Communication Disorders in Patients with Hemispheric Intracranial Neoplasm

Ann-Marie Thomson

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I declare that the original work presented in this thesis is my own and that the thesis was composed by me.

Signed.

Date.....11/10/96.....

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ABSTRACT

Disorders of language are present in more than 50% of patients who have a tumour of the left, dominant, hemisphere of the brain. Yet compared with aphasia in stroke remarkably few studies have attempted to examine the nature or severity of language problems in patients with brain tumours, despite the frequency with which this condition occurs and the distress it causes to both patient and family. This study was designed to investigate communication impairment due to brain tumour and to identify the effects on language function of biopsy, resective surgery, radiotherapy and chemotherapy.

Data were collected from a consecutive series of patients with a tumour of the left hemisphere who were admitted to the Department of Clinical Neurosciences, Western General Hospital, Edinburgh. As disorders of communication may follow damage to the right hemisphere patients with a tumour of the non-dominant hemisphere were also included in the study. A comprehensive language assessment was carried out prior to neurosurgery and again approximately seven days later. Some patients were also assessed before and after radiotherapy and chemotherapy. Neuroradiological data were recorded for each patient. Emotional status was measured before and after treatment and handedness was identified using a recognised inventory.

A total of 318 language assessments were carried out on 164 patients. 138 patients had a solitary intracranial tumour. Twenty and six patients respectively formed two separate control groups.

The main results from this study are that language disorders were identified in 58% of patients with a tumour of the dominant hemisphere. Dysphasia was more common in patients with malignant tumours. There were significant correlations between location of tumour and type or degree of language deficit; the patterns did not conform to those of localisation of dysphasia seen in patients with stroke. Patients who were dysphasic prior to resective surgery showed significant post-operative improvement while the language of non-dysphasic patients was not damaged by resective surgery. Stereotactic biopsy did not appear to cause dysphasia in patients with a dominant hemispheric tumour; conversely the language of patients who were dysphasic prior to biopsy was often worse after this procedure. Current methods of assessing language impairment in the right hemisphere were found to be inadequate and to require further investigation. The majority of patients with a brain tumour reported surprisingly low levels of psychological distress; where mood disorders did occur they tended not to be dependent on hemispheric localisation of damage as has been suggested in stroke.

These are largely new findings which contribute to the understanding of how language function is affected by the pathophysiological changes and treatment methods associated with intracranial tumour, and allow objective advice to be given to patients concerning possible effects of treatments on language function.

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The most precious and indispensable portion of the adult's cortex is the major speech area.

Wilder Penfield (1965)

CHAPTER 1

Introduction

The annual incidence of malignant glioma in the UK is approximately 13 cases per 100 000 although this may be a conservative estimate. A proportion of these cases will present with disorders of language and communication, causing profound distress to both patients and their families. Despite this, few studies have investigated the nature of communication impairment in patients with a tumour of the dominant or non-dominant hemisphere or evaluated the effects of brain tumour treatments on communication deficits. Studies describing language impairment after left hemisphere stroke are prolific. It is likely, however, that findings relating to patterns of dysphasia and localisation of function will have limited application to tumour-induced communication disorders because of the neurophysiological differences which exist between the two diseases. This study was therefore carried out in the belief that the results might lead to improvements in both current knowledge of neurolinguistic dysfunction in patients with a brain tumour and the clinical management of such patients. While the prognosis for survival is often very poor, the quality of the remaining life can be enhanced greatly by the appropriate employment of treatments known to alleviate communication difficulties.

In this first chapter the literature relevant to the study is reviewed. The aims of the study are also described. The rationale for the selection of research methods is outlined in chapter 2, with a more detailed description of test administration, including amendments to the recommended use of tests, in later chapters. Results relating to patterns of language disorders in patients with a hemispheric intracranial neoplasm and the effects of brain tumour treatments on language dysfunction are presented and discussed in chapter 3. A smaller study which investigated the efficacy of the only standardised test of right hemisphere communication dysfunction in patients with a tumour of the non-dominant hemisphere is described in chapter 4. Patients in the study were screened for psychological disturbance because of a possible connection between lower language test scores and higher levels of either anxiety or depression; the results are discussed in chapter 5. Changes in language function after surgery and the use of SPECT scanning in a small group of patients are discussed in chapter 6. The expectation is that some of the findings of this study may have an identifiable clinical application; the implications of the study and subsequent research are described in chapter 7.

Review of the Literature

1.1. Language Disorders

Kertesz (1979) offers the following definition of aphasia:
"aphasia is a neurologically central disturbance of language characterised by paraphasias, word finding difficulty, and variably impaired comprehension, associated with disturbance of reading and writing, at times with dysarthria, non-verbal constructional and problem-solving difficulty and impairment of gesture."

The current knowledge associated with the history of aphasia, the aphasic syndromes and the localisation of language disorders has been largely derived from stroke studies.

1.1.1. Historical Perspectives on Aphasia- The Growth of Localisationist Beliefs

References to impairments of speech can be found in the earliest of medical writings (Benton, 1964). The Hippocratic writings which date back to around 400 B.C. cite many episodes of speech disturbance although it is often not clear if the description refers to motor speech disorders or deficits of central language processing. By 1800 a large body of information relating to aphasia had accumulated.

The neuropathology of aphasia emerged as a subject of interest and controversy as a consequence of the anatomist and phrenologist Franz Joseph Gall (1758-1828)'s description of the human brain as a group of organs, each being responsible for a specific cognitive function or character trait with speech articulation and word memory localised in the frontal lobes. This was a precursor to Broca's 1865 pronouncement that "we speak with the left hemisphere" after autopsies on patients who had non-fluent dysphasia (or "aphemia" as Broca termed it) in life revealed lesions in the left posterior frontal lobe. There followed a period of major interest in aphasia and much research into the features of the disease itself and the notion of functional localisation. In 1874 Carl Wernicke published an article describing "sensory aphasia", now referred to as Wernicke's aphasia, in which he attributed this particular language disorder to damage of the left temporal lobe. The work published by Wernicke and 10 years later by one of his disciples, the aphasiologist Lichtheim, included clinical descriptions of two further aphasic syndromes, conduction aphasia and transcortical motor aphasia.

Broca and Wernicke were pioneers of a localisationist school, maintaining that damage to interconnected cortical centres would result in language impairments, but not necessarily intellectual deficits. According to their model language disorders

were separable into discrete, recognisable syndromes. The two current main proponents of the localisationist school are Harold Goodglass and Andrew Kertesz who have both produced aphasia test batteries and many additional publications. Their work has been greatly influenced by Geschwind whose publications in 1965 and 1970 reinforced a neuroanatomical model for syndromes involving deficits of language.

The other main camp, the cognitive school, challenged localisationist beliefs by describing aphasia as a unitary disorder which varies in severity rather than by syndrome. The most influential 20th century proponents of the cognitive model, Pierre Marie (1853-1940) and Henry Head (1861-1940) believed that in aphasia "intelligence is always lamed". Currently the main advocate of the cognitive school is Hildred Schuell whose language assessment, the Minnesota Test for Differential Diagnosis of Aphasia (MTDDA) (1965, revised 1973), is based on the principles of the school. Although the shortened version of the MTDDA, published by Thompson and Enderby in 1979, is favoured by some clinicians, the most clinically popular language batteries are those devised by contemporary localisationists, Goodglass & Kaplan (1972) and Kertesz (1982).

1.1.2. The Aphasic Syndromes

Many different terms have been applied to the various aphasic syndromes over the last 130 years. The relevant literature is vast: Kertesz (1979), Sarno (1981), Goodglass and Kaplan (1983) and Chapey (1994) provide comprehensive reviews.

Broca's aphasia

Wernicke (1874) called this motor aphasia; Bay (1962) cortical dysarthria; Geschwind (1970) non-fluent aphasia. Broca himself used the term aphemia (1863). Pick's (1913) and Weisenburg and McBride's (1935) expressive dysphasia are used interchangeably with Broca's aphasia. Goodglass and Kaplan prefer to use Broca's aphasia rather than expressive to avoid the suggestion that verbal output is normal in the other dysphasic syndromes.

Broca's aphasia is characterised by scant, hesitant, effortful and paraphasic spontaneous speech with frequent word finding difficulties. Agrammatism is typical and is characterised by the retention of content words or nouns and the loss of function words and verb tense markers. Nouns are more commonly used than verbs, producing speech that is often referred to as telegraphic. Patients are typically described as having relatively well preserved comprehension with impaired output; assessment usually demonstrates some degree of comprehension impairment, however (Kertesz, 1976). Writing is affected in a similar fashion to spoken

language. Reading comprehension is usually relatively good while reading aloud is usually poor, often as a result of impaired articulation.

Wernicke's aphasia

Wernicke referred to this as sensory aphasia. It has also been labelled impressive aphasia (Pick, 1913), cortical sensory aphasia (Goldstein,1948), pragmatic jargon (Wepman & Jones, 1961) and is now more commonly termed fluent or Wernicke's aphasia. Receptive aphasia is favoured by some clinicians although this term only acknowledges the presence of the comprehension deficit and not the impairments affecting spoken language production.

The principal features are impaired comprehension and fluently articulated but paraphasic speech. Nouns are often substituted by paraphasias and informative elements are either missing or difficult to locate in the fluent use of grammatical connecting words, complex verb tenses and clauses within clauses. Neologisms are common as is jargon in more severe cases. Output is paragrammatic rather than agrammatic relating to the incorrect use rather than absence of grammatical markers such as verb tense. Pressure of speech and logorrhea are common as are naming or word finding difficulty and impaired reading and writing. Prosody usually follows a normal pattern. Writing errors mirror spoken output: written language is often profuse and tangential and exhibits the same paraphasic and neologistic errors as spoken language.

Global aphasia

A combination of the features of fluent and non-fluent dysphasia has generally been labelled global aphasia although Weisenburg and McBride termed it mixed in 1935 and Schuell (1965), who describes aphasia as a unitary syndrome with varying degrees of severity, identified global aphasia as type V (severe).

Impairment is apparent in all modalities of language as both comprehension and expression are damaged. The patient may produce meaningless, sterotyped utterances which may occasionally sound meaningful because of the normality of the accompanying prosody. Detailed formal testing is almost always precluded because of severe deficits in both receptive and expressive channels. In some cases comprehension recovers sufficiently for the syndrome to appear more similar to Broca's aphasia than global.

Anomia

Anomia or word finding difficulty is common to all aphasic syndromes and as such has no localising value within the dominant hemisphere. Anomic aphasia usually occurs in patients with a resolving Wernicke's or other fluent aphasia but can also appear as a syndrome in its own right. Output is fluent, often circumlocutory,

occasionally paraphasic and demonstrates obvious word finding difficulty. Paraphasias tend to be verbal or semantic in nature rather than literal. Comprehension is usually within normal limits as is repetition. Although a naming deficit is the main identifying sign confrontation naming tests will often elicit remarkably good performances with signs of word finding difficulty only apparent in spontaneous speech or prolonged testing using low frequency items.

Conduction aphasia

Wernicke named this condition in 1874. Many other terms have since been employed, for example agrammatism (Pick, 1913, 1931), mixed aphasia (Weisenburg & McBride, 1935) and central aphasia (Goldstein, 1948) although conduction aphasia is the currently preferred label.

Separating the supposedly characteristic features of relatively fluent speech, good comprehension but poor repetition is seen as controversial by some aphasiologists who argue that such patients are rarely if ever seen while others maintain that conduction aphasics do not form a single, homogeneous group.

Transcortical motor aphasia (TMA) and transcortical sensory aphasia (TSA)

Wernicke coined these terms which have been more or less universally applied to these two conditions. The features of TMA and TSA are similar to those of Broca's and Wernicke's aphasia respectively except for the disproportionately well preserved repetition in the case of both TMA and TSA. Despite often accompanying dysphasic difficulties, dysarthria and dyspraxia have not been described here as the investigation of motor speech disorders was not included in the aims of the study.

1.1.3. Recovery of Aphasia

Spontaneous recovery of some degree of language function is a recognised phenomenon after stroke (Basso, Capitani & Zanobio, 1982; Cappa & Vallar, 1992; Kertesz, Lau & Polk, 1993) and may result from either functional compensation and /or relocation of language mechanisms as the brain recovers (Kertesz, Harlock & Coates, 1979). Some initial signs of impairment are thought to be partly attributable to diaschisis, identified by Von Monakow in 1914 (as described by Kertesz, 1988a), where acute damage to the nervous system as in stroke disconnects contiguous brain tissue thus impairing a wide area. Function may be restored when innervation is probably obtained from undamaged non-perisylvian left hemisphere (Kertesz, 1988b), although the non-dominant hemisphere may have some, as yet undefined, role (Heilman, Bowers, Valenstein & Watson, 1986; Cappa & Vallar,1992; Gainotti, 1993).

Typically, language recovery in stroke is incomplete with residual deficits persisting (Crary & Kertesz, 1988; Chapey, 1994). Malignant brain tumours expand and infiltrate extensively with time, with the trend being one of eventual deterioration, rather than the gradual improvement in language function which generally occurs in stroke (Kertesz, 1979; Haas, Vogt, Schiemann & Patzold, 1982).

The effects of rehabilitation on recovery of language in stroke has been addressed in the literature but these studies will not be reviewed here: the evaluation of language therapy was not an aim of the present study.

1.1.4. Localisation of Language Function

In this section each of the aphasic syndromes will be matched with corresponding neuro-anatomical sites using data largely from CT and MR studies in stroke patients. The role of functional imaging and cortical mapping during awake craniotomy will also be reviewed.

Because of the extensive literature this review will focus on those studies which are most directly relevant to the present study.

1.1.4.1. Lesion studies - structural imaging

The last two decades have seen advances in knowledge relating to the mechanisms and location of language function, largely due to the advancement of neuroimaging techniques. When the current neuroradiological means of *in vivo* localisation, CT and MR scanning, and standardised language testing are combined, reasonable conclusions can be drawn regarding the cortical and subcortical localisation of language function, although exact localisation is still often debated (Damasio, 1992; Kertesz et al, 1979; Kertesz, 1991). Most studies have involved patients with stroke, possibly due both to the relative stability of language dysfunction after a period of spontaneous recovery and to ease of definition of the brain lesion boundaries with either CT or MR at the time of language assessment (Kinkel & Jacobs, 1976; Basso, Lecours, Moraschini & Vanier, 1985). Correlations between tumour and functional impairment are much more speculative as structural imaging does not distinguish between the dead, dysfunctional and displaced neurons associated with tumour growth and infiltration (Anderson, Damasio & Tramel, 1990).

There is little absolute agreement in the literature concerning the exact cortical territories associated with particular language syndromes (Albert, Goodglass, Helm, et al, 1980) therefore the following section on localisation of the aphasia syndromes represents the most generally held views on localisation.

Localisation of Broca's aphasia

Defining the exact limits of the area of the dominant hemisphere which are associated with Broca's aphasia is still a subject of some debate (Albert et al, 1980). Broca's aphasia will typically result from a lesion in the posterior portion of the third frontal gyrus and the adjacent frontal operculum (Lesser, Lueders, Dinner, et al, 1984; Kertesz, 1991), but may also occur with damage either in the anterior parietal or in the anterior temporal region (Mohr, 1976; Kertesz et al, 1979). A more severe deficit tends to accompany lesions which extend into the subcortical structures (Bruner, Kornhuber, Seemuller, et al, 1982; Knopman, Selens, Niccum et al, 1983; Levine & Sweet, 1983).

Localisation of Wernicke's aphasia

Autopsy and CT studies have demonstrated that the superior temporal gyrus, Heschl's gyrus and the planum temporale are typically damaged in Wernicke's aphasia while extensions into the posterior insula, inferior parietal region, the middle and inferior temporal gyri and the supramarginal and angular gyri will add to the clinical picture (Kertesz & Benson, 1970; Cappa, Cavallotti & Vignolo, 1981; Kertesz, 1983; Kertesz, 1991).

Localisation of global aphasia

Global aphasia is associated with destruction of both the anterior and posterior language areas, i.e. lesions involving both Broca's and Wernicke's area (Kertesz, Lesk & McCabe, 1977).

Localisation of anomia

Anomia can occur as a result of damage to Broca's or Wernicke's areas (Kertesz et al, 1979). It can appear in isolation or as one of the stages of a resolving dysphasic syndrome (Kertesz, 1976). Anomia can also occur, however, in cases where the lesion is remote from the established language areas of the brain (Ojemann, Ojemann, Lettich & Berger, 1989).

Localisation of conduction aphasia

The arcuate fasciculus is the locus where damage is likely to produce conduction aphasia although the insula is often also involved (Damasio & Damasio, 1983).

Localisation of TMA

The localisation of the lesion in TMA is usually either directly anterior or superior to Broca's area (Rubens & Kertesz, 1983) or within the neighbourhood of the supplementary motor cortex (Rubens, 1975; Kertesz, 1991). The supplementary motor area appears to be involved in the planning or initiation of motor activity,

including speech function (Penfield & Welch, 1951; Jonas, 1981; Rostomily, Berger, Ojemann & Lettich, 1991).

Localisation of TSA

Little information is available from current literature about lesions involved in TSA although a group study conducted by Kertesz, Sheppard & MacKenzie (1982) linked the clinical picture with infarction in the territory of the posterior cerebral artery or in watershed area lesions of the posterior temporo-occipital region.

Throughout the aphasic syndromes larger lesion size in stroke will tend to result in greater impairment of function (Kertesz et al, 1979).

Subcortical localisation of language disorders

Discrepancies are common regarding the nature of language disorders associated with subcortical lesions. Language deficits have been reported as occurring with strokes involving, for example, the putamen (Naeser, Alexander, Helm-Estabrooks, et al, 1982; Cappa, Cavallotti, Guidotti, et al, 1983), the dominant thalamus (Graff-Radford, Damasio, Yomada, et al,1985) and the basal ganglia (Wallesch, Kornhuber, Brunner et al, 1983); agraphia is perhaps especially common with subcortical strokes (Kertesz, 1992). A cortico-striato-pallido-thalamo-cortical loop has been proposed by several researchers as a means of connecting cortical and subcortical regions in language function (Crosson, 1985; Wallesch & Propagno, 1988). Damage to white matter itself may cause variable change in language status if important connecting fibres are interrupted (Alexander, Naeser & Palumbo, 1987). Despite the amount of recent interest the role of subcortical structures in language function is still largely speculative. Crosson (1992) suggests that innovations in PET and SPECT may in the future provide more conclusive information on subcortical language processing than the structural imaging of CT and MR. As such approaches are currently limited in their application we must rely on inferences from symptoms and their localisation to provide working models of the relationship between normal function and the brain (Caplan, 1981).

