	.261	.520	.399		.664	.618
	LPFC (R)	.199	.972	.796	.750	.388	.514	.229	.032	.749	.585	.224	.265	.643	.835	.748	.290	.580	.781	.841	.664		.799
	PPC (R)	.361	.465	.604	.176	.901	.687	.111	.484	.909	.895	.571	.720	.280	.565	.284	.144	.525	.101	.605	.618	.799	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 97.
Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > uniform tumor growth pattern group during left foot movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.108	.424	.251	.848	.769	.989	.249	.768	.894	.158	.653	.541	.467	.938	.444	.930	.721	.760	.962	.870	.609
	LP (L)	.108		.115	.498	.285	.346	.772	.226	.794	.656	.576	.759	.534	.234	.930	.669	.881	.287	.514	.803	.904	.199
	LP (R)	.424	.115		.765	.518	.114	.309	.021	.771	.267	.518	.473	.580	.201	.449	.590	.405	.205	.694	.862	.795	.597
	PCC	.251	.498	.765		.847	.728	.830	.425	.802	.503	.944	.821	.766	.565	.788	.948	.893	.567	.375	.849	.925	.206
SMN	Lat (L)	.848	.285	.518	.847		.989	.889	.846	.391	.940	.888	.750	.208	.970	.553	.764	.874	.950	.222	.453	.514	.802
	Lat (R)	.769	.346	.114	.728	.989		.964	.897	.813	.920	.949	.313	.475	.620	.786	.700	.938	.587	.670	.771	.477	.689
	Sup	.989	.772	.309	.830	.889	.964		.992	.705	.960	.861	.844	.504	.922	.654	.721	.468	.894	.562	.266	.650	.605
SN	ACC	.249	.226	.021	.425	.846	.897	.992		.806	.903	.612	.414	.723	.790	.615	.479	.982	.909	.119	.557	.580	.712
	AINS (L)	.768	.794	.771	.802	.391	.813	.705	.806		.645	.896	.318	.576	.989	.636	.562	.967	.936	.335	.076	.264	.980
	AINS (R)	.894	.656	.267	.503	.940	.920	.960	.903	.645		.899	.421	.254	.826	.842	.062	.883	.910	.399	.032	.324	.408
	RPFC (L)	.158	.576	.518	.944	.888	.949	.861	.612	.896	.899		.683	.910	.957	.790	.330	.994	.995	.253	.757	.521	.984
	RPFC (R)	.653	.759	.473	.821	.750	.313	.844	.414	.318	.421	.683		.662	.390	.832	.151	.858	.329	.647	.841	.251	.166
	SMG (L)	.541	.534	.580	.766	.208	.475	.504	.723	.576	.254	.910	.662		.294	.234	.739	.768	.785	.127	.020	.170	.778
	SMG (R)	.467	.234	.201	.565	.970	.620	.922	.790	.989	.826	.957	.390	.294		.610	.330	.921	.979	.099	.010	.083	.484
DAN	FEF (L)	.938	.930	.449	.788	.553	.786	.654	.615	.636	.842	.790	.832	.234	.610		.818	.284	.651	.315	.307	.653	.317
	FEF (R)	.444	.669	.590	.948	.764	.700	.721	.479	.562	.062	.330	.151	.739	.330	.818		.849	.694	.720	.879	.326	.581
	IPS (L)	.930	.881	.405	.893	.874	.938	.468	.982	.967	.883	.994	.858	.768	.921	.284	.849		.790	.367	.261	.633	.572
	IPS (R)	.721	.287	.205	.567	.950	.587	.894	.909	.936	.910	.995	.329	.785	.979	.651	.694	.790		.412	.108	.166	.485
FPN	LPFC (L)	.760	.514	.694	.375	.222	.670	.562	.119	.335	.399	.253	.647	.127	.099	.315	.720	.367	.412		.629	.894	.501
	PPC (L)	.962	.803	.862	.849	.453	.771	.266	.557	.076	.032	.757	.841	.020	.010	.307	.879	.261	.108	.629		.809	.111
	LPFC (R)	.870	.904	.795	.925	.514	.477	.650	.580	.264	.324	.521	.251	.170	.083	.653	.326	.633	.166	.894	.809		.439
	PPC (R)	.609	.199	.597	.206	.802	.689	.605	.712	.980	.408	.984	.166	.778	.484	.317	.581	.572	.485	.501	.111	.439	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 98.
Summary of p-values of one-tailed t-tests of the diffuse tumor growth pattern group > uniform tumor growth pattern group during right foot movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.349	.561	.927	.505	.284	.887	.579	.605	.757	.674	.475	.518	.832	.914	.344	.884	.763	.441	.944	.603	.342
	LP (L)	.349		.254	.915	.886	.917	.852	.890	.847	.567	.972	.920	.799	.721	.919	.350	.976	.874	.946	.892	.585	.298
	LP (R)	.561	.254		.829	.949	.950	.941	.920	.791	.424	.914	.868	.919	.663	.998	.141	.944	.893	.914	.685	.665	.166
	PCC	.927	.915	.829		.344	.098	.365	.709	.381	.078	.879	.759	.156	.302	.915	.295	.626	.350	.963	.982	.820	.153
SMN	Lat (L)	.505	.886	.949	.344		>.999	.913	.864	.274	.639	.388	.552	.567	.879	.774	.964	.798	.938	.975	.711	.880	.985
	Lat (R)	.284	.917	.950	.098	>.999		.477	.233	.331	.307	.625	.211	.620	.227	.447	.710	.940	.295	>.999	.992	.924	.957
	Sup	.887	.852	.941	.365	.913	.477		.406	.348	.119	.298	.118	.095	.023	.537	.807	.712	.417	.966	.633	.562	.771
SN	ACC	.579	.890	.920	.709	.864	.233	.406		.047	.013	.657	.246	.177	.695	.662	.968	.693	.281	.943	.997	.922	.985
	AINS (L)	.605	.847	.791	.381	.274	.331	.348	.047		.042	.056	.026	.094	.350	.440	.872	.202	.283	.882	.824	.718	.953
	AINS (R)	.757	.567	.424	.078	.639	.307	.119	.013	.042		.022	.010	.050	.444	.587	.112	.263	.368	.711	.565	.466	.683
	RPFC (L)	.674	.972	.914	.879	.388	.625	.298	.657	.056	.022		.442	.091	.705	.757	.767	.510	.388	.955	.999	.994	.951
	RPFC (R)	.475	.920	.868	.759	.552	.211	.118	.246	.026	.010	.442		.038	.332	.838	.674	.101	.149	.949	.962	.819	.834
	SMG (L)	.518	.799	.919	.156	.567	.620	.095	.177	.094	.050	.091	.038		.173	.032	.379	.566	.221	.508	.738	.490	.896
	SMG (R)	.832	.721	.663	.302	.879	.227	.023	.695	.350	.444	.705	.332	.173		.148	.471	.322	.088	.993	.795	.981	.802
DAN	FEF (L)	.914	.919	.998	.915	.774	.447	.537	.662	.440	.587	.757	.838	.032	.148		.400	.619	.906	.847	.887	.753	.872
	FEF (R)	.344	.350	.141	.295	.964	.710	.807	.968	.872	.112	.767	.674	.379	.471	.400		.969	.691	.840	.872	.817	.899
	IPS (L)	.884	.976	.944	.626	.798	.940	.712	.693	.202	.263	.510	.101	.566	.322	.619	.969		.478	.980	.764	.833	.945
	IPS (R)	.763	.874	.893	.350	.938	.295	.417	.281	.283	.368	.388	.149	.221	.088	.906	.691	.478		.983	.819	.871	.812
FPN	LPFC (L)	.441	.946	.914	.963	.975	>.999	.966	.943	.882	.711	.955	.949	.508	.993	.847	.840	.980	.983		.981	.978	.978
	PPC (L)	.944	.892	.685	.982	.711	.992	.633	.997	.824	.565	.999	.962	.738	.795	.887	.872	.764	.819	.981		.600	.813
	LPFC (R)	.603	.585	.665	.820	.880	.924	.562	.922	.718	.466	.994	.819	.490	.981	.753	.817	.833	.871	.978	.600		.567
	PPC (R)	.342	.298	.166	.153	.985	.957	.771	.985	.953	.683	.951	.834	.896	.802	.872	.899	.945	.812	.978	.813	.567	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

Supplementary Table 99.
Summary of p-values of one-tailed t-tests of thediffuse tumor growth pattern group > uniform tumor growth pattern group during tongue movement for right hemispheric tumors.