Localisation caveats

Although the theory of localisation of function is supported by reputable contemporary aphasiologists, even its most influential proponents advocate caution when attributing function to specific neuro-anatomical loci. On the basis of the "suspicious coincidence" of similar deficits occurring across a group of patients with matching lesions Phillips, Zeki and Barlow (1984) attribute individual loci with incontrovertibly subserving particular functions. Goodglass and Kaplan (1979), on the other hand, propose an interactive language system rather than a one-to-one relationship between brain loci and individual language components. In support of

this are cases where damage to specific areas believed to subserve particular language functions does not result in the expected language impairment (Basso et al, 1985). For Miller (1983) and Kertesz (1991) one of the major problems with localisation is knowing whether or not the performance observed should be attributed to a damaged area that is functioning without some of its components or to other structures taking over less capably from the damaged one. Furthermore neuropsychological testing very soon after sudden neural damage may result in deficits of variable severity being observed in similarly located lesions (Kertesz, 1979; 1991). Albert et al (1980) describe language "zones" which represent the focus of a brain function and which may be variously influenced by neighbouring regions. Caplan (1981) states that lesion studies of aphasia (and other pathological behaviours) lead to an understanding of localisation of symptoms but not necessarily of normal behaviour. The "uncertain relation" between brain activity and human behaviour necessitates care in observation and caution in prediction (Lezak, 1995).

1.1.4.2. Lesion studies - functional imaging

The pitfalls of drawing firm conclusions about language disturbances on the basis of structural damage alone are highlighted above. Positron Emission Tomography (PET) and Single Photon Emission Computerised Tomography (SPECT) can supplement existing knowledge by depicting brain function and by providing information on how a lesion may be affecting other regions remote from it (Metter, Hanson, Jackson, et al, 1990). Caution must also be exercised, however, with the interpretation of results obtained from functional imaging.

PET studies

Relatively few centres currently have the facilities required to operate PET scanning. The literature contains few clinical group studies. In their study on 44 dysphasic stroke patients Metter et al (1990) made the unremarkable observation that the temporoparietal region is implicated in aphasia. However, they also concluded that further studies comparing aphasic and non-aphasic stroke patients are essential for an understanding of the relationship between the extent of regional functional disruption and the location and extent of structural damage. They stress the importance of establishing the remote effects of local damage. The few published single case studies have focused on crossed aphasia where PET scanning showed evidence of dysfunction in the structurally unaffected left hemisphere (Schweiger, Wechsler & Mazziotta, 1987; Cappa, Perani, Bressi, et al, 1993) and again the authors recommend further studies to confirm the likelihood of functional impairment in a structurally unimpaired region. In general the success of

associating function with structure using patients with focal brain damage has been limited; in the majority of cases lesions are large and patients may have more than one functional deficit (Price, Wise, Watson, et al, 1994).

PET studies using normal subjects have been relatively more successful (Mazziotta, Phelps, Carson & Kuhl, 1982; Maximilian, 1982; Gur, Gur, Rosen, et al, 1983; Demonet, Celsis, Nespoulos, et al, 1992a; Howard, Patterson, Wise, et al, 1992; Price et al, 1994). Results are often broadly in accord with or partly confirm observations of language and localisation of damage from stroke studies; Demonet et al (1992a) found the main activation of phonological and semantic processing of auditorily presented linguistic material to be located unsurprisingly in the temporal lobe. Demonet, Chollet, Ramsay, et al (1992b) rationalise studies with conflicting or unexpected results as containing tasks whose specifications are too vague (e.g. "passive listening") or involving several distinct components of language processing which result in simultaneously conflicting profiles of brain activation. Price et al (1994) concluded that the association of specific elements of processing with individual anatomical areas using PET is still premature and will continue to be so until there is a greater awareness of how subtle modifications to experimental design influence brain activity.

SPECT studies

Although the resolution is much less impressive than that achieved using PET, HMPAO SPECT can provide early evidence of ischaemic changes in cerebrovascular disease (Costa & Ell, 1991). It is particularly effective in evaluating patterns of blood flow in patients with intractable epilepsy (Andreasen, 1988; Newton, Berkovic, Austin, et al, 1992; Duncan, Patterson, Roberts, et al, 1993; Jennett & Lindsay, 1994). HMPAO SPECT studies of patients with brain tumours have demonstrated varying amounts of tracer uptake implying variations in amount of tumour blood flow (Costa & Ell, 1991). SPECT may be used to provide information on the effect of radiation on the brain in treated patients (Ebmeier, Booker, Gregor, et al, 1994).

Attempts to define regional cerebral blood flow in brain damaged patients and normal controls during language activation tasks have resulted in conflicting conclusions because of difficulties involved in eliminating artifacts inherent in the test situation (Walker-Batson, Wendt, Devou, et al, 1988; Lechevalier, Petit, Eustache, et al, 1989) and occasional methodological oversights. Brown, Bartlett, Wolf, et al (1985) and Walker-Batson, Devous, Millay, et al (1989) found no differences in regional blood flow between active language tasks and passive listening or a resting state and concluded that researchers should therefore be

cautious when using the resting state as a baseline measurement. Language processing has been identified in the right hemisphere (Knopman, Rubens, Selnes, et al, 1984; Lechevalier et al, 1989) but results obtained may be spurious. Lechevalier et al (1989) pointed out that the right hemisphere will naturally be activated during linguistic tasks because of the attentional component and also if the test materials result in emotional reactions.

Where a language task has a motor component problems arise in identifying the linguistic brain activity (Burchiel, 1994): for example Gomez-Tortosa, Martin, Sychra, et al (1994) administered a confrontation naming test (the Boston Naming Test) during SPECT imaging which required the subject to vocalise responses. Knopman et al (1984) on the other hand did not acknowledge that activation of the right hemisphere in their study may have been at least in part due to the subject having to push a button with the left index finger during the language task. SPECT scanning has been used in several cases to confirm a diagnosis of crossed aphasia (Gomez-Tortosa et al, 1994; Walker-Batson et al, 1988; Ferro, Cantinho & Baeta, 1991).

Functional MRI

Functional magnetic resonance imaging is the most recently-developed method of functional scanning. The procedure is safe and totally non-invasive and can be repeated on the same subjects as often as necessary (Wong, 1995). It can be used in the study of epilepsy and to aid identification of motor, sensory and cognitive areas prior to tumour resection (Wong, 1995). Language activation studies involving the auditory cortex and Broca's area have been described (Hinke, Hu, Stillman, et al, 1993; Binder, Rao, Hammeke, et al, 1993; Binder, Rao, Hammeke, et al, 1994). Although it is still currently gaining interest as a clinical and research tool the early indications are that functional MRI may be widely used in the future and that it could lead to improvements in the understanding of language processing (Binder et al, 1994).

Ferro et al (1991) emphasise the importance of combining structural and functional imaging methods while Walker-Batson et al (1989) suggest that with careful attention to methodology and improvements in the sensitivity of newer models SPECT may enhance current understanding of neural mechanisms.

1.1.4.3. Cortical mapping

Penfield and Jasper (1954) and Penfield and Roberts (1959) were the first to demonstrate the value of direct stimulation of cortical areas during neurosurgical procedures performed under local anaesthetic as a technique for locating and

mapping language areas close to epileptogenic foci. An electrical current is applied to the exposed cortex during a simultaneous naming task; areas associated with language are identified when naming is arrested. Despite often being termed "stimulation mapping" the effect of the current on language is inhibitory, probably from the temporary inactivation of local neurons (Ojemann et al, 1989). The technique, which has been used extensively by Ojemann and his team in Seattle, is becoming more widely used in the USA and Britain during surgery for intractable epilepsy and for demarcating cortical areas subserving language during tumour resection. Stimulation mapping identifies brain areas which are essential for language; the short period of mapping time during surgery does not permit functional reorganisation whereas SPECT and PET indicate post-lesional participation of brain areas which may have previously not been crucial for language (Ojemann et al, 1989). In a review Ojemann (1991) described the cortical organisation of language as lateralised to one hemisphere but subject to substantial intra-hemispheric variation between individuals in patterns of localisation, with particular variability in the temporoparietal cortex (Ojemann, 1978; Van Buren, 1978). Traditional notions of localisation have been further challenged by suggestions that the language cortex is much smaller than was previously thought (Ojemann et al, 1989; Haglund, Berger, Shamseldin, et al, 1994). Cortical mapping enables the neurosurgeon to define the safe limits of tumour resection for each patient when the tumour is near suspected language areas and thus reduce the risk of postoperative language deficit (Ojemann et al, 1989; Haglund et al, 1994).

1.1.4.4. Summary

While cortical mapping and structural and functional imaging techniques all contribute to current knowledge on localisation of language function, information obtained should be interpreted cautiously. Although CT and MR are used to identify the lesion site, neither can demonstrate the functional consequences in either local or distant brain tissue. Despite their potential for depicting brain activity during language tasks, methodological problems are still inherent in many SPECT and PET studies and functional MRI is still in its infancy. The value of intra-operative mapping of language loci cannot be denied. Several significant studies which have demonstrated that much individual variation exists in brain areas subserving language have reinforced the significance of cortical mapping during awake craniotomy (Van Buren, Fedio & Canal Frederick, 1978; Ojemann et al, 1989). However, when considering Ojemann's et al's (1989) conclusion that the findings obtained from cortical mapping indicate a need for revision of the classical

model of language localisation it should be borne in mind that the patients involved in such studies did not have "normal" brain function. Epilepsy of long standing, its underlying causes such as early anoxic damage, or the growth of brain tumours could all significantly alter the normal relationship between brain loci and language function.

1.1.5. Assessment of Aphasia

There are five available types of language assessment reviewed by Walker (1992):

i) Classic multimodal or multi dimensional batteries and screening tests;
ii) Target or task-specific tests;
iii) The cognitive neuropsychological targeted approach;
iv) Functional assessments;
v) Tests for specific aetiological groups, e.g. dementias.

Selection of methods of language assessment will depend on both the amount and the nature of the information required in connection with communication abilities. Language assessment is discussed in greater detail in chapter 3.

1.1.6. Language and Communication in the Non-Dominant Hemisphere

Since the nineteenth century the non-dominant hemisphere has been recognised as contributing in some way to language and communication. The following section will provide a brief outline of the development of theories of right hemisphere language processing followed by a review of the features of language involved. Non-verbal aspects of communication such as facial expression are not included here as no standardised test of these features was used in the present study.

1.1.6.1. Historical perspectives

Comprehensive reviews of the growth of awareness of right hemisphere function are provided by Benton (1977) and Joanette, Goulet and Hannequin (1990). Although the right hemisphere was generally regarded as the functionally "minor" or "silent " hemisphere a few clinicians from the time of Broca onwards proposed that it might have functional significance. John Hughlings-Jackson published a pioneering paper in 1915 in which he attributed automatic and emotional speech to the right hemisphere. While associations were being gradually demonstrated between non-verbal deficits, such as visuospatial disabilities and constructional apraxia, and right hemisphere disease it was not until the middle of the twentieth century that clinicians began to probe the possible contribution of the right

hemisphere to language. The belief currently held is that the left hemisphere has the predominant role in language while the contribution of the right hemisphere belongs in the broader category of verbal communication.

1.1.6.2. Features of right hemisphere language and communication

Disagreement amongst researchers

Language and communication disorders following right hemisphere damage are difficult to measure as clinicians do not have a range of formal test materials to apply. There has been much disagreement over the years, therefore, as to the contribution of the right hemisphere, probably because of a lack of uniformity in the nature of the clinical studies (Joanette et al, 1990) and because of the confounding nature of visuospatial and attentional deficits and neglect which very often accompany right hemisphere disease (Heilman, Bowers, Valenstein & Watson, 1986; Myers, 1994).

A further source of confusion is the indiscriminate grouping in studies of right brain damaged patients with different neuropathologies, with some groups comprising a higher proportion of communication-impaired patients than others (Joanette & Goulet, 1992). Appropriateness of the control groups used may also be lacking (Joanette & Goulet, 1992).

Conflicting results abound in studies of linguistic deficits after right hemisphere damage. Naming deficits which were not attributable to perseveration or lack of spontaneity were identified by Gainotti, Caltagirone, Miceli and Masullo (1981) and Joanette, Lecours, Lepage and Lamoureux (1983) but not by Cappa, Papagno and Vallar (1990); impairments of auditory comprehension were found by DeRenzi and Vignolo (1962) and Swisher and Sarno (1969) but not by Cappa et al (1990); and verbal fluency was found to be impaired by Diggs and Basili (1987) and Schneidermann and Saddy (1988) but Cavalli, DeRenzi, Faglioni and Vitale (1981) and Cappa et al (1990) found no such deficit.

Agreement amongst researchers

As a result of studies involving commissurotomised and right-brain damaged patients, combinations of left and right brain damaged patients and normal subjects and patterns of recovery in aphasic stroke patients many researchers agree that specific features of verbal communication may be attributed to the right hemisphere. These features are "extralinguistic" (Myers, 1994) and permit speakers to understand what is actually meant by the words used. Although Schneidermann and Saddy (1988) identified possible syntactic input from the right hemisphere, damage to the non-dominant hemisphere will tend to affect the semantic aspects of word processing rather than syntactic, phonological or phonetic aspects (Joanette &

Goulet, 1990). Not every patient with right hemisphere disease will have communication impairments and those that do will inevitably differ in severity of impairment (Bryan, 1988; Joanette & Goulet, 1992; Myers, 1994), as is the case with left hemisphere damage.

Communication deficits which may be attributable to right hemisphere damage will be described briefly. Studies have largely concentrated on verbal and written comprehension and oral expression. The available literature on writing skills in patients with right hemisphere damage is scant with impairments of reading and writing attributed more to visuoperceptual or visuospatial deficits than to faulty language processing (Pimental & Kingsbury,1989).

Metaphorical language

Patients with right hemisphere disease often fail to understand the figurative meaning of idioms, metaphors and proverbs and tend to interpret them literally (Winner & Gardner, 1977; Van Lancker, 1987; Brownell, Simpson, Bihrle, et al, 1990). It is possible that the general ability to appreciate different types of alternative meaning may be damaged and that impairments are not restricted to metaphor (Brownell et al 1990).

Humour

Several studies have documented the difficulties right hemisphere damaged patients often have in understanding humourous material (Gardner, Ling, Flamm & Silverman, 1975; Brownell, Michel, Powelson & Gardner, 1983). Brownell et al (1983) proposed that appreciation of humour involves sensitivity to both surprise and coherence and that right hemisphere damaged patients lack comprehension of the latter.

Inference

An inability to make inferences from presented information will tend not to be apparent when simple or very explicit material is used (Brookshire & Nicholas, 1984; McDonald & Wales, 1986; Tompkins, 1991). Joanette and Goulet (1992) concluded that the existence of an inference deficit is only suggested and not demonstrated by existing studies. Tasks which demand more of attentional and cognitive skills are more effective in demonstrating impairments (Hough, 1990) which implies that impaired attention and cognition may result in a low test score regardless of the status of inferential abilities. Joanette and Goulet (1992) suggested that when linguistic tasks are generally more complex the integrity of both hemispheres is essential; when the right hemisphere is damaged complex tasks such as inference may become more effortful due to a reduction in processing power rather than faulty inferential ability.

Prosody

Earlier studies associated prosodic disturbances solely with emotional or affective disorders (Heilman, Scholes & Watson, 1975; Ross, 1981). The prosodic features of pitch, intonation, duration of pauses and emphatic stress all convey both emotional and linguistic information (Myers, 1994). Impairments of both prosodic comprehension (Tompkins & Flowers, 1985; Tompkins, 1991) and production (Ross & Mesulam, 1979; Weintraub, Mesulam & Kramer, 1981; Behrens, 1988) may occur with right hemisphere damage. Shapiro and Danly (1985) identified anatomical variations. Acoustic analysis of the speech wave revealed restricted intonational range among patients with right anterior and right central damage, and exaggerated pitch and intonational range in patients with right posterior damage. Ryalls, Joanette and Feldman (1987) concluded that lateralisation of non-affective prosody remains an open issue and requires further investigation while Joanette and Goulet (1992) claimed that prosody is the only verbal communication deficit which has been satisfactorily linked with right hemisphere damage.

Discourse and narrative skills

The spoken output of patients with right hemisphere damage, in both conversation and in narrative tasks such as picture description or story telling, may contain fewer and less relevant concepts and less specific information than that of non-brain-damaged controls (Joanette, Goulet, Ska & Nespoulos, 1986; Bloom, Borod, Obler & Gerstmann, 1992). Information content may be reduced but volume of words may be profuse (Roman, Brownell, Potter, et al, 1987; Sherratt & Penn, 1990). Verbal output is often repetitive and tangential (Tompkins & Flowers, 1985). Narrative discourse could be impaired, however, as a result of deficits at levels of cognitive processing not exclusive to language (Joanette et al, 1986). Also present may be difficulty comprehending intended rather than literal meaning during conversation (Kaplan, Brownell, Jacobs & Gardner, 1990), following verbal indirect commands (e.g. "Can you open the door?" might be interpreted as an indirect request for the door to be opened or an enquiry about the other person's physical strength; Foldi, 1987; Weylman, Brownell, Roman & Gardner, 1989) and integrating connected discourse into a coherent narrative (Brownell, 1988; Hough, 1990).

Lexical-semantic processing

The right hemisphere is described as contributing to the semantic processing of words, as in oral naming or verbal fluency tasks, by several researchers (Lesser, 1974; Brownell, Potter & Michelow, 1984) while others disagree (Coughlan & Warrington, 1978; Bishop & Byng, 1984.). Gainotti, Caltagirone and Miceli (1983)

concluded that diminished intellectual functioning will substantially affect performance while Coughlan and Warrington (1978) suggested that errors in lexical-semantic tasks may be attributable to deficits at a higher level of cognitive functioning which affect, in an as yet undefined manner, the operation of strategies to formulate responses. The hypothesis that the right hemisphere contributes to lexical-semantic processing is "plausible" (Joanette et al, 1990), but requires further study.

1.1.6.3. Summary

There is still controversy surrounding the nature of communication deficits following right hemisphere damage. A major obstacle is the lack of uniformity in clinical tools and research methodology. The perceptions of researchers are also seen to alter over time: collaborative work with Goulet prompted Joanette (1992) to support the existence of impairments of prosody after right hemisphere damage after having described it as an open issue in an earlier study with Ryalls (1987). There is some agreement, mainly as a result of studies of right brain damaged and left brain damaged patients and normal controls, that right hemisphere damage can result in a general impairment of the ability to master the social and figurative aspects of language with selective deficits in metaphorical language, humour, discourse and prosody. Most researchers stress the need for further research as difficulties lie in separating linguistic deficits from other types of cognitive impairment associated with right hemisphere damage.