		DMN				SMN			SN							DAN				FPN			
	ROI	MPFC	LP (L)	LP (R)	PCC	Lat (L)	Lat (R)	Sup	ACC	AINS (L)	AINS (R)	RPFC (L)	RPFC (R)	SMG (L)	SMG (R)	FEF (L)	FEF (R)	IPS (L)	IPS (R)	LPFC (L)	PPC (L)	LPFC (R)	PPC (R)
DMN	MPFC		.775	.834	.585	.674	.258	.265	.433	.713	.139	.446	.095	.602	.434	.574	.752	.299	.055	.354	.769	.095	.894
	LP (L)	.775		.298	.365	.211	.126	.066	.029	.329	.374	.443	.231	.269	.132	.491	.238	.238	.484	.349	.133	.144	.456
	LP (R)	.834	.298		.810	.123	.270	.161	.079	.277	.387	.070	.245	.392	.135	.102	.407	.231	.600	.086	.358	.016	.915
	PCC	.585	.365	.810		.559	.655	.337	.090	.661	.596	.489	.425	.701	.663	.745	.778	.638	.765	.171	.385	.236	.750
SMN	Lat (L)	.674	.211	.123	.559		.158	.199	.741	.956	.344	.777	.562	.870	.270	.910	.959	.254	.234	.701	.313	.326	.137
	Lat (R)	.258	.126	.270	.655	.158		.138	.413	.655	.139	.287	.854	.709	.483	.262	.595	.286	.779	.314	.312	.344	.826
	Sup	.265	.066	.161	.337	.199	.138		.469	.512	.534	.652	.194	.678	.298	.536	.209	.121	.012	.422	.123	.159	.179
SN	ACC	.433	.029	.079	.090	.741	.413	.469		.947	.612	.464	.802	.719	.394	.639	.958	.276	.271	.084	.019	.659	.604
	AINS (L)	.713	.329	.277	.661	.956	.655	.512	.947		.535	.939	.872	.555	.123	.900	.983	.790	.690	.879	.420	.970	.662
	AINS (R)	.139	.374	.387	.596	.344	.139	.534	.612	.535		.554	.617	.528	.036	.231	.209	.063	.053	.248	.003	.749	.401
	RPFC (L)	.446	.443	.070	.489	.777	.287	.652	.464	.939	.554		.889	.514	.173	.708	.986	.420	.199	.330	.118	.966	.575
	RPFC (R)	.095	.231	.245	.425	.562	.854	.194	.802	.872	.617	.889		.814	.772	.656	.962	.623	.671	.290	.222	.953	.510
	SMG (L)	.602	.269	.392	.701	.870	.709	.678	.719	.555	.528	.514	.814		.778	.710	.858	.913	.761	.692	.148	.872	.407
	SMG (R)	.434	.132	.135	.663	.270	.483	.298	.394	.123	.036	.173	.772	.778		.428	.448	.558	.526	.313	.100	.657	.701
DAN	FEF (L)	.574	.491	.102	.745	.910	.262	.536	.639	.900	.231	.708	.656	.710	.428		.574	.323	.099	.684	.121	.531	.172
	FEF (R)	.752	.238	.407	.778	.959	.595	.209	.958	.983	.209	.986	.962	.858	.448	.574		.808	.368	.983	.491	.951	.425
	IPS (L)	.299	.238	.231	.638	.254	.286	.121	.276	.790	.063	.420	.623	.913	.558	.323	.808		.253	.652	.227	.530	.214
	IPS (R)	.055	.484	.600	.765	.234	.779	.012	.271	.690	.053	.199	.671	.761	.526	.099	.368	.253		.079	.149	.150	.338
FPN	LPFC (L)	.354	.349	.086	.171	.701	.314	.422	.084	.879	.248	.330	.290	.692	.313	.684	.983	.652	.079		.181	.258	.410
	PPC (L)	.769	.133	.358	.385	.313	.312	.123	.019	.420	.003	.118	.222	.148	.100	.121	.491	.227	.149	.181		.150	.416
	LPFC (R)	.095	.144	.016	.236	.326	.344	.159	.659	.970	.749	.966	.953	.872	.657	.531	.951	.530	.150	.258	.150		.507
	PPC (R)	.894	.456	.915	.750	.137	.826	.179	.604	.662	.401	.575	.510	.407	.701	.172	.425	.214	.338	.410	.416	.507	

Abbreviations: ACC: Anterior cingulate cortex, AINS: Anterior insula, DAN: Dorsal Attention network, DMN: Default Mode network, FEF: Frontal eye field, FPN: Fronto Parietal Network, IPS: Intraparietal sulcus, Lat: Lateral Sensorimotor Cortex, LP: Lateral parietal, LPFC: Lateral prefrontal cortex, MPFC: Medial prefrontal cortex, PCC: Posterior cingulate cortex, PPC: Posterior parietal Cortex, RPFC: Rostral prefrontal cortex, SMG: Supramarginal gyrus, SMN: Sensorimotor network, SN: Salience network, Sup: Superior Sensorimotor Cortex.

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Ich, Hense, Katharina, geboren am 26.01.1990 in Geseke erkläre hiermit, dass ich die vorliegende Arbeit ohne unzulässige Hilfe Dritter und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe. Die aus anderen Quellen direkt oder indirekt übernommenen Daten und Konzepte sind unter Angabe der Quelle gekennzeichnet. Insbesondere habe ich nicht die entgeltliche Hilfe von Vermittlungs- bzw. Beratungsdiensten (Promotionsberater oder andere Personen) in Anspruch genommen.
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