1.1.6.4. Localisation of language and communication in the right hemisphere

While the identification and mapping of the neuro-anatomical correlates of language in the left hemisphere has been the subject of extensive research over the last 130 years the right or non-dominant hemisphere remains largely uncharted. Visuospatial and attentional defects are unanimously attributed in part to right hemispheric damage (Heilman et al, 1986; Joanette et al, 1990; Springer & Deutsch, 1993) as are some communication deficits (Joanette et al, 1990; Helmstaedter, Kurthen, Linke & Elger, 1994; Myers, 1994). Absence in the literature of clinical syndromes of impairment following right hemisphere damage or precise associations between deficits and lesion loci has led to the view that organisation of function in the right hemisphere is diffuse or less focally organised (Semmes, 1968; Kertesz, 1983; Heilman et al, 1986; Pimental & Kingsbury, 1989). Lack of knowledge or sufficient research, however, may have compounded this notion (Pimental & Kingsbury, 1989). Advances in functional imaging techniques may

provide some opportunity in the future for identifying the anatomical regions subserving features of right hemisphere language and communication. A recent PET study by Bottini, Corcoran, Sterzi, Paulesu, et al (1994) identified widespread activation in the right hemisphere during tasks involving metaphorical language. The technique is still in its infancy, however, and will require much refining.

1.1.6.5. Assessment of right hemisphere language and communication

Language disorders following right hemisphere damage can be difficult to analyse because of their relatively subtle nature and the number of contaminating factors involved (Joanette et al, 1990). While subtests from aphasia batteries can be used in the first instance to rule out aphasia (Myers, 1994) researchers have tended to use informal tests of right hemisphere language. The only commercially available assessment tools are the Rehabilitation Institute of Chicago Evaluation of Communication Problems in Right Hemisphere Dysfunction (RICE) (BURNS et al, 1985) and the Right Hemisphere Language Battery (RHLB) (Bryan, 1989). The latter will be considered in more detail in chapter 4.

1.2. Intracranial Tumours

The following section will review relevant aspects of intracranial tumours regarding type, symptomatology and management. Information relating to supratentorial tumours alone will be reviewed as patients with tumours of the cerebellum and brainstem were not included in the study.

1.2.1. Incidence, Type and Clinical Signs

1.2.1.1. Incidence

Approximately 15% of all human malignant tumours are intracranial tumours (Walton, 1989). Estimates of the incidence of malignant gliomas range from 4 to 13 cases annually per 100 000 (Adams, Graham & Harriman, 1988; Lindsay, Bone & Callander, 1991; Whittle, 1992). The cause of most intracranial tumours is unknown (Lindsay et al, 1991).

1.2.1.2. Type

The most commonly occurring primary brain tumours are gliomas which arise from the neuroglia or supporting cells of the nervous system (Jennett & Lindsay, 1994). The World Health Organisation (WHO) classification of brain tumours describes three grades of glioma: low-grade glioma (astrocytoma and

oligodendroglioma), anaplastic glioma (astrocytoma and oligodendroglioma) and glioblastoma multiforme (Cohadon, 1990; Jennett & Lindsay, 1994).*

Low-grade astrocytomas are often diffuse with a perimeter which may be hard to define. In extreme cases there may be no identifiable tumour mass (Jennett & Lindsay, 1994). These gliomas carry the most favourable prognosis but only represent about twenty percent of gliomas (Vecht, 1993).

Oligodendrogliomas are sharply defined tumours (Lindsay et al, 1991) which are usually relatively benign (Walton, 1989). They comprise approximately five percent of gliomas (Jennett & Lindsay, 1994). Occasionally a mixed variant, an oligoastrocytoma, appears comprising astrocytoma and oligodendroglioma.

Anaplastic gliomas are characterised by cells of various morphology and differentiation. These tumours may appear to have a more clearly defined border than low grade glioma although microscopic examination of peritumoural brain often shows diffuse infiltration (Burger, Fogel, Green et al, 1985). Endothelial proliferation is the other hallmark of these tumours. Anaplastic change can occur in low grade glioma. Anaplastic gliomas occur mostly in the age group 30 to 39.

Glioblastoma multiforme is differentiated from anaplastic astrocytoma by the presence of necrosis. This is a highly malignant tumour with rapid growth. Glioblastoma multiforme can occur at any age but is most frequent in the age group 50 to 59.

Other commonly-occurring intracranial tumours are metastases and meningiomas. Metastatic tumours, which may comprise 20 to 25% of cerebral neoplasms (Bannister, 1985; Swash & Schwartz, 1989), spread to the brain through the arterial system or the vertebral veins (Jennett & Lindsay, 1994); most are found in the vicinity of the terminal branches of the middle cerebral artery. The primary source is usually the lung; other common primary sites include the breast, kidney, gut and malignant melanoma. In approximately fifteen percent of cases the primary site is not known (Jennett & Lindsay, 1994). Metastatic tumours usually have a clear, well-delineated border, often surrounded by profuse oedema.

Meningiomas are usually benign tumours arising from the dura. These tumours compress rather than invade adjacent brain (Lindsay et al, 1991). Clear boundaries and accessability often permit complete excision although their vascularity can present surgical problems. Where excision has been incomplete prognosis may still be good as there may be little change in the size of residual tumour some years after surgery. Meningiomas comprise approximately 15% of intracranial tumours (Swash & Schwartz, 1989).

*

In the complete WHO grading of gliomas there are four grades. Grade one tumours are very rare in adults and are not considered here.

1.2.1.3. Clinical signs

Depending on the location and rate of growth of the tumour it may cause the signs and symptoms associated with raised intracranial pressure of headache, vomiting and papilloedema (Bannister, 1985; Walton, 1989). Headache, like vomiting, is usually worse in the morning and is of little or no localising value except that when it is unilateral it may indicate the hemisphere in which the tumour is sited (Walton, 1989). Papilloedema, where the retinal veins are distended, the optic disc is pinker than normal and the edges of the disc are blurred, is a characteristic sign of raised intracranial pressure but may not be obvious either in the early stages of tumour development or in some patients with large tumours (Walton, 1989).

In addition to the manifestations of raised intracranial pressure there may be focal neurological signs such as progressive contralateral limb weakness or dysphasia. Less well-localised signs and symptoms such as memory impairment, disorientation, intermittent loss of balance and poor concentration may also occur (Walton, 1989). Neuropsychological impairment is greater in rapidly growing malignant gliomas (Hom & Reitan, 1984). Focal or generalised seizures are often present and may precede any other signs or symptoms suggestive of brain tumour (Lindsay et al, 1991; Whittle, 1992). The growth of a tumour may affect structures remote from it resulting in false localising signs (Bannister, 1985; Walton, 1989).

The progression of clinical signs tends to be rapid in the case of glioblastoma and metastatic tumours but slower in patients with astrocytomas, meningiomas and oligodendrogliomas. The stage of development at which a tumour of any type is detected will depend upon various factors listed above.

1.2.2. Treatment of Brain Tumours

1.2.2.1. Corticosteroids

Corticosteroids reduce the surrounding oedema which accompanies many brain tumours. A course of steroids begun prior to surgery will usually effect an improvement in clinical signs (Swash & Schwartz, 1989), which can return on cessation of the drug (Jennett & Lindsay, 1994).

1.2.2.2. Biopsy

Although tentative diagnosis of type of tumour may be possible in some cases from CT and MRI scanning, histological diagnosis will be confirmed by analysis of tumour tissue obtained at biopsy (Jennett & Lindsay, 1994). Many centres now use

CT or MRI guided stereotactic biopsy techniques rather than free-hand burrhole biopsy. The latter had a significant failure rate as well as often causing functional impairments and sometimes even death (Hitchcock & Sato, 1964). Image-directed stereotactic biopsy permits access to deep lesions which surgeons previously avoided because of the significant risk to adjacent brain (Appuzzo & Sabshin, 1983). The proportion of positive diagnoses is high with this method and surgical complications are few (Thomas, 1992). Decisions regarding treatment will be guided by the outcome of biopsy.

1.2.2.3. Resective surgery

Modern standard neurosurgical methods of glioma and other intracranial tumour resection involve the use of lasers, ultrasonic aspirators, bipolar diathermy and the operating microscope, all of which have helped decrease morbidity and mortality after surgery (Thomas, 1992). Operative mortality has decreased from forty percent in the earliest reports to less than three percent (Cohadon, 1990).

The initial treatment for many gliomas is surgical resection which eradicates the bulk of the tumour. Extensive surgery is correlated with better postoperative neurological function and better seizure control than conservative surgery (Cohadon, 1990; Vecht, Avazaat, van Putten, et al, 1990). Complete tumour removal is usually only possible with some meningiomas as gliomas infiltrate the brain and cannot be fully resected without the risk of an iatrogenic deficit (Cohadon, 1990). The optimal approach for intracranial meningioma is total resection but where there is a significant risk of postoperative neurological impairment subtotal resection followed, in some cases, by radiotherapy can achieve results similar to total resection (Goldsmith, Wara, Wilson, et al, 1994). While surgery may not be indicated for multiple metastases a solitary metastatic tumour is usually resected and treated with adjuvant radiotherapy (Jennett & Lindsay, 1994).

Tumour recurrence is inevitable in the majority of low grade astrocytomas and in all anaplastic astrocytomas and glioblastomas. The value of further surgery for recurrent gliomas varies from case to case. Without additional treatment malignant tumours recur rapidly (Cohadon, 1990).

1.2.2.4. Radiotherapy

The effectiveness of radiotherapy as an adjuvant treatment in brain tumour has been demonstrated by several prospective, randomised, controlled trials (Thomas, 1992). Postoperative radiotherapy for malignant brain tumours significantly extends mean survival time and increases the percentage of survivors at two years (Whittle

& Gregor, 1991). The increased incidence of radionecrosis with high dose radiotherapy has resulted in guidelines suggesting that the optimal amount of radiation given is 60 Gy.

Interstitial radiation, or brachytherapy, offers the alternative of implanting an isotope directly into the core of the tumour thus avoiding irradiating non-gliomatous brain. Brachytherapy has been used in some centres in the treatment of deep-seated tumours (Cohadon, 1990). Results show that survival times are comparable to those achieved by surgery followed by external beam radiotherapy in patients with low-grade and anaplastic gliomas but shorter in patients wtih glioblastomas (Cohadon, 1990).

Stereotactic external beam therapy, or the "gamma knife", is generally ineffective in malignant glioma (Whittle & Gregor, 1991). Surgery to remove necrotic tissue is common following stereotactic radiosurgery (Whittle & Gregor, 1991) and in twenty five to thirty percent of cases following brachytherapy (Thomas, 1992).

1.2.2.5. Chemotherapy

The benefits of chemotherapy as an adjunctive postoperative treatment for gliomas are less well defined than those of radiotherapy. Lindsay et al (1991) state that some studies attribute some degree of tumour regression to chemotherapy while other randomised control trials have obtained disappointing results. The most effective drug, BCNU, increases the survival rate at eighteen and twenty four months by a small amount (Whittle & Gregor, 1991; Thomas, 1992) and may have some application in patients with malignant astrocytomas but has been found to be of no benefit in low grade gliomas (Lindsay et al, 1991).

1.2.3. Prognosis

Several factors influence the survival time following diagnosis of a malignant glioma. Age of the patient is the strongest single predictor of duration of survival, even with statistical adjustments for the occurrence in older or younger patients of different types of gliomas (Vecht, 1993; Cohadon, 1990). The significance of patient age will be discussed more fully in chapter three. Functional status at the time of diagnosis is of high prognostic significance (Cohadon, 1990; Thomas, 1992). A history of epilepsy is a positive prognostic feature (Cohadon, 1990) although the better prognosis may be due to earlier investigation and identification of the disease (MRC Brain Tumour Working Party, 1990) and the fact that two

thirds of patients with low grade glioma, which carries a better prognosis in any case, present with epilepsy (Vecht, 1993).

1.3. Language and Brain Tumours

1.3.1. Introduction

Aphasia studies have commonly dealt with language impairment of vascular origin; relatively little research has been published about the effects of brain tumours on language. There is agreement, however, among the few studies available that aphasia is a possible consequence of dominant hemispheric tumour. Retrospective studies by Recht, McCarthy, O'Donnell, et al (1989) and Miceli, Caltagirone, Gainotti, et al (1981) found that 53% and 52%, respectively, of patients with dominant hemispheric tumours had some degree of language impairment while 58% of the hundred patients recruited for Tandon and Mahapatra's (1993) study were dysphasic. Thomas, O'Connor and Ashley (1995) identified dysphasia in a smaller percentage of such patients (37%), although this group had undergone biopsy or resection of the tumour prior to language assessment. The methods used in these studies, however, preclude any real understanding of the type or severity of language disorder: Recht et al retrospectively assigned a dysphasia grading of 0, 1 or 2 to each of their 32 patients depending on whether language impairment was absent, mild-moderate or severe by referring to neurologic entries in medical notes entered from three to nine years previously; Tandon et al do not describe any method of language assessment, formal or informal, but imply that classification was based upon whether the patient reported the presence of language disturbance; and similarly, in the study by Thomas et al an unspecified researcher recorded a yes-no response from the patient and carer in answer to whether or not speech and language difficulties were present.

1.3.2.The Nature of Aphasia in Brain Tumour

In brain tumour aphasia evolves and is often relatively mild. Subtle word finding difficulties are often the only identifiable signs of language deficit (Haas et al, 1982; Kertesz, 1979; Goodglass & Kaplan, 1972), even with large tumours within the language zone (Albert et al, 1980). Conversely following cerebrovascular events aphasia is of sudden onset and although it may initially be more severe in nature it will tend to improve with time (Kertesz & Phipps, 1980). The incidence of aphasia is also higher among patients following an acute dominant hemispheric vascular incident than in brain tumour (Miceli et al, 1981).

Few group studies have been designed to describe the nature of aphasia in patients with brain tumours. Haas et al (1982) assessed 43 patients with dominant and non-dominant hemispheric gliomas using a standardised aphasia battery (the Aachen Aphasia Test) and found that the main feature of tumour aphasia is anomia, regardless of location of the lesion. Coughlan and Warrington (1978) identified word comprehension and word retrieval deficits in a cohort consisting mostly of patients with cerebral tumours and Kanzer (1942), Goodglass and Kaplan (1972) and Kertesz (1979) report similar findings from clinical observation. Single case studies are slightly more prolific in the literature but these tend to describe an isolated occurrence of an unusual or unexpected language disorder which may not be prevalent in a larger group of patients with a similar neuropathological history (e.g. Warrington & Shallice,1980; McKenna & Warrington, 1978; Mori, Yamadori & Furumoto, 1989).

1.3.3. Aphasia in Stroke versus Tumour

Tumour aphasia is rarely classifiable into the traditional syndromes derived principally from stroke studies (described above) (Kertesz et al, 1979). There is no significant correlation between the lobar location of the lesion and the presence of language impairment (Recht et al, 1989); Haas et al (1982) found that performance on an aphasia battery was independent of whether the tumour was presylvian or postsylvian or infiltrated the basal ganglia.

In a study by Anderson et al (1990) a group with supratentorial tumours who were closely matched with a stroke group for location of damage, gender, educational level and as far as possible age performed significantly better than their stroke counterparts over a range of neuropsychological tests including language tests. As expected six out of seven stroke patients in the study with a lesion in Wernicke's area produced paraphasic errors while none of the matched tumour patients did.

A significant correlation exists betwen lesion size and functional impairment in stroke while this is not the case with tumour (Anderson et al, 1990; Recht et al, 1989). A large tumour may be "silent" for a relatively long period if it does not interrupt vital interconnections between different areas of the brain while a small lesion in a critical location may have disastrous early effects (Walsh, 1994).

In stroke patient age does not correlate with occurrence of language impairment (Miceli et al, 1981; Kertesz & Sheppard, 1981; Recht et al, 1989) but correlates well with type of aphasia: different aphasic syndromes are found among older and younger stroke populations (Obler, Albert, Goodglass & Benson, 1978; Kertesz &

Sheppard, 1981; Miceli et al, 1981). A relationship between age and occurrence of aphasia does exist in tumour, however, with the older patients more often experiencing severe language impairment (Miceli et al, 1981; Recht et al, 1989). Greater severity of dysphasia in tumour with increasing age may reflect the higher incidence of malignant tumours in the older population although this is speculative.

In addition to age, tumour grade correlates positively with degree of language impairment (Recht et al; Kertesz, 1991). This relationship is not restricted to language as more extensive neuropsychological impairment accompanies higher grades of malignancy (Hom & Reitan, 1984). The greater and more rapid growth of highly malignant tumours such as glioblastoma and anaplastic astrocytoma, coupled with their more neuronally-destructive nature, leaves the brain less able to compensate (Recht et al, 1989).

A potential relationship between patient gender and incidence of aphasia has been suggested in a few vascular group studies (McGlone, 1977 and 1980; Miceli et al, 1981) but refuted by Kertesz and Sheppard (1981) as a result of statistically similar Western Aphasia Battery test scores in men and women. This has not so far been explored in brain tumour. Educational level may influence language test scores but not the extent of recovery after stroke (Shewan & Kertesz, 1984). No such evidence exists for brain tumours.

1.3.4. Right Hemisphere Language and Brain Tumours

There are no prospective group studies described in the literature which have investigated the effects of non-dominant hemispheric brain tumours on language. Cavalli et al (1981) combined eight brain tumour and 32 stroke patients and assessed their competence as a homogeneous group of right brain damaged patients on a linguistic cognitive task. A few single case studies of crossed aphasia appear in the literature (e.g. Primavera, 1993; Giovagnoli, 1993).

1.4. Mood Disorder

1.4.1. Introduction

Postoperative improvements in mood were demonstrated in a recent study of patients with brain tumours whose emotional state was assessed before and after tumour surgery (Irle, Peper, Wowra & Kunze, 1994). Male patients reported anxiety or depression less often than females. The presence of psychological disturbances may be an expected outcome of a combination of the reaction to the diagnosis of a terminal condition with the direct effects on mood of the tumour or its

treatment. In the present study the possibility was considered that mood changes may influence language test performance therefore levels of anxiety and depression were measured as part of the pre- and postoperative assessment procedure.

1.4.2. Mood Disorder after Brain Damage

There is disagreement as to the presence and extent of mood disorders, in particular depression, in patients with focal brain damage. Pimental and Kingsbury (1989) and Irle et al (1994) described mood disorders as a possible consequence of brain damage while a series of studies by Robinson and co-workers (1984) showed that mood disorders after brain damage are both frequent and potentially severe, often being present six months after stroke and persisting for up to two years after. A correlation was demonstrated in this series between lesion location and mood changes: patients with left anterior strokes were shown to suffer from major depression while patients with right anterior strokes were inappropriately cheerful and apathetic (Robinson & Benson, 1981; Robinson, Kubos, Starr, et al). House, Dennis, Warlow, et al (1990), however, did not find any link between mood symptoms and hemispheric location of the lesion and concluded in another study (1991) involving 128 patients and controls that undue emphasis had been placed in the literature on mood disorders after stroke and that symptoms, when present, largely resolved after twelve months. A further study supported Robinson et al's (1984) claim that severity of physical disability affected scores for depression but contrary to Robinson et al's findings demonstrated a relationship between acute aphasia and depression (Hermann, Wyler, Somes & Clement, 1993). Variations in results obtained from studies may be due to both the application of different diagnostic criteria, where patients displaying episodic emotionalism or lability are categorised as depressed in one series of studies but not in another, and differences in patient selection resulting from opting to assess hospital inpatients or patients at home (House et al,1990).

Little has been published on the relationship between brain tumours and mood (Irle et al, 1994). The abrupt onset of brain damage in stroke may provoke different neurophysiological and psychological reactions from tumour (Irle et al, 1994). In addition most stroke studies have focused on depression while the commonest symptom of mood disturbance in tumour may be anxiety (Greer, Moorey, Baruch, et al, 1992). Findings from stroke studies may not therefore be applicable to patients with tumours.

The literature on mood disorder in more diffuse types of brain dysfunction, as in closed head injury and the dementias (Lezak, 1995), is less relevant here although

clearly there may be some parallels as regards psychological reactions to serious and chronic illness or disability.

1.5. Determining Cerebral Dominance

When awareness of dominance is essential, as in the case of surgery for intractable epilepsy, the more reliable but invasive methods of assessment are preferred. Temporarily impairing the function of one hemisphere in a preoperative Wada test will allow identification of the dominant hemisphere (Lezak, 1995). Cortical stimulation with awake, cooperative patients will also permit mapping of functions in either hemisphere (Ojemann, 1979; Ojemann et al, 1989). These are special cases, however, where determining cerebral lateralisation will influence surgical decisions. In general clinical practice, and certainly in research, the need to determine cerebral dominance would rarely merit using invasive and inherently risky procedures.

Probably the most effective non-invasive means of indicating cerebral dominance involve demonstrating the preferred hand or foot for a variety of tasks or completing a questionnaire or inventory regarding hand preference for a range of activities (Lezak, 1995). Several studies, as described by Lezak (1995), have identified writing, drawing and throwing as the activities most likely to separate right and left handers.

The findings of many studies of cerebral dominance are contradictory, however, with the general conclusions being that using non-invasive methods of assessment it is impossible to be absolutely sure of cerebral dominance and particularly difficult to ascertain the cerebral dominance of non-right handers (Lezak, 1995).

1.6. Summary

Because of the retrospective nature of most of the few existing tumour studies, conclusions regarding the nature or severity of language impairment in patients with supratentorial brain tumours may be inaccurate because of the limitations of the methods used to obtain the data. Furthermore findings obtained from stroke studies may not be applicable to tumour as the two disease processes are very different in their neuropathology and progression and the two groups, even when carefully matched, present with dissimilar neuropsychological profiles (Anderson et al, 1990). Only a prospective tumour study combining neuroradiological imaging (Recht et al, 1989) and comprehensive assessment of language will properly address the issues involved.

The intention of the present prospective study is to provide a thorough evaluation of the disorders of language and communication which accompany intracranial tumours by addressing the following aims.

1.7. Aims of the Study

(1) To determine how the location of the lesion and corresponding language disorders relate to the recognised clinical patterns of aphasia. The expectation is that because of the different neuropathological processes involved variations might exist in the nature of aphasia as a result of tumour and stroke. Tumour aphasia may therefore not be classifiable using the same syndrome definitions as are used with aphasia in stroke.

(2) To investigate whether specific language disorders can be associated with tumour type, patient age and/or gender.

(3) To study the effects of the various methods of treatment available for brain tumours on language impairment i.e. resection, biopsy, radiotherapy, chemotherapy and corticosteroids. The expected outcome is that where language impairment exists, deficits might show improvement as a result of the various treatments whereas language function might not be significantly altered by biopsy.

(4) To investigate the possible influence of anxiety and depression on language disorders in patients with a brain tumour.

(5) To determine whether current neurolinguistic tools are appropriate for evaluating language and communication in patients with a brain tumour.

CHAPTER 2

Selection of Assessment Methods

2.1. Neuroradiological Investigation of Brain Tumours

Several different types of investigation may be performed when a brain tumour is suspected and these were applied as appropriate to patients in the present study.

2.1.1. Computerised Tomography (CT)

By directing beams of X-ray through the head from a succession of positions on an arc CT scanning produces a series of parallel slices of the cranium and the intracranial contents (Jennett & Lindsay, 1994). It can differentiate between cerebro-spinal fluid, haematoma, infarcted brain, tumour, oedema and normal brain (Jennett & Lindsay, 1994). CT will enable identification of the site of a tumour, provide information about its possible nature (more so if a contrast agent is given), and other pathophysiological variables such as midline shift, ventricular compression and peritumoural oedema (Lindsay et al, 1991).

2.1.2. Magnetic Resonance Imaging (MRI)

MRI is a diagnostic technique based on the tendency of protons of atoms to align in the direction of a strong magnetic field. As protons of different elements spin at specific frequencies each can be recognised, thus allowing different pathological processes to be distinguished from one other. Unlike CT this method of imaging does not use harmful ionising radiation. MRI has better resolution than CT and may be more sensitive in delineating the boundary between tumour and oedema (Lindsay et al, 1991; Hadley, 1992). It is also more effective in identifying deeper tumours, such as lesions of the pineal gland, third ventricle and pituitary, and tumours of the brainstem and cerebellum which may be obscured in CT scanning (Hadley, 1992; Jennett & Lindsay, 1994). CT and MR imaging can detect and localise supratentorial tumours equally well (Hadley, 1992) although CT, because it is more readily available, is the usual primary investigation of choice.

2.1.3. Single Photon Emission Computerised Tomography (SPECT)

A radioisotope such as Tc 99m is intravenously injected. This crosses the blood-brain barrier. Radioactivity indicating cerebral blood flow at the time of the injection is then detected by a gamma-camera (Jennett & Lindsay, 1994). SPECT is a more widely available method of measuring regional cerebral blood flow than

PET and has been used in previous studies to demonstrate tumour blood flow (Costa & Ell, 1991).

2.1.4. Additional Investigation

Because of the high incidence of metastatic tumours investigations such as chest x-ray, pelvic and abdominal examinations are undertaken to identify a potential primary site.

2.2. Language Assessment

Language tests which were considered to be appropriate to left and right hemisphere functioning were selected in order to identify language and communication impairments in patients with brain tumours and to measure change after treatment.

2.2.1. Assessing Language in the Dominant Hemisphere

When choosing the appropriate test or group of tests for the study most of the available assessment tools in the five categories described by Walker (1992) were excluded, for different reasons. As noted previously, Walker's five categories are:
(I) Classic multimodal or multidimensional batteries and screening tests;
(ii) Target or task-specific tests;
(iii) The cognitive neuropsychology targeted approach;
(iv) Functional assessments;
(v) Tests for specific aetiologic groups.

Group (v) was not considered relevant as no tests have been designed specifically for the assessment of language disorders in patients with brain tumours. It seemed unlikely that a selection of target or task-specific tests as in Group (ii) would provide a means of assessment superior to a standardised language test battery. Functional assessments (iv), while providing valuable information regarding the patient's ability to communicate with family members in a socially normal context rather than a hospital clinic, were discounted because of the time constraints, particularly at the pre-operative assessment which often had to take place at very short notice. In addition it was felt that the data acquired would be insufficent for analysis of the pattern of language dysfunction.

The cognitive neuropsychological approach (iii) is used by psycholinguistic researchers and clinically by some therapists. The only published group of tests, the Psycholinguistic Assessment of Language Processing in Aphasia (PALPA) (Lesser, 1992) is based on the assumption that the language system is organised in separate

processing modules with interconnecting pathways and that these modules can be individually disrupted by brain damage. The tests have been designed to determine the functional status of the components of the model rather than investigate relationships between language abnormalities and anatomical location of damage. Only the tests pertaining to the components of language processing which the clinician believes to be faulty are selected otherwise testing would be prohibitively lengthy.

While a detailed profile of a single patient's strengths and weaknesses may be clinically useful in devising individual therapy plans and for measuring change in selected components of language this group of tests was not considered to be suitable for assessing the patients in this study for a number of reasons. Information obtained by using the tests is restricted to the single word level and as no conclusions could be drawn regarding either sentence comprehension or construction the data obtained would be of limited value. Because of the subtest selection procedure different tests might be used for different patients so that trends among subgroups of patients, e.g. those with tumours in the same neuroanatomical region, would be difficult to identify. Furthermore as the currently available version of the PALPA has not been psychometrically validated the reliability of the data obtained for group research rather than clinical purposes would be questionable.

The first category of tests, classic multimodal or multidimensional test batteries, offers a more appropriate selection of assessment options for the patients in the study. As so little exists in the literature regarding the nature of language breakdown in patients with brain tumours it was considered crucial to select tests which would permit thorough assessment of all modalities of language but would not take a prohibitive length of time to administer and would be sensitive to change. Screening tests were excluded on the basis that only a superficial assessment is possible with such tests; the merits of screening tests in terms of time taken to perform are overshadowed by the lack in depth of information obtained and reduction in ability to identify change.

2.2.1.1. Comprehensive language batteries

A comprehensive test of language was required to assess the patients in this study. Of the assessments available, The Porch Index of Communicative Abilities (Porch, 1967) does not adequately assess spontaneous speech and auditory comprehension and requires the tester to receive extensive training to master the scoring system: a 40 hour workshop is strongly advised by the author; this was not available prior to assessing patients in this study. The other main tests are overlong,

such as the Minnesota Test for Differential Diagnosis of Aphasia (Schuell, 1965) and the Boston Diagnostic Aphasia Examination (BDAE) (Goodglass & Kaplan, 1972) which can take between 2 and 6 hours to administer, and were thus rejected. Tests of excessive length will rarely be used in their entirety, despite being comprehensive (Kertesz, 1979) and calculating summary scores or drawing up full profiles of performance then becomes impossible. Patients in this study were usually admitted to hospital for a pre-theatre "work-up" involving blood tests, X-ray, EEG, ECG and assessment by the speech therapist and possibly the neuropsychologist with surgery often planned for one or two days after admission; time available for language testing was often severely limited. The Western Aphasia Battery (WAB) (Kertesz, 1982) was therefore selected as the most appropriate means of assessing langauge disorders in patients with a dominant hemisphere tumour.

The WAB is based on the sound psycholinguistic principles of the BDAE but takes considerably less time to administer: the author suggested that testing should take about 90 to 105 minutes. The average time taken to complete the test by patients with brain tumours is considerably less. The WAB appeared to be the battery of choice in the absence of dedicated test materials for patients with brain tumours because it satisfies the requirements of testing and test batteries as outlined by Goodglass and Kaplan (1979):

> The purposes of aphasia testing are: (1) diagnosis of presence and type of aphasic syndrome, leading to inferences concerning cerebral localisation; (2) measurement of the level of performance over a wide range, for both initial determination and detection of change over time; (3) comprehensive assessment of the assets and liabilities of the patient in all language areas as a guide to therapy.

Kertesz (1979) believes that for a test to meet these requirements it should have the following characteristics:

(I) The test should explore all potentially disturbed language modalities.
(ii) The subtests should discriminate betwen clinically relevant aphasia types.
(iii) The test items should include a range of difficulty in order to examine a representative range of severity of deficit.
(iv) There should be enough items to minimise random test-retest variability.
(v) The administration and scoring should be standardised and replicable.
(vi) The effect of intelligence, education and memory should be minimised to achieve as purely as possible a test of language.

(vii) It should discriminate between normals, aphasics and non-aphasic brain-damaged individuals.
(viii) The length should be practical to accomplish administration of all subtests in one sitting.
(ix) The subtest items should measure the same factor.
(x) The test should measure what is generally acknowledged in the field as a language deficit or aphasia.

Standardisation of the WAB

The WAB has undergone two standardisations, one in 1974 using 150 patients and 59 controls and another in 1979 with 365 consecutive patients and 161 controls. It is designed for both clinical and research use and has been used in many studies. It meets favourably the requirements of a good test listed above (Shewan & Kertesz, 1980; Kertesz 1986) and other authorities (Lezak, 1995; Spreen & Risser, 1991) are also satisfied with the reliability, validity and statistical structure of the battery.

Kertesz describes the tests as being appropriate for all levels of aphasia severity (Kertesz, 1979); it will be argued that the tests are most sensitive when difficulties are clinically obvious and least sensitive, often to the extent of not identifying the presence of any language difficulty, when deficits are subtle and witnessed by the patient and tester only in spontaneous conversation. Using a longer, more detailed battery such as the BDAE might have proved more effective in some cases in detecting less obvious impairments but this test would not have been a feasible choice for the reasons noted above.

2.2.1.2. Test of Word Finding - the GNT or the BNT

While a test of naming is included in the WAB the items are mostly high frequency and are not sufficiently demanding for patients with subtle naming disorders. As anomia is a common language disorder in patients with brain tumours it was felt that a more extensive naming test would be a useful adjunct. There are currently two standardised, validated naming tests - the Graded Naming Test (McKenna & Warrington, 1983) and the Boston Naming Test (Kaplan, Goodglass & Weintraub, 1983).

Graded Naming Test (GNT)

The GNT contains 30 pictures of objects graded in naming difficulty. The authors hoped that by including less frequent items the test would be a sensitive indicator of mild word retrieval difficulties, enabling the tester to detect deficits "before they become clinically evident". At first sight the GNT might have seemed an appropriate choice; it is a British test and an unusually high proportion of patients

with brain tumours (32 out of 46) was involved in the validation. However various drawbacks precluded its use in this study. The test is not designed to measure anomia per se; the score obtained is described as a measure of the individual's present naming vocabulary and is most usefully interpreted in comparison with the results obtained from other indices of intelligence such as the Vocabulary and Picture Completion subtests of the Wechsler Adult Intelligence Scale (WAIS), or the National Adult Reading Test (NART). Many patients with brain tumours have language impairments which would have affected their performance on the WAIS subtests and NART; meaningful comparisons between these scores and those of the GNT would thus be difficult to make. Testing patients using the WAIS subtests and NART in addition to the WAB would have lengthened the test time to an extent which would not have been justified in the context of the present study.

The Boston Naming Test (BNT)

As the Visual Confrontation Naming subtest of the Boston Diagnostic Aphasia Examination (BDAE) contains mostly high-frequency words (Goodglass & Kaplan, 1979) the Boston Naming Test (BNT) was devised by the authors as a supplementary test of word finding. The test consists of 60 line drawings of objects which are graded in difficulty. The authors attempted to select items with as few alternative names as possible.

The BNT is a test widely used to assess word retrieval in patients with known or suspected brain dysfunction (Nicholas, Brookshire, MacLennan, et al, 1989; Thompson & Heaton, 1989). Most of the research carried out to date using the BNT has been with the 85-item experimental version. However the 60-item version published in 1983 offers a slightly briefer and perhaps better assessment (Van Gorp, Satz, Kiersch & Henry, 1986) and is "the most efficient instrument when a single measurement of naming ability is needed" (Huff, Collins, Corkin & Rosen, 1986).

As a test of language disorder the BNT correlates well with the Visual Confrontation Naming subtest (r=.81) and the overall Aphasia Severity Rating of the BDAE (Goodglass & Kaplan, 1983).

The BNT is a "wide ranging test" (Goodglass & Kaplan, 1983) and was designed for use with children aged five and a half to ten and a half, patients with dementia and adult aphasics. Norms are provided for children and normal adults in age groups from 18 to 59 years; norms are also provided for adults with less or more than 12 years formal education. Norms are available for aphasics based on the severity rating obtained from the BDAE although these are not subdivided by age.

Although the BNT was devised in the USA clinical experience suggests that there is little cultural bias among the test items. "Pretzel" is the only item which

consistently puzzled patients in the present study although many recognised it as American and some were in fact aware of its name. Performance on one item out of sixty was not thought to have any significant impact on interpretation of results. Overall the BNT is a quick, easy test to use and has provided useful additional information on word finding ability to that available from the WAB.

2.2.2. Assessing Right Hemisphere Language and Communication.

The Right Hemisphere Language Battery (RHLB) (Bryan,1989) was selected to assess patients with tumours of the right hemisphere rather than the only other potential measure of language function in the right hemisphere, the Rehabilitation Institute of Chicago Evaluation of Communication Problems in Right Hemisphere Dysfunction (RICE) (Burns, Halper & Mogil, 1985), for the following reasons:
(I) the RHLB is a published, standardised battery of tests while the RICE has not been standardised or validated;
(ii) the RHLB was validated using British patients while the American RICE may be subject to cultural bias.

The six subtests and discourse analysis rating scales of the RHLB were devised to evaluate the aspects of communication impairment associated with damage to the right hemisphere: comprehension of metaphorical or abstract language including idioms and humour, inference, some aspects of semantic processing and the ability to comprehend and produce emphatic stress.

As experience was gained using the test to assess patients with a tumour of the right hemisphere doubt emerged as to the validity of the scores and the individual test profiles obtained from the battery. A small study was thus set up to measure the efficacy of the RHLB by comparing the test performances of patients with tumours and a control group with no history of brain disease. The results from that study are described in chapter 4. After assessing 20 patients the RHLB was replaced by the WAB. The Boston Naming Test (BNT) was additionally used to assess word finding skills in this patient group.

2.2.2.1. The WAB and the right hemisphere tumour group

Using an aphasia battery to assess the language and communication of patients with tumours of the right hemisphere can be justified at several levels:
(I) The role of the right hemisphere in linguistic processsing is still largely an unresolved issue. When attempting to identify communication impairments after right hemisphere damage potential aphasic errors should also be screened (Bryan, 1988; Meyer, 1994);

(ii) The fact that some studies have suggested that semantic or syntactic impairments can result from right hemisphere damage (Lesser, 1974; Schneidermann & Saddy, 1988; Bryan, 1988; Joanette et al, 1990) implies that using an aphasia battery with this patient group may yield interesting results by either supporting or refuting claims made in existing literature.

The WAB, rather than any other aphasia battery, was chosen to replace the RHLB because of its many strengths and because it was already in use to assess patients with tumours of the left hemisphere. Using the same test materials with all patients in the study enabled comparisons of linguistic behaviour between right and left hemisphere groups. In retrospect, therefore, the integrity of the study benefited from using the same test battery with both left and right hemisphere tumour patients.

2.2.2.2. The BNT and the right hemisphere group

Studies by Lesser (1974), Gainotti et al (1981), Joanette et al (1983) and Joanette and Goulet (1988) have suggested that naming deficits can be identified after right hemisphere damage. The BNT was therefore included to provide information on the status of confrontation naming in patients with right hemisphere brain tumours.

2.3. Mood Disorder

As mood disorders have been identified as potential sequelae to brain damage (Robinson et al, 1984; Pimental & Kingsbury, 1989; Irle et al, 1994), and disturbances might influence language test performances, a method for evaluating mood disorders in the patients in this study and possible correlations with language impairment was considered an appropriate addition to the assessment protocol.

2.3.1. Screening For Mood Disorder - The Hospital Anxiety and Depression Scale (HAD)

Hamilton and Shapiro (1990) and Snaith and Turpin (1990) review the many observer and self rating scales available for the evaluation of anxiety and depression. Observer checklists and rating scales are more time consuming and often require familiarity with the patient's behaviour over a wide range of everyday activities. Self rating scales are perhaps more appropriate for use in clinical trials and studies: tester-patient contact usually occurs infrequently with limited time available for observation of behaviour; the patient can usually complete a questionnaire at the time of assessment or at a point later in the day; and self assessment questionnaires can be repeated as often as required while retaining their validity (Hamilton & Shapiro, 1990). The practical benefits of self-rating scales

outweigh the potential disadvantages of patients failing to complete the questionnaire truthfully or being unable to read as a result of language disturbance or limited education.

Since the contribution of affective status to language disorder and performance in language testing in patients with brain tumours was one of the aims, but not the main focus, of the present study, a short, self-rating questionnaire was considered to be the most suitable method of assessment. The Hospital Anxiety and Depression Scale (HAD) (Zigmond & Snaith, 1983) was designed for use in non-psychiatric hospital departments to screen for both anxiety and depression. By eliminating questions relating to physical disorder the authors of the HAD have attempted to obtain a "purer" mood score relatively uncontaminated by primary symptoms of physical illness (which can overlap with physical symptoms of depression and anxiety). The instruction to patients to complete the questionnaire with reference to how they have been feeling in the past week is particularly appropriate to the patient group in the study who have often been aware of impending brain surgery and a potentially life-threatening condition for only a short period of time.

Fourteen items are included, seven of which relate to anxiety and seven to depression. The HAD can discriminate to some extent betwen anxiety and depression and provides a measure of the severity of both: "borderline" scores fall between 8 and 10 and higher scores indicate clinically significant mood disturbance.

Like other clinically useful self-rating scales the HAD is "reasonably valid" and can be repeated as often as necessary (Hamilton & Shapiro,1990).

2.4. Determining Cerebral Dominance

The inclusion of an evaluation of cerebral lateralisation was considered necessary to avoid inaccurate conclusions being drawn regarding the effects of brain tumours on language function.

While the temporary impairment of the function of one hemisphere, as in the Wada technique, or direct cortical stimulation may be relatively reliable in ascertaining cerebral dominance (Lezak, 1995) neither of these methods would have been practical or ethical as a routine procedure in the present study. As previously discussed, a handedness questionnaire or inventory seemed to be the most acceptable option.

2.4.1. The Handedness Inventory

Briggs and Nebes (1975) revision of Annett's (1967) questionnaire includes 12 items with a handedness score devised from a five point scale. Possible scores range

from -24, which is the most left-handed score, to +24 which is most right-handed. An estimate of degree of laterality is therefore obtained rather than a categorical classification of right or left. Patients are not required to demonstrate or enact activities; many would be unable to comply fully because of motor weakness associated with their illness.

The scoring system of +9 and above indicating right handedness, between -9 and +8 mixed-handedness and from -9 to -24 left handedness was used by Loo and Schneider (1979). to designate 14% of a group of 1599 subjects non-right-handers. This conforms with the literature on expected proportions of handedness.

CHAPTER 3

Language Disorders in Patients with Intracranial Tumours

3.1. Introduction

An evaluation of the disorders of language and communication which were found in this study to be associated with intracranial tumours is presented below. The methods used for all patients are described followed by two results sections containing findings and discussions relating to patients with a tumour of the left or right hemisphere respectively.

3.2. Method

3.2.1. Referral of Patients

Patients with a solitary tumour of either the dominant or non-dominant hemisphere were referred for assessment following admission to the Department of Clinical Neurosciences (DCN). Referrals were made by medical and nursing staff. There was no apparent selection bias and the cohort was essentially a consecutive series of patients. At the time of testing patients had to be well enough to cope with being physically moved from the ward to an assessment room and to be able to sit upright and comply with testing for an hour or longer.

3.2.2. Surgical and Non-Surgical Treatment

Patients with a solitary intracranial tumour were treated variously with biopsy, resective surgery, radiotherapy and chemotherapy. Each of these types of treatment is described.

3.2.3. Assessment Measures

Data were collected for each patient involved in the study relating to their neuroradiological, communication and affective status, which will be discussed in chapter 6. The patients in the study all completed the Briggs and Nebes (1975) revision of Annett's (1967) Handedness Inventory (appendix I, p168) and obtained a laterality score as described in the previous chapter. Patients whose score indicated a strong left-handed preference were excluded as it was impossible to be sure of dominance. Where used, the terms dominant and non-dominant refer to left and right respectively.

3.2.4. Patient Consent

A standard consent form was signed by patients to acknowledge their agreement to participate in the study (appendix I, p.161). Where language impairment precluded sufficient comprehension of the consent form a close relative was asked instead. Consent was given by all patients or relatives for those included in the study although several patients withdrew after initial assessment; their circumstances are described below. The study was approved by Lothian Health Board and the relevant ethics committee.

3.2.5. Statistical Methods

All data was entered on DBase IV using a Samsung Syncmaster 3 PC and transferred to SPSS for Windows for all statistical analysis. Statistical tests used will be described in each relevant section. In the following presentation of results a probability level of less than 0.05 will be taken to indicate significance.

3.2.6. Neuroradiological Assessment

Information pertaining to tumour location was obtained in each case from GE 8800 Phillips computerised tomography scanner with occasional additional magnetic resonance imaging (MRI) using a 1.5T Siemens scanner. Templates (shown in appendix I, p.166 and 167) were devised by the neurosurgeon involved in the study to further localise the tumour within the dominant hemisphere. Six regions were identified by the templates: three lobar areas - the frontal pole (1), the temporal pole (2) and the occipital pole (3); two cortical areas known to have significance for language - the area of the frontal region containing Broca's area (4) and temporoparietal region containing Wernicke's area (5) - and the subcortical region (6). Agreement was strong between the neurosurgeon and neuroradiologist who independently assigned the tumours to one or more regions using the templates. The templates were not used to localise tumours of the non-dominant hemisphere.

3.2.7. Language Assessment: General Considerations

3.2.7.1. Exclusion criteria prior to language testing

The patients included in the study were between the ages of 18 and 75. Exclusion criteria were: first language not English; impairments of hearing and vision not corrected or correctable by spectacles or hearing aid; or history of psychiatric disorder, alcoholism, head injury or other known brain disease.

3.2.7.2. Timing and frequency of testing

Testing was usually carried out on the day preceding biopsy or resective surgery. Most patients had a second language assessment within a week after the first. Although it is possible that reassessment several weeks after surgery might have permitted a more complete recovery the concern was that many patients would be lost to follow-up, some would by then have begun other treatments such as radiotherapy and others might have deteriorated because of tumour progression.

3.2.7.3. Test environment

Because sustained concentration was required by the patient, a quiet, private room was used for testing. Because of the general activity and distracting background noise occurring in even a quiet hospital ward, assessment took place at the patient's bedside only if testing was previously halted with just the BNT to complete; the patient was fully alert in each case, sitting upright in or at the side of the bed.

3.2.7.4. Cessation of language testing

Language assessment was discontinued if the patient became drowsy or excessively tired during testing. Testing was either abandoned, or postponed until the patient was fully awake and if necessary was spread over two sessions. No patient was tested while lying flat in bed or in a drowsy or fatigued state at the outset of testing.

3.2.8. Language Assessment

The Western Aphasia Battery (WAB) was used to assess the language of patients with tumours of the left hemisphere while patients with tumours of the non-dominant hemisphere were originally assessed using the Right Hemisphere Language Battery (RHLB). This was later replaced by the WAB when the RHLB was shown in a separate study to be uninformative in patients with brain tumours. This study will be discussed in chapter 4. The Boston Naming Test (BNT) provided an additional word finding score for most of the patients in both groups. BNT and WAB test times were recorded except in cases where associated limb weakness precluded completion of the writing or drawing subtests of the WAB, which would have led to an artificially low test time.

3.2.8.1. The Western Aphasia Battery

The WAB contains subtests aimed at evaluating the various language modalities and in addition a collection of short non-verbal tests, as shown in Table 1.

Table 1: Verbal and non-verbal subtests of the WAB

VERBAL SUBTESTS	
Spontaneous Speech	Information Content
	Fluency
Auditory Comprehension	Yes/no Questions
	Auditory word Recognition
	Sequential Commands
Repetition	
Naming	Object Naming
	Word Fluency
	Sentence Completion
	Responsive Speech
Reading	
Writing	
NON-VERBAL SUBTESTS	
Praxis	
Construction	Drawing
	Block Design
	Calculation
	Raven's Coloured Progressive Matrices

(The above depicts how Andrew Kertesz categorised the battery subtests. Calculation and Raven's Matrices have been grouped with Drawing and Block Design although they are not tests of construction.)

Scoring the WAB

Four summary scores can be derived from groups of subtest scores. The oral language subtests of spontaneous speech, auditory comprehension, repetition and naming are combined to provide the Aphasia Quotient (AQ) which is informative regarding severity and type of aphasia and is of particular value when the patient has motor impairments and is unable to cope with the written language subtest. An AQ of between 93.8 and the maximal score of 100 is taken to reflect language within normal limits; 93.8 was the mean AQ obtained by a non-aphasic brain damaged

control group during the standardisation of the WAB. In addition the scores obtained in these subtests can be used to classify the patient according to category or type of aphasia. Shewan (1986) proposed the Language Quotient (LQ) which combines the oral language subtests with reading and writing and presents a more comprehensive picture of language performance. The Performance Quotient (PQ) is a summary of the scores obtained in all the subtests apart from the oral language tests and the Cortical Quotient (CQ) includes all subtest scores to give a profile of overall cognitive function. The PQ was not included in the data analysis; it is rarely, if ever, used and is of uncertain validity. The AQ, LQ and CQ were considered adequate in providing a sufficiently comprehensive description of patient performance in this study. Scores were occasionally missing for writing and drawing because of hand weakness; the CQ was then prorated, providing no more than two subtest scores were missing. The AQ and LQ were never prorated; if a writing score was impossible to obtain the LQ was considered missing data.

Information relating to the quality or nature of the language problem is not available from summary scores (Lezak, 1995). In this study a comparison of summary scores before and after surgery provides indices of general changes in language behaviour while analysis of changes in the mean scores of individual subtests serves to highlight change in specific aspects of language function as will be described more fully in the results and discussion chapters.

Changes to the administration and scoring of the WAB

The WAB was administered and scored as directed in the test manual with minor modifications. Although the WAB is described as having good inter-tester and test-retest reliability (Kertesz, 1979) it was felt that some of the instructions for administration were not sufficiently detailed to preclude idiosyncratic interpretation of scoring. A meeting with Andrew Kertesz and Pat McCabe, the neuropsychologist in the Department of Neurology in St Joseph's Hospital, Ontario, provided helpful guidelines in addition to those available in the test manual. The revision of scoring was implemented with the new cases in the study subsequent to the meeting with Drs Kertesz and McCabe and all tests carried out before the meeting were re-scored to ensure uniformity. This was possible because all responses made by patients were recorded in the test booklet with spoken language subtests also recorded on audio tape. It was believed that the subtle alterations to the guidelines would not compromise the interpretation of summary scores as all tests before and after treatment were scored following identical rules. The Aphasia Quotient of 93.8 was retained as the boundary between dysphasia and normal language. Amendments to scoring are described below.

The spontaneous speech subtest

The patient is initially asked six biographical questions and is then required to describe a picture of people involved in a variety of activities. Both quantity of information and fluency are rated. The score allocated for fluency is determined by the nature of dysphasic features present in the spoken output, for example according to the test booklet a score of eight requires "Circumlocutory, fluent speech. Marked word finding difficulty. Verbal paraphasia. May have semantic jargon. The sentences are often complete but may be irrelevant." It is not explicit in either the test manual or test booklet that the presence of only one of the features listed is sufficient to obtain any of the scores, despite the risk of an inappropriately generous score being awarded if the interpretation is that all features must be present. The scoring for fluency was changed accordingly when Kertesz clarified this point.

The naming subtest

The tester is instructed to cue or allocate partial scores where appropriate. In this study a right or wrong response was recorded with the patient either obtaining full points for an item or none. Cueing and partial scoring provide information relating to the nature of errors produced whereas the aim in this study was to identify the presence of word finding problems and assess the post-treatment change in naming ability.

Word fluency

The score for fluency in the spontaneous speech section of the WAB differs from word fluency in that the former refers to the grammatical and verbal competence of expressive language whereas word fluency is normally tested by naming as many single words as possible within a given category and time span. In the WAB the patient is required to name as many animals as possible within one minute. The maximal score awarded is twenty, even when more than twenty animals are listed during testing. It was felt that recording the number of items named without the ceiling of twenty might provide additional information when analysing the performances of patients with and without language disturbances. Two separate scores for word fluency were therefore recorded, the first was the actual number of animals listed by the patient in one minute and the second was the score out of a possible twenty, labelled in the results section as word fluency(a) and word fluency(b), respectively. When included in the summary quotients AQ, LQ and CQ, the score used was word fluency (b).

The reading subtest

The reading test has 9 sections, A through to I. The tester is required to stop after B if the combined score of A and B is 50 or more and a prorated score out of

100 is then awarded. If the combination of A and B is less than 50 then the other 7 subtests should be completed and all subtest scores should be added to provide the total for reading comprehension. In this study the reading test was initially administered in this way but after several months all patients were given a prorated score for their performance in A and B and the other 7 subtests were not used at all. The reason for this change was that A and B are the most demanding of the reading subtests. Of the patients who carried out subtests C to I very few did not score 100%: each of these subtests is based on comprehension at the single word level. As the majority of patients tended to have subtle language deficits, tests involving comprehending paragraphs and following written instructions, as is required in A and B, were far more likely to identify weaknesses. It appeared reasonable to assume that carrying out a series of simple, single word subtests would not significantly add to the information obtained from the two previous complex tasks. All patients were therefore rated on the basis of their performance in A and B only and the combined score was prorated regardless of whether it was greater or less than 50.

The writing subtest

A prorated score for the writing test can be calculated from the points accumulated in subtests A, B and C if the total is greater than 80, otherwise D, E, F and G should be completed. A, B and C provide a more demanding test of writing skills and are more likely to highlight dysgraphic difficulties, while the other four subtests require limited ability to write single numbers, letters and words and to copy a written sentence. D, E, F and G were discarded; test results were uninformative as most patients obtained the maximal score. It was also likely that these extra tests might tire more vulnerable patients unnecessarily. A writing score was prorated from subtests A, B and C in every case.

Instructions for scoring the written picture description subtest are provided in the test booklet, as follows:

"Score 34 points for a full description, 8 points for each complete sentence with 6 words or more, 1 point for each correct word in incomplete or short sentences. Deduct 1/2 point for each spelling or paraphasic error. Score isolated words 1 point, to a maximum of 10 points. Punctuation is not scored."

There are several criticisms of these guidelines:

(a) The scoring system does not discriminate between patients who write an effortless, syntactically perfect, detailed picture description and those who struggle to write four sentences containing six words each and an additional two single

words. Providing there are no spelling or paraphasic errors both score the maximum 34.

(b) Similarly, two sentences, one containing 6 words with a simple *subject - verb - object* construction and another with complex syntactic structure containing clauses and sub-clauses, will both score 8 points. While such scoring seems to acknowledge the large range of writing ability within the normal population (and therefore presumably within the patient cohort in the study prior to brain disease) and takes account of degrees of "normality" in that some people have greater writing skills than others, it does not cater for patients with superior premorbid writing ability whose score may still be "normal" despite the presence of relative impairment.

(c) A score of 34 can be obtained on condition that there are 34 words in incomplete or short sentences and no paraphasias, despite the fact that deficient language skills may be the cause of the incompleteness of the sentences. Here the artificially high writing score may fail to identify language impairment.

The patients in the study very often had subtle writing deficits which the standard WAB scoring system was not capable of identifying; the raw scores for writing may not represent the true extent of tumour-induced dysgraphia. It would be unfair to direct criticism at the WAB itself as it is an extremely useful clinical and research tool which has been well validated and is widely used. The problems stem more from its being validated for the most part using stroke patients who arguably have more severe, and perhaps more predictable, signs of impairment than patients with brain tumours (Anderson et al, 1990; Archibald, Lunn, Ruttan, et al, 1994). There was, however, no standardised, validated writing test for patients with brain tumours available during the period of the study therefore the test booklet instructions were followed as above when scoring the picture description.

The drawing subtest

An important omission from the administration and scoring instructions is that the test cards containing the target pictures should be shown to the patient for a few seconds each; long enough for the patient to understand what is required but not long enough to enable copying. It was explained by Kertesz and McCabe (personal communication, 1993) that target pictures are shown so that impaired auditory comprehension will have a limited impact on performance, although this is not explicit in the manual.

The only item for which the patient is not shown a target picture is the human figure. The request to draw one should be given as follows: "I want you to draw a person from top to toe, face on as though they were looking at you." Again this instruction is not included in the manual or test booklet but was recommended by

Kertesz and McCabe to increase the likelihood of patients producing a figure which can be scored by following a set of standard rules. To be awarded the maximal score of five the drawing must have facial features, hair or ears, neck and body, arms and legs, hands and feet; points are deducted in accordance with missing parts.

Although it was not possible to amend the earlier tests where patients did not see the test cards prior to drawing, all drawing subtests were subsequently re-scored using these new rules. Consideration of drawings produced suggests that this will not have introduced a large amount of error into the analysis.

3.2.8.2. The Boston Naming Test

In accordance with the test instructions the BNT was i) discontinued if after six successive failures the patient showed signs of discomfort or frustration and ii) continued until the end if the patients were unaware of or unaffected by errors.

The authors recommend beginning at item 1 with aphasic patients and at item 30 with normal adults. All patients in the study began at the first item and continued to the end unless frustration or anxiety precluded their reaching the end. This ensured uniformity of administration throughout the patient cohort and perhaps more importantly prevented wrong assumptions being made about patients' word finding abilities.

Scoring the BNT

Cues should be given if the patient is unable to name an item spontaneously. If the patient misperceives or does not recognise a picture a "stimulus" or semantic cue is given, e.g. for item number 35 "dominoes" the stimulus cue "a game" is provided. If successful the patient is credited with the point. If the stimulus cue has not prompted the correct answer within 20 seconds the patient can then be given a phonemic cue, eg "dom" for dominoes, but is not awarded the point. In this study no cues were given during either pre- or post-operative BNT. A right/wrong response was recorded for each item as a measure of word retrieval for the following reasons:

(a) Types of error were not a focus of the study therefore data relating to error type or response to cueing were not collected.

(b) Patients were tested prior to biopsy or resection. Reassessment usually occurred within a week of the first assessment. It was believed that success as a result of cueing might strengthen the memory of cued items so that correct naming of the items at the second assessment might be more attributable to the memory of the cue rather than to improvement in word finding ability after treatment. It was felt,

therefore, that there was a slight risk of cueing artificially improving post-operative scores.

(c) Misperception or failure to recognise stimulus items was rare in the patients in the study.

Altering the administration of a test from the form in which it was validated may reduce the relevance of the norms to the data being collected. This was not thought to present any major drawbacks here as patients' test scores were analysed more in relation to each other before and after surgery, and between and within subgroups of patients, than with reference to the normal population. Furthermore Huff et al (1986) showed that when an "uncued" group of BNT scores are compared with a "cued" group, omitting cues during testing does not affect the psychometric properties of the BNT.

3.3. The WAB and BNT in Patients with a Dominant Hemisphere Intracranial Tumour

3.3.1.Patterns of Language Disorder at Initial Assessment (A)

3.3.1.1. Patients

Sixty-five patients with a dominant hemispheric tumour had a language assessment before any surgical intervention. The characteristics of this group are shown in Table 2.

Table 2: Characteristics of 65 patients who had a dominant hemispheric tumour.

	Male Patients (n=39)	**Female Patients (n=26)**
Age Range	20 - 73 years	18 - 75 years
Mean Age (S.D.)	48.2 years (S.D.15.8)	54.6 years (S.D.14.9)
Median	46.0 years	56.0 years

3.3.1.2. Results (1): WAB test scores

Subtest and summary scores obtained before either resective surgery or biopsy by all 65 patients with a dominant hemispheric tumour are shown in Table 3. Thirty eight patients (58.5%) obtained an AQ of less than 93.8, indicating language impairment at initial assessment. Comparisons of test scores revealed highly significant differences in test performance between dysphasic and non-dysphasic patients. These scores are presented in Table 4 (here and elsewhere p=0.000 means

$p<0.0005$). Six patients in the dysphasic group and four patients in the group with normal language were unable to attempt the writing subtests of the WAB. Writing scores, LQ and WAB test time were not recorded for these patients. Analysis of scores for the non-verbal subtests is not presented here as the results obtained from these subtests added little to the main findings. It was believed that the Cortical Quotient, which includes the scores for the non-verbal subtests, would provide an adequate measure of overall cognitive functioning.

For the purpose of comparison of test performance in the discussion below Table 5 shows six scores obtained by 141 stroke patients in Kertesz's standardisation of the WAB (Kertesz presents only these six scores in his standardisation). Stroke group scores are all substantially lower than those of the tumour patients; it is presumed that alterations to the administration and scoring did not artificially increase the WAB scores of the patients with tumours as the changes made the subtests more exacting.

Table 3: WAB scores for all patients with a dominant hemispheric tumour on first assessment.

(Maximal score)	**Number**	**Mean**	**S.D.**	**Minimum Score**	**Maximum Score**
Information Content (10)	65	8.3	2.0	2.0	10.0
Fluency (10)	65	8.7	1.8	3.0	10.0
Spontaneous Speech Total (20)	65	16.9	3.6	6.0	20.0
Yes/no Questions (60)	65	56.1	9.3	0.0	60.0
Auditory Word Recognition (60)	65	56.1	8.8	26.0	60.0
Sequential Commands (80)	65	64.3	23.2	0.0	80.0
Comprehension Total (20)	65	17.7	3.9	2.6	20.0
Repetition (10)	65	8.5	2.4	0.2	10.0
Object Naming (60)	65	49.7	17.8	0.0	60.0

Word Fluency (a) (no maximal)	65	11.2	7.2	0.0	24.0
Word Fluency (b) (20)	65	10.9	6.7	0.0	20.0
Sentence Completion (10)	65	8.9	2.7	0.0	10.0
Responsive Speech (10)	65	8.9	2.7	0.0	10.0
Naming Total (10)	65	7.7	2.9	0.0	10.0
Reading Paragraphs (40)	62	30.1	11.6	0.0	40.0
Reading Commands (20)	61	17.4	5.3	0.0	20.0
Reading Total (10)	61	7.8	2.9	0.0	10.0
Written Picture Description (34)	56	20.9	13.0	0.0	34.0
Writing Total (10)	56	6.6	3.4	0.0	10.0
Aphasia Quotient (100)	65	84.0	20.2	25.0	100.0
Language Quotient (100)	56	80.5	21.4	17.3	100.0
Cortical Quotient (100)	57	84.6	17.6	29.0	99.4
Test Time (in minutes)	52	61.5	29.6	33.0	195.0

Table 4: WAB scores at first assessment for 38 dysphasic patients (i.e. obtained an AQ of 93.7 or less) and 27 non-dysphasic patients (i.e. obtained an AQ of 93.8 or higher) with a dominant hemisphere tumour.

(Maximal score)	**Dysphasic Group Mean (S.D.)**	**Non-Dysphasic Group Mean (S.D.)**	**Significance Level**

Information Content (10)	7.2 (2.1)	9.7 (0.6)	0.000
Fluency (10)	7.8 (1.9)	9.9 (0.4)	0.000
Spontaneous Speech Total (20)	15.1 (3.7)	19.5 (0.6)	0.000
Yes/no Questions (60)	53.49 (11.4)	60.0 (0.0)	0.001
Auditory Word Recognition (60)	53.4 (10.8)	59.9 (0.2)	0.001
Sequential Commands (80)	54.3 (25.9)	78.4 (4.3)	0.000
Comprehension Total (20)	16.1 (4.4)	19.8 (0.4)	0.000
Repetition (10)	7.7 (2.8)	9.8 (0.3)	0.000
Object Naming (60)	42.7 (20.7)	59.6 (1.4)	0.000
Word Fluency (a) (no maximal)	7.2 (5.6)	16.8 (5.1)	0.000
Word Fluency (b) (20)	7.2 (5.6)	16.1 (4.4)	0.000
Sentence Completion (10)	8.1 (3.3)	10.0 (0.0)	0.001
Responsive Speech (10)	8.1 (3.4)	10.0 (0.0)	0.001
Naming Total (10)	6.4 (3.1)	9.6 (0.5)	0.000
Reading Paragraphs (40)	24.7 (12.2)	38.2 (3.3)	0.000
Reading Commands (20)	15.5 (6.4)	20.0 (0.0)	0 000
Reading Total (10)	6.3 (3.1)	9.7 (0.6)	0.000
Written Picture Description (34)	13.5 (12.3)	30.9 (4.1)	0.000

Writing Total (10)	4.5 (3.2)	9.3 (0.90	0.000
Aphasia Quotient (100)	74.4 (21.8)	97.6 (1.7)	0.000*
Language Quotient (100)	68.5 (21.5)	96.5 (2.9)	0.000
Cortical Quotient (100)	74.8 (18.8)	96.3 (2.2)	0.000
Test Time (in minutes)	73.8 (32.6)	46.0 (15.1)	0.000

*This inevitably low p-value is presented for the purposes of comparison.

Table 5: Mean aphasia quotient and scores for five subtests obtained by 141 stroke patients in the standardisation of the WAB. Mean age of the group=65.3. (Kertesz, 1979)

	Information Content	**Fluency**	**Auditory Comp. Total**	**Repetition**	**Naming Total**	**Aphasia Quotient**
Mean	4.8	5.4	12.4	5.8	4.5	53.5
S.D.	3.4	3.1	5.8	3.7	3.3	29.9

3.3.1.3. Results (2): BNT scores

Fifty nine patients with a tumour of the dominant hemisphere completed the BNT at initial assessment. The mean score for the entire group demonstrates word finding difficulties as it falls below the normal range provided by the test authors (i.e. 46 - 60). Scores are shown in Table 6.

Table 6: BNT scores obtained at initial assessment by 59 patients with a tumour of the dominant hemisphere.

Mean (S.D.)	**Minimum**	**Maximum**
38.2 (17.6)	0	59

Patients were divided into subgroups, anomic and non-anomic, using the arbitrary division of a score of 48 or less indicating word finding difficulties and 49 or more out of a possible 60 indicating word finding skills within normal limits.

The norms provided by the BNT authors suggest a mean score of 55.7 for 83 normal adults between the ages of 20 and 59. Adopting a score of 48 as a cut-off can be justified on the grounds that none of the normal controls in the standardisation of the BNT in the age range 40-59 scored less than 49: the mean age of the patients in this study with a dominant hemispheric tumour falls within this range. The proportion of patients who scored 48 or less before resection is similar to the number of such patients identified in this study as dysphasic by the WAB, 63% and 58% respectively. Finally the score of 48 represents approximately two standard deviations below the mean of the normative sample which is a commonly used cut-off criterion. BNT scores for the subgroups of anomic and non-anomic patients are shown in Table 7.

Table 7: BNT scores obtained at initial assessment by 37 anomic patients with a tumour of the dominant hemisphere (i.e. scored 48 or less out of 60) and 22 non-anomic patients with a tumour of the dominant hemisphere (i.e. scored 49 or more out of 60).

	Mean (S.D.)	**Minimum**	**Maximum**
Anomic Group (n=37)	29.2 (16.1)	0	48
Non-Anomic Group (n=22)	53.6 (3.5)	48	59

3.3.1.4. Discussion: language disorders in patients with a dominant hemisphere tumour

In this study 58.5% of patients with a dominant hemisphere tumour were identified as dysphasic at initial assessment. The nature of language disorders in such patients and the suitability of the available test materials are discussed below.

The main feature separating language disorders in patients with a dominant hemisphere brain tumour from those in patients after stroke is severity of impairment. This phenomenon has been observed in other studies (Kertesz, 1979; Goodglass & Kaplan, 1972; Haas et al, 1982). The subtest and summary scores obtained by the 65 patients with a tumour of the dominant hemisphere are on inspection higher, indicating on average milder language deficits, than the scores obtained by the stroke patients in the standardisation of the WAB. The explanation may be a consequence of the differences which exist between the two disease processes. Tumour aphasia evolves, often very gradually, as the tumour itself grows and displaces brain tissue, with neuronal damage usually only occurring in the later

stages. The gradual onset of clinical signs may enable the patient to adapt to emerging language problems by slowing the rate of speech, pausing before replying or mentally rehearsing a response before uttering it, strategies which were frequently used during conversation and language testing by the dysphasic patients in the study. The rapid neuronal death associated with stroke may allow little time for the integration of either compensatory or coping strategies. Test scores may also be influenced by the timing of assessment. Progressive dysphasia is usually recognised and investigated fairly quickly and language performance in patients with tumours may appear less impaired because testing will usually occur at a relatively early stage in the progression of the disease and associated language disturbance.

Tumour aphasia has been described as anomic (Kertesz, 1979; Kertesz & Phipps, 1980; Goodglass & Kaplan, 1982). The results of this study support Kertesz's claim in that pure dysphasic syndromes were rare and many patients obtained low scores for the BNT and naming subtest of the WAB. But when the test performances of patients whose AQ indicates the presence of language impairment at initial assessment are compared with patients with normal language function, highly significant differences are evident in every subtest of the WAB. This suggests that dysphasia in patients with a dominant hemisphere tumour is very much broader than anomia. It is apparent that all modalities of language can demonstrate impairments.

The mean scores for reading and writing are lower on inspection for the dysphasic tumour group than the groups containing 141 stroke patients and 35 stable strokes in Kertesz's validation of the WAB. Why reading and writing should show greater impairment in the tumour group is not entirely clear, especially when the means for the stroke patients appear to be substantially lower for the spontaneous speech subtests (both information content and fluency), all tests of auditory comprehension and the naming subtests. It is possible that compensatory strategies are not as straightforward to devise or establish in non-oral language.

While differences in the neuropathology, pathophysiology and implementation of coping strategies may contribute to higher test scores in patients with tumours the likelihood is that the language test batteries available are not entirely appropriate tools for the comprehensive assessment of patients with brain tumours. All existing tests of language were standardised using mostly stroke patients. Kertesz (1979) assessed a group of 34 patients with an intracranial tumour during the standardisation of the WAB. There are no subtest data available for this group, however Kertesz concludes that the tumour group is "quite dissimilar" to the stroke

group and that tumour patients can rarely be classified into any of the traditional aphasic syndromes. Anderson et al (1990) demonstrated that stroke and tumour groups matched for location and relative size of lesion perform "radically differently" across a broad range of neuropsychological tests, including tests of language. The tumour group in Anderson et al's study had fewer, milder language impairments than the stroke group. The likelihood is that the standardisation of aphasia test batteries using a population with more severely impaired language will result in assessment tools not sufficiently sensitive to identify the subtler, milder deficits of the tumour patients.

3.3.2. Patterns of Language Disorder at Initial Assessment (B): The Significance of Lesion Location, Type of Tumour and Patient Characteristics

In the following section analysis of potential relationships between language test scores and factors such as lesion location, tumour neuropathology, age and sex of the patient will be discussed. Confounding associations between some of the above variables, and the size of the relevant groups and subgroups, preclude simultaneous analysis of multiple variables.

Statistical analysis mostly involved the use of, where appropriate, paired and unpaired t-tests, one way analysis of variance and correlations using Pearson's *r* and its derivative, the point biserial *r*. Additional statistical procedures are described in the text.

3.3.2.1.. Results (1): Lesion location and language scores

Using CT/MR scans and the brain templates described above tumours of the dominant hemisphere were assigned independently by a neurosurgeon and neuroradiologist to one or more of six regions. The regions represent the following areas of the brain:

Region 1	**Frontal pole**
Region 2	**Temporal pole**
Region 3	**Occipital pole**
Region 4	**Frontal region (including Broca's area)**
Region 5	**Lateral temporoparietal region (including Wernicke's area)**
Region 6	**Central/deep structures of the brain.**

Scan data for 69 patients was analysed; this number comprises the 65 patients with a left hemisphere tumour in the main study and an additional four patients who

were assessed before beginning chemotherapy who had not recently had tumour biopsy or resection.

Tumour was identified in an average of two regions, most commonly deep in the brain and less frequently in the frontal pole. Tumour growth invaded the occipital pole in only three cases; scores for that region were consequently not included for analysis. Numbers of cases with tumour in each region and the mean language scores for each of the regions are shown in Table 8. These data are also depicted in Figure 1 on p.58. On inspection, language impairment is more severe in association with tumour in Broca's area than in the other regions. Language deficits are also evident with a lesion in the temporal pole and less so in the temporoparietal region. Impairments, including time taken to complete the WAB, appear to be least severe when tumour is found in the deeper structures of the brain.

Table 8: Mean language scores for 69 patients with tumour growth in one or more of five regions of the dominant hemisphere: the frontal pole (region 1), temporal pole (region 2), frontal region containing Broca's area (region 4), the lateral temporoparietal (region 5) and central region (region 6).

Subtest/ maximal score	**Region 1 n=13 (S.D.)**	**Region 2 n=24 (S.D.)**	**Region 4 n=27 (S.D.)**	**Region 5 n=31 (S.D.)**	**Region 6 n=37 (S.D.)**
Spontaneous Speech Total /20	15.9 (4.4)	15.7 (4.2)	14.9 (4.4)	16.9 (3.7)	17.0 (3.9)
Sequential Commands /80	64.6 (23.4)	59.5 (27.6)	55.3 (27.4)	63.2 (24.4)	63.8 (23.1)
Comprehension Total /20	17.8 (3.6)	16.5 (5.1)	16.0 (5.0)	17.7 (3.7)	17.7 (3.5)
Repetition /10	8.8 (2.2)	7.6 (2.8)	7.5 (3.1)	8.2 (2.7)	8.8 (2.2)
Object Naming /60	48.2 (16.8)	41.2 (23.0)	41.5 (21.8)	51.0 (16.5)	50.3 (17.2)
Word Fluency (a)	9.2 (7.1)	9.1 (6.5)	7.0 (5.9)	11.7 (6.9)	11.0 (7.6)
Reading Paragraphs /40	25.9 (15.8)	28.7 (12.9)	24.6 (14.3)	29.7 (12.4)	30.6 (12.1)
Reading Total /10	6.6 (3.9)	7.3 (3.3)	6.2 (3.6)	7.6 (3.1)	8.0 (2.9)

Written Picture Description /34	17.5 (13.6)	19.3 (13.0)	14.9 (13.4)	20.6 (12.5)	22.0 (13.8)
Writing Total /10	5.8 (3.3)	6.0 (3.5)	4.9 (3.6)	6.4 (3.4)	6.8 (3.7)
Aphasia Quotient /100	82.1 (21.1)	76.2 (24.4)	73.0 (24.7)	83.5 (21.4)	85.1 (19.6)
Language Quotient /100	74.6 (25.0)	75.5 (24.4)	68.9 (25.3)	79.4 (23.2)	81.9 (21.3)
WAB time (in minutes)	71.1 (44.4)	63.0 (22.4)	64.6 (23.9)	64.3 (23.6)	59.6 (33.5)
BNT /60	39.6 (16.9)	29.2 (18.6)	26.4 (19.5)	36.5 (18.7)	40.9 (15.9)

An additional variable, extent of tumour, was devised. Extent refers to the total number of regions invaded by each tumour and was used as a rough indicator of tumour size. The data were examined for significant correlations between language scores and location of tumour using the point biserial *r*. Pearson's *r* was used to evaluate the relationship between language scores and the extent of tumour: the extent measure is an index of a continuous variable, tumour size.

Correlation coefficients between language scores and both tumour presence versus absence in each region and extent of tumour are shown in Table 9. A positive correlation indicates poorer language performance in the presence of tumour. Significant results are marked with an asterisk (*). A significant relationship exists between poorer performance for all the language tests and presence of tumour in the region containing Broca's area. Scores for spontaneous speech, word finding, auditory comprehension, repetition and AQ are reduced when tumour is present in the temporal pole. No significant relationships can be identified between language scores and any other region containing tumour. A more extensive tumour is significantly correlated with lower language scores. The correlations in the last row of the table indicate that tumours invading region 2 and especially region 4 tended to be relatively large.

Figure 1: Mean BNT and WAB scores obtained by patients with tumour growth in one or more of five regions of the dominant hemisphere: the frontal pole (region 1), temporal pole (region 2), frontal region containing Broca's area (region 4), the lateral temporoparietal (region 5) and central region (region 6).

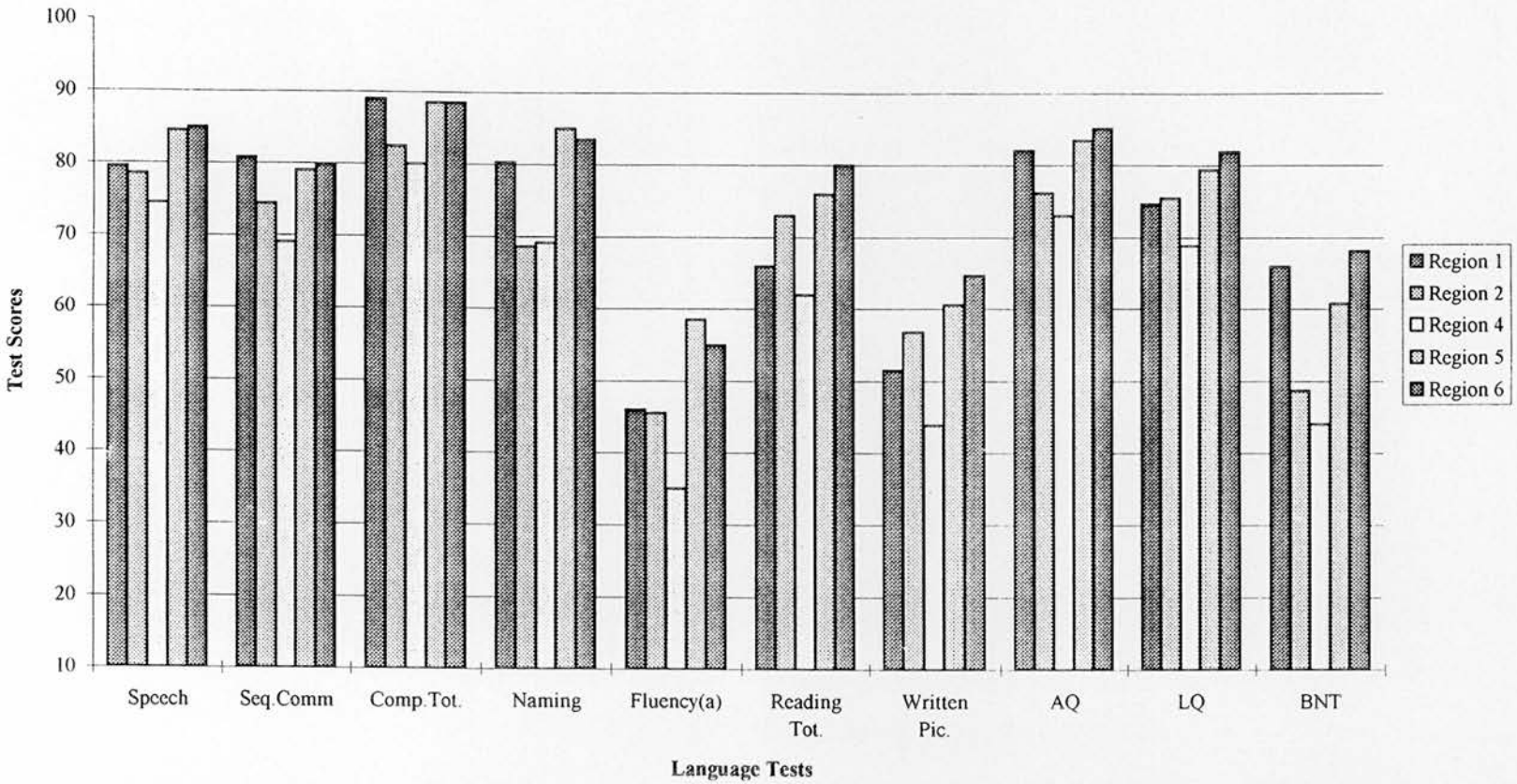


Table 9: Correlations between language scores, tumour region and extent of tumour for 69 patients with dominant hemisphere tumour (* indicates significance where p<0.05).

Subtest	Reg.1	Reg.2	Reg.4	Reg.5	Reg.6	Extent of tumour
Spont. Speech	0.13	*0.25	*0.46	0.01	-0.02	*0.37
Sequential Commands	0.01	0.18	*0.34	0.07	0.06	*0.28
Comp. Total	0.00	*0.24	*0.38	0.01	0.02	*0.29
Repetition	-0.05	*0.32	*0.37	0.15	-0.13	*0.29
Object Naming	0.05	*0.37	*0.40	-0.05	-0.01	*0.37
Word Fluency (a)	0.14	0.22	*0.48	-0.06	0.04	*0.35
Reading Paragraphs	0.20	0.11	*0.40	0.06	-0.01	*0.36
Reading Total	0.21	0.14	*0.44	0.06	-0.05	*0.37
Written Pic. Description	0.14	0.10	*0.40	0.02	-0.09	0.24
Writing Total	0.12	0.12	*0.41	0.05	-0.07	*0.27
Aphasia Quotient	0.05	*0.30	*0.46	0.04	-0.05	*0.36
Language Quotient	0.16	0.19	*0.48	0.06	-0.05	*0.37
WAB time (in minutes)	0.19	0.05	0.10	0.10	-0.05	0.16
BNT	-0.04	*0.36	*0.52	0.07	-0.18	*0.39
Extent of tumour	*0.28	*0.48	*0.78	*0.25	0.23	

3.3.2.2. Discussion: Lesion location and language scores

Two unexpected but very important points have emerged from the analysis of language scores and tumour location. The first is that tumour in the temporoparietal region, which contains Wernicke's area, does not appear to have a detrimental effect on language. This contradicts findings from stroke studies which, since the 1860's, have associated lesions in Wernicke's area with deficits of auditory comprehension and paraphasias, jargon and perseveration in expressive language. It cannot be argued that region 5 on the template was too limited: it was one of the largest and certainly encompassed Wernicke's area; or that Wernicke's area was under-represented: more patients had tumour in that region than in the region containing Broca's area. In some cases tumour could have been present in the region without invading Wernicke's area itself, but this could also be said of region 4 and Broca's area. Extent of tumour is not surprisingly a significant factor in that a larger tumour invading a greater number of regions will be accompanied by more severe language impairment. The fact that greater tumour extent is more strongly associated with tumours involving region 4 than with tumours involving region 5 suggests that tumour size may contribute to (but not entirely account for) the pattern of findings concerning these regions.

The second unexpected finding is that tumour in Broca's area is associated with impairments of all modalities of language, including auditory comprehension. The expected pattern from stroke studies is that a lesion in this area will affect expressive language but less so comprehension.

Tumour in the temporal pole may result in specific impairments of language. This is an interesting finding although the close proximity of Broca's area may have some influence on language performance.

These are new findings and demonstrate that there is much to learn about the effect of location of tumour on language function. It is possible that, for example, distance effects are substantial. It is also difficult to separate the effects of location from type of tumour; patients with a more highly malignant tumour may present with more severe language dysfunction which may be relatively independent of the site of the tumour. Evaluation of these factors would require very large patient groups.

3.3.2.3. Results (2): Tumour type and language scores

Sixty five patients with a dominant hemisphere tumour were categorised according to tumour neuropathology as diagnosed after biopsy. One patient did not belong to any of the tumour categories and was not included for analysis, leaving 64. All patients with brain metastases had a solitary lesion. Tables 10 and 11 show

mean WAB test times and subtest and summary scores obtained at initial assessment for patients in each of the tumour neuropathology groups. Subtest scores, AQ, LQ and BNT are also shown in Figure 2 p.63. Table 12 shows mean BNT scores for the groups. The test scores obtained by patients with a meningioma and those with a low grade glioma are similar and demonstrate the fewest signs of language impairment while the performance of the patients with a glioblastoma indicates the most severe language disorder. The range of test performance for the summary scores and many of the subtests is also broader among the glioblastoma group as is denoted by the larger standard deviations. One way analysis of variance on AQ in different tumour types produced a marginally significant F-ratio but post hoc tests identified no significant differences between any pair of scores.

Table 10: WAB Subtest scores for patients with each of the different tumour neuropathologies: Type 1 glioblastoma multiforme, Type 2 anaplastic astrocytoma or oligodendroglioma, Type 3 metastatic carcinoma, Type 4 low grade astrocytoma or oligodendroglioma and Type 5 meningioma.

Subtest	**Type 1 n=22 (S.D.)**	**Type 2 n=11 (S.D.)**	**Type 3 n=12 (S.D.)**	**Type 4 n=9 (S.D.)**	**Type 5 n=10 (S.D.)**
Information Content	7.2 (2.1)	8.2 (2.2)	8.5 (2.2)	9.9 (1.3)	9.5 (0.7)
Fluency	8.1 (1.7)	8.4 (2.5)	8.8 (2.1)	9.3 (1.3)	9.5 (0.5)
Spontaneous Speech Total	15.3 (3.5)	16.6 (4.7)	17.3 (3.8)	18.3 (2.6)	19.0 (1.2)
Yes/no Questions	52.5 (13.0)	57.6 (4.8)	55.8 (10.3)	60.0 (0.0)	59.1 (2.0)
Auditory Word Recognition	52.9 (9.9)	54.1 (12.7)	57.7 (8.1)	59.8 (0.7)	59.8 (0.4)
Sequential Commands	51.4 (25.6)	61.6 (28.7	69.5 (19.5)	74.6 (9.9)	78.7 (2.8)
Comprehension Total	15.7 (4.5)	17.3 (4.6)	18.3 (3.7)	19.4 (1.0)	19.8 (0.5)
Repetition	7.8 (2.6)	7.6 (3.4)	8.9 (2.2)	9.6 (0.7)	9.6 (0.4)
Object Naming	40.1 (22.8)	50.7 (15.5)	53.8 (15.4)	54.7 (11.1)	59.1 (2.0)

Word Fluency (a)	7.4 (6.4)	11.3 (7.5)	12.4 (8.2)	15.6 (6.8)	14.7 (3.3)
Word Fluency (b)	7.2 (5.9)	11.0 (7.1)	12.1 (7.8)	14.9 (6.1)	14.5 (2.8)
Sentence Completion	7.9 (3.2)	8.0 (4.0)	9.5 (1.2)	10.0 (0.0)	10.0 (0.0)
Responsive Speech	8.1 (3.2)	8.2 (4.1)	9.3 (2.3)	9.8 (0.7)	10.0 (0.0)
Naming Total	6.3 (3.2)	7.2 (3.4)	8.5 (2.4)	8.9 (1.8)	9.4 (0.3)
Reading Paragraphs	24.1 (12.0)	31.3 (12.5)	33.2 (10.1)	33.3 (12.9)	36.8 (4.1)
Reading Commands	16.0 (5.2)	16.2 (8.0)	18.9 (2.0)	17.8 (6.7)	19.6 (1.1)
Reading Total	6.3 (3.0)	7.8 (3.3)	8.4 (2.4)	8.4 (3.2)	9.3 (1.0)
Written Picture Description	14.8 (12.9)	19.1 (13.6)	23.6 (14.3)	27.4 (10.8)	26.7 (8.4)
Writing Total	4.9 (3.6)	6.2 (3.6)	7.1 (3.7)	8.4 (2.3)	7.9 (2.6)

Table 11: WAB test time (in minutes) and WAB summary scores obtained by patients in each of the tumour type groups at initial assessment: Type 1 glioblastoma multiforme, Type 2 anaplastic astrocytoma or oligodendroglioma, Type 3 metastatic carcinoma , Type 4 low grade astrocytoma or oligodendroglioma and Type 5 meningioma.

	Type 1 n=22 (S.D.)	**Type 2 n=11 (S.D.)**	**Type 3 n=12 (S.D.)**	**Type 4 n=9 (S.D.)**	**Type 5 n=10 (S.D.)**
Aphasia Quotient	74.6 (20.7)	80.2 (27.2)	87.7 (19.7)	93.1 (10.1)	95.6 (2.9)
Language Quotient	69.9 (21.5)	76.7 (28.7)	87.2 (14.9)	89.8 (16.0)	92.5 (7.3)
Cortical Quotient	76.0 (17.6)	79.6 (26.2)	90.1 (9.6)	92.1 (11.7)	94.0 (3.4)
WAB Test Time	66.7 (17.1)	61.3 (29.2)	65.0 (54.5)	56.0 (26.7)	54.7 (25.5)

Figure 2: Mean BNT and WAB scores obtained by patients with each of the different tumour neuropathologies: glioblastoma multiforme (Type 1), anaplastic astrocytoma or oligodendroglioma (Type 2), metastatic carcinoma (Type 3), low grade astrocytoma or oligodendroglioma (Type 4) and meningioma (Type 5).

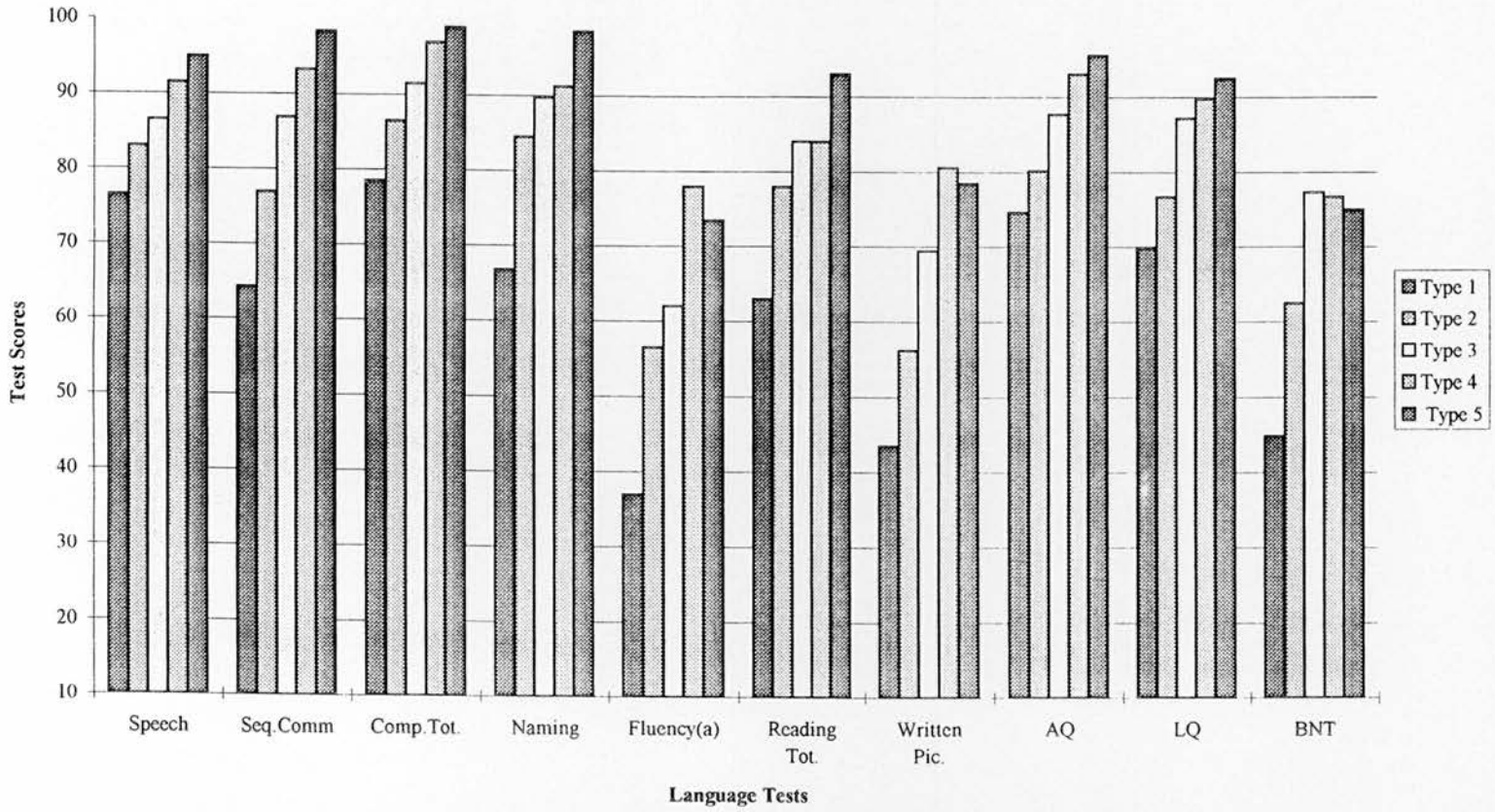


Table 12: BNT mean scores and test times for all patients with a dominant hemispheric tumour in each of the tumour type groups: Type 1 glioblastoma multiforme, Type 2 anaplastic astrocytoma or oligodendroglioma, Type 3 metastatic carcinoma, Type 4 low grade astrocytoma or oligodendroglioma and Type 5 meningioma.

	Type 1 n=22 (S.D.)	**Type 2 n=11 (S.D.)**	**Type 3 n=12 (S.D.)**	**Type 4 n=9 (S.D.)**	**Type 5 n=10 (S.D.)**
BNT Score	26.9 (20.6)	37.5 (19.1)	46.4 (9.1)	46.0 (10.8)	45.0 (8.7)
BNT Test Time	10.0 (5.5)	9.7 (8.2)	6.6 (4.0)	8.0 (2.9)	6.8 (2.4)

3.3.2.4. Discussion: Tumour type and language scores

Hom and Reitan (1984) demonstrated that patients with a rapidly growing intrinsic cerebral tumour had greater neuropsychological impairment than those with a more slowly growing tumour. In their study glioblastoma multiforme, anaplastic astrocytoma and metastases were described as having rapid growth and low grade astrocytoma and oligondendroglioma slow growth. In the present study as it was not possible to separate the patients into two equally-sized groups with rapidly and slowly growing tumours using Hom and Reitan's classification and compare their respective language performance, test scores for each of the five tumour types were presented. At initial assessment language test scores can be seen to be less impaired when the tumour is less malignant. There is no apparent demarcation between the tumour types which may be described as rapidly or slowly growing: the subtest scores for the metastatic group are on inspection more similar to the scores of the anaplastic group, which would not be surprising as Hom and Reitan describe both as rapidly growing, yet the BNT score and aphasia and language quotients of the metastatic group appear closer in nature to those of the low grade glioma group. A very large group of patients would have to be recruited to ensure there were adequate numbers within each of the tumour neuropathologies for accurate identification of similarites and differences between the groups. The results obtained in this study partially support Hom and Reitan's findings in that impairment of language function is likely to be more severe in the case of the more highly malignant tumours; patients with a glioblastoma consistently seem to obtain lower scores for the WAB and BNT than patients in the other tumour categories.

Inspection of test performance in each of the tumour categories shows higher test scores for patients with meningiomas than in the lower grade gliomas. The invasive nature of gliomas may interrupt essential connections within the language network, with rapid expansion permitting less neural compensation. Meningiomas very gradually compress rather than destroy brain tissue and are perhaps therefore associated with a milder, often temporary, disruption of language function. Where language impairments do accompany meningiomas the often very slow growth of the lesion may facilitate compensatory strategies which may render subtle deficits difficult to identify using the test materials currently available.

3.3.2.5. Patient age and language scores

Two separate studies previously demonstrated a relationship between increasing patient age and occurrence of dysphasia in patients with brain tumours (Miceli et al, 1981; Recht et al, 1989). In the present study correlations between patient age and Aphasia and Language Quotients for both initial assessment and change scores were shown to be non-significant using Pearson's r for all patients with a dominant hemispheric tumour. A statistically significant negative correlation was seen to exist between patient age and pre-operative BNT scores ($p=0.018$), however, with lower BNT scores accompanying increasing age as described above.

The relationship between patient age and tumour type was analysed using one way analysis of variance. Patients with an anaplastic astrocytoma were shown to be significantly younger than patients with either a glioblastoma or a metastatic tumour. No other significant differences were found despite several other studies describing an association between low grade glioma and younger patients (Scanlon & Taylor, 1979; Cohadon, 1990).

3.3.2.6. Patient gender and language scores

A correlation between incidence of aphasia and gender in patients with brain tumours has not been described elsewhere in the literature. In this study patient gender did not appear to influence Aphasia or Language Quotients or BNT scores at either initial or post-operative assessment in patients with a dominant hemispheric tumour.

3.3.3. Language Scores Before and After Resection in Patients with a Dominant Hemisphere Tumour (A)

3.3.3.1. Introduction

All therapies currently available in the management of patients with brain tumours are palliative: the aim is to relieve symptoms (Cohadon, 1990) and to facilitate a reasonable quality of life rather than to cure the disease (Vecht et al, 1990; Whittle & Gregor, 1991). The aim of resective neurosurgery is to relieve both the symptoms of raised intracranial pressure and the neurological deficits related to brain shifts by reducing tumour mass (Cohadon, 1990; Thomas, 1992). In this study it was anticipated that improvements in language function might be evident after resective surgery in patients whose language was impaired before surgery and that no new language deficits might be introduced when language function was normal before surgery.

3.3.3.2. Method

Tumour resection was performed using several techniques, depending on size, location and expected tumour type. These included classical craniotomy and "lesionectomy"; cytoreductive surgery; stereotactic micro-craniotomy and lesion localisation (Sabin & Whittle, 1990); and stereotactic craniotomy, with cortical stimulation of the awake patient prior to lesion resection (Ojemann et al, 1989). Lesions were resected using an ultrasonic aspirator. Normal brain was only excised where necessary for technical reasons. Language assessment using the WAB and BNT were carried out before and after resection.

3.3.3.3. Patients

Forty patients had a second language assessment after resective surgery. The characteristics of this group are as follows:

Table 13: Characteristics of patients with a dominant hemisphere tumour who had a language assessment before and after resective surgery.

	Resection (n=40)
Male Patients	25
Female Patients	15
Age Range	18 - 73 years
Mean Age	49.4 years (S.D. 15.4)
Median Age	53 years

Five of the original 65 patients did not have a second language assessment for the following reasons: two patients deteriorated after resection; one patient had hospice care arranged with no further treatment offered other than steroids and pain relief; one patient was discharged before a second assessment was carried out and was unwilling to return as an outpatient; and one patient had come to DCN for a second opinion only.

3.3.3.4. Time between assessments

Of the 40 patients who were assessed using the WAB and BNT before and after tumour resection, 27 were reassessed seven days or less after initial assessment when they were considered sufficiently recovered from surgery to return home. The remaining 13 patients were assessed longer than seven days after initial assessment (see Table 14) for various reasons.

Table 14: Number of days between assessments in patients with a resected dominant hemispheric tumour who were reassessed longer than seven days after initial assessment.

Number of Days	8	9	11	12	14	17	41	64
Number of Patients	3	2	1	1	3	1	1	1

Three of the five patients who were reassessed eight and nine days later had had a meningioma excised with a relatively long recovery period. Of the remaining two, one patient with a metastatic tumour was reassessed when sufficiently recovered and the other was reassessed only four days after surgery but resection had been deferred for several days after initial assessment thereby increasing the time difference.

The patient who was reassessed after 17 days had been discharged soon after resection but returned for reassessment; the patient with the 41 day gap had not felt well enough for reassessment prior to discharge and agreed to be re-tested when returning for another outpatient appointment; and the patient who was reassessed after 64 days was an elective admission who had surgery postponed for several months after initial assessment. The remaining five patients all had a longer than average recovery period and were reassessed prior to discharge home.

3.3.3.5. Results (1): WAB test scores before and after resective surgery

Forty of the patients in the present study with a tumour in the dominant hemisphere had resective surgery; the scores obtained by this group are shown in Tables 15 and 16. All subtest scores (apart from yes/no questions, auditory word recognition and responsive speech which were almost at ceiling before resection; repetition; reading paragraphs and the reading total) and all three summary scores

show significant improvement after surgery. All locations of tumours were included in these analyses. Just as dysphasia would not necessarily be a consequence of a stroke at any location in the left hemisphere not all patients in this study with a tumour of the left hemisphere were dysphasic. It was considered that the effect of resective surgery on language might be more apparent, therefore, when the group was separated into patients who were dysphasic before surgery (i.e. obtained an AQ of less than 93.8, according to the recommendations of the author of the WAB) (n=25) and those with normal language (i.e. those whose AQ was 93.8 or higher) (n=15). The scores for patients who were classified as dysphasic before resection are shown in Tables 17 and 18. All verbal subtests show significant improvement after surgery except for auditory word repetition and responsive speech, both of which are simple tests with mean scores almost at ceiling on initial assessment; repetition; and reading paragraphs. All three summary scores show highly significant improvement at second assessment, as is demonstrated in Table 18.

Paired t-tests were carried out on first versus second score for each subtest and summary score.

Table 15: Mean scores for WAB subtests obtained before and after resection by all patients with a dominant hemispheric tumour.

Subtest	**Number of pairs**	**Maximal Score**	**Mean Pre-op (S.D.)**	**Mean Post-op (S.D.)**	**Significance Level**
Information Content	40	10	8.5 (1.5)	9.0 (1.3)	0.015
Fluency	40	10	8.8 (1.5)	9.4 (1.0)	0.004
Spontaneous Speech Total	40	20	17.3 (2.7)	18.4 (2.1)	0.002
Yes/no Questions	40	60	57.6 (4.4)	58.9 (2.1)	0.055
Auditory Word Recognition	40	60	58.0 (5.4)	59.3 (2.3)	0.127
Sequential Commands	40	80	69.8 (17.8)	76.2 (7.2)	0.009
Comprehension Total	40	20	18.6 (2.6)	19.4 (1.0)	0.012

Repetition	40	10	9.0 (1.4)	9.2 (1.2)	0.142
Object Naming	40	60	52.2 (14.8)	54.5 (12.0)	0.037
Word Fluency (a)	40	>20	11.6 (6.0)	14.2 (5.8)	0.001
Word Fluency (b)	40	20	11.5 (5.7)	13.8 (5.2)	0.002
Sentence Completion	40	10	9.4 (1.9)	9.8 (0.7)	0.042
Responsive Speech	40	10	9.4 (1.9)	9.7 (1.1)	0.183
Naming Total	40	10	8.2 (2.2)	8.8 (1.7)	0.004
Reading Paragraphs	40	40	31.4 (10.2)	32.8 (10.5)	0.262
Reading Commands	40	20	17.9 (4.1)	19.1 (3.3)	0.014
Reading Total	40	10	7.9 (2.6)	8.5 (2.3)	0.090
Written Picture Description	34	34	20.4 (11.9)	27.5 (8.4)	0.000
Writing Total	34	10	6.4 (3.2)	8.4 (2.0)	0.000

Table 16: WAB summary scores (AQ, LQ and CQ) before and after resection for all patients with a dominant hemispheric tumour.

Summary Score	**Number of Pairs**	**Maximal Score**	**Mean Pre-op (S.D.)**	**Mean Post-op (S.D)**	**Significance Level**
Aphasia Quotient	40	100	87.6 (13.7)	92.3 (10.1)	0.003
Language Quotient	34	100	81.1 (18.3)	89.1 (13.5)	0.001
Cortical Quotient	37	100	84.5 (15.3)	90.7 (10.2)	0.001

Table 17: WAB subtest scores before and after resection for patients with a dominant hemispheric tumour who were dysphasic (obtained an AQ of 93.7 or less) before resection.

Subtest	Number of pairs	Maximal Score	Mean Pre-op (S.D.)	Mean Post-op (S.D.)	Significance Level
Information Content	25	10	7.8 (1.5)	8.6 (1.4)	0.023
Fluency	25	10	8.2 (1.5)	9.2 (1.1)	0.003
Spontaneous Speech Total	25	20	16.0 (2.7)	17.8 (2.4)	0.002
Yes/no Questions	25	60	56.2 (5.0)	58.6 (2.5)	0.018
Auditory Word Recognition	25	60	56.8 (6.6)	58.8 (2.8)	0.136
Sequential Commands	25	80	64.0 (20.5)	74.2 (8.4)	0.009
Comprehension Total	25	20	17.7 (3.0)	19.1 (1.1)	0.010
Repetition	25	10	8.6 (1.6)	8.9 (1.4)	0.199
Object Naming	25	60	47.8 (17.4)	51.6 (14.5)	0.033
Word Fluency (a)	25	>20	9.2 (5.2)	11.8 (4.9)	0.014
Word Fluency (b)	25	20	9.1 (5.1)	11.8 (4.9)	0.012
Sentence Completion	25	10	9.0 (2.2)	9.7 (0.9)	0.041
Responsive Speech	25	10	9.0 (2.3)	9.5 (1.3)	0.185
Naming Total	25	10	7.5 (2.5)	8.3 (2.0)	0.009
Reading Paragraphs	25	40	27.7 (11.1)	30.6 (11.7)	0.135

Reading Commands	25	20	16.7 (4.8)	18.5 (4.1)	0.013
Reading Total	25	10	7.0 (2.9)	7.9 (2.6)	0.040
Written Picture Description	22	34	15.3 (11.6)	25.3 (9.7)	0.000
Writing Total	22	10	5.0 (3.0)	7.9 (2.3)	0.000

Table 18: WAB summary scores before and after resection for patients with a dominant hemispheric tumour who were dysphasic (i.e. obtained an AQ of 93.7 or less) prior to resection.

Summary Score	**Number of Pairs**	**Maximal Score**	**Mean Pre-op (S.D.)**	**Mean Post-op (S.D.)**	**Significance Level**
Aphasia Quotient	25	100	81.8 (14.5)	89.1 (11.5)	0.004
Language Quotient	22	100	73.4 (18.5)	85.4 (15.4)	0.001
Cortical Quotient	23	100	77.8 (16.0)	87.4 (11.7)	0.002

The mean WAB scores obtained by the group whose language was pre-operatively within normal limits are shown in Tables 19 and 20. There is no significant difference between any of the test scores, including the summary scores, before and after resection except in the case of word fluency (a).

Table 19: WAB subtest scores before and after resection for patients with a dominant hemispheric tumour whose language was classified as normal (i.e. obtained an AQ of 93.8 or higher) on initial assessment before resection.

Subtest	**Number of pairs**	**Maximal Score**	**Mean Pre-op (S.D.)**	**Mean Post-op (S.D.)**	**Significance Level**
Information Content	15	10	9.6 (0.6)	9.7 (0.5)	0.334
Fluency	15	10	9.8 (0.4)	9.8 (0.4)	1.000

Spontaneous Speech Total	15	20	19.4 (0.7)	19.5 (0.6)	0.334
Yes/no Questions	15	60	60 (0.0)	59.4 (1.2)	0.082
Auditory Word Recognition	15	60	59.9 (0.3)	60 (0.0)	0.334
Sequential Commands	15	80	79.4 (1.6)	79.7 (1.3)	0.639
Comprehension Total	15	20	19.9 (0.2)	19.9 (0.2)	0.742
Repetition	15	10	9.7 (0.4)	9.7 (0.3)	0.301
Object Naming	15	60	59.4 (1.7)	59.4 (1.7)	1.000
Word Fluency (a)	15	>20	15.7 (5.1)	18.3 (4.9)	0.047
Word Fluency (b)	15	20	15.3 (4.6)	17.2 (3.7)	0.072
Sentence Completion	15	10	10 (0.0)	10 (0.0)	1.000
Responsive Speech	15	10	10 (0.0)	10 (0.0)	1.000
Naming Total	15	10	9.5 (0.5)	9.7 (0.5)	0.127
Reading Paragraphs	15	40	37.5 (3.7)	36.5 (6.7)	0.456
Reading Commands	15	20	20 (0.0)	20 (0.0)	1.000
Reading Total	15	10	9.5 (0.7)	9.3 (1.3)	0.370
Written Picture Description	12	34	29.8 (4.8)	31.5 (2.9)	0.298
Writing Total	12	10	9.0 (1.1)	9.4 (0.6)	0.264

Table 20: WAB summary scores before and after resection obtained by patients whose language was classified as normal (i.e. AQ of 93.8 or higher) before resection:

Summary Score	Number of Pairs	Maximal Score	Mean Pre-op (S.D.)	Mean Post-op (S.D.)	Significance Level
Aphasia Quotient	15	100	97.1 (1.9)	97.7 (1.8)	0.065
Language Quotient	12	100	95.3 (3.2)	95.9 (3.8)	0.435
Cortical Quotient	14	100	95.5 (2.5)	96.1 (2.8)	0.152

The time taken to complete the WAB was recorded except in cases where the patient had not fully completed the test, for example where limb weakness precluded attempting the writing and drawing subtests. Although there is no significant change after resection in either the dysphasic or non-dysphasic groups there is a significant difference between the test time for the two groups. Table 21 shows that for patients with language difficulties prior to resection test time was substantially longer than for those with normal language. Despite the improvement in post-operative scores the test time is not significantly better. Test time is shown in minutes.

Table 21: WAB pre-and post-operative mean test times for the two groups of patients who were dysphasic and non-dysphasic at initial assessment.

	Number of Pairs	Mean Pre-op Test Time (S.D.)	Mean Post-op Test Time (S.D)	Significance Level
Dysphasic Group	21	70.2 (35.5)	63.2 (33.2)	0.396
Non-Dysphasic Group	12	44.3 (5.4)	42.1 (7.4)	0.210

3.3.3.6. Results (2): Assessment of practice effect using the WAB

In the standardisation of the WAB a group of 35 stable, chronic aphasics were assessed twice with a mean length of time of 1.9 years separating the two assessments; results showed high test-retest reliability. Patients with brain tumours in the present study had a language assessment prior to biopsy or resective surgery

and again an average of seven days later. To investigate the possibility of a practice effect influencing scores when the same test materials were used with so little time intervening a small control group of stroke patients was recruited. Untreated tumour patients would be too prone to change to be used as controls for this purpose and normal controls would be too liable to ceiling effects.

The criteria for inclusion were:

(a) Occurrence of a single left sided vascular event at least one year prior to assessment. A year has been proposed as a reasonable time scale in which functional impairments post-stroke should stabilise (Kertesz & McCabe, 1977; Kertesz et al, 1979).

(b) Evidence of at least a mild language deficit. A completely recovered dysphasic patient would score too close to the maximal at initial assessment to permit analysis of a possible practice effect.

(c) Ability to cope emotionally with (in some cases) a complete stranger assessing their language for research purposes, when they may have had no contact with a speech therapist for some time.

(d) Willingness to undergo the same language assessment twice.

(e) Aged within the range of the tumour study.

All subjects were ex-patients of speech and language therapy departments and in each case the therapist who had treated them checked suitability and willingness before any contact was made regarding involvement in the study. All but one of those approached subsequently gave consent. As will be discussed there was no obvious practice effect in the test performance of the six patients and as the results appeared to replicate the findings of Kertesz's larger study no further stroke controls were assessed.

While the tumour patients in the study tended to complete the WAB reasonably quickly stroke patients can take longer than two hours (Kertesz, 1979). The aim here was not to carry out the entire WAB but to obtain an Aphasia Quotient in every case and where possible a Language Quotient. The patients all managed to complete the verbal subtests in an hour but were often obviously fatigued by the end. This precluded a similar evaluation of a practice effect with the Boston Naming Test as more visits than two (test and re-test) per patient was considered unfairly demanding.

Patients were assessed at home in all but two cases where the patients' preference was to attend the hospital.

The WAB subtest and summary scores for the stroke control group are shown in Tables 22 and 23. Two of the patients were unable to complete the writing subtest

because of weakness of their preferred hand. Test time was not recorded: the first patient stated prior to assessment that they would like to stop after one hour; in every other case testing was stopped after an hour. This provided sufficient time for all patients to complete the verbal subtests of the WAB. There is no significant change in any of the subtest or summary scores on second assessment. The group is very small therefore significant change is harder to demonstrate than in a larger group. However, the mean subtest scores and especially the summary scores are very similar on the two test occasions. These findings are in keeping with those of the 35 stable strokes assessed by Kertesz in his standardisation of the WAB, as shown in Table 24.

Table 24: WAB subtest scores for six stable dysphasic stroke patients on two test occasions. Second assessment was carried out seven days after the first.

Subtest	**Number of pairs**	**Maximal Score**	**Mean 1st Assesst. (S.D.)**	**Mean 2nd Assesst. (S.D.)**	**Significance Level**
Information Content	6	10	6.7 (2.1)	6.7 (2.7)	1.000
Fluency	6	10	6.2 (2.6)	6.3 (2.8)	0.363
Spontaneous Speech Total	6	20	13.0 (4.6)	13.0 (5.3)	1.000
Yes/no Questions	6	60	58.0 (2.4)	59.0 (1.5)	0.175
Auditory Word Recognition	6	60	56.2 (3.3)	57.3 (2.9)	0.135
Sequential Commands	6	80	60.0 (18.5)	61.5 (19.7)	0.336
Comprehension Total	6	20	16.1 (4.4)	17.8 (2.1)	0.233
Repetition	6	10	7.6 (2.6)	7.7 (2.7)	0.750
Object Naming	6	60	45.3 (12.4)	43.0 (16.4)	0.448
Word Fluency (a)	6	>20	6.5 (6.3)	7.2 (5.6)	0.484

Word Fluency (b)	6	20	6.5 (6.3)	7.2 (5.6)	0.484
Sentence Completion	6	10	8.3 (3.2)	8.7 (1.6)	0.695
Responsive Speech	6	10	8.7 (2.4)	8.3 (3.2)	0.363
Naming Total	6	10	6.9 (1.9)	6.7 (2.2)	0.593
Reading Paragraphs	6	40	20.7 (9.8)	19 (15.1)	0.727
Reading Commands	6	20	13.4 (7.7)	14.1 (8.0)	0.488
Reading Total	6	10	5.1 (2.9)	4.9 (3.7)	0.833
Written Picture Description	4	34	19.5 (12.2)	24.6 (9.6)	0.475
Writing Total	4	10	6.4 (2.9)	7.6 (2.3)	0.453

Table 23: WAB summary scores for 6 stable dysphasic stroke patients on two test occasions. The second assessment took place seven days after the first in each case.

Summary Score	**Number of Pairs**	**Maximal Score**	**Mean 1st Assesst. (S.D.)**	**Mean 2nd Assesst. (S.D.)**	**Significance Level**
Aphasia Quotient	6	100	72.3 (18.2)	72.4 (19.5)	0.919
Language Quotient	4	100	69.2 (19.4)	72.2 (24.4)	0.511
Cortical Quotient	3	100	81.3 (9.2)	84.9 (11.9)	0.196

Table 24: Test retest reliability of the WAB in 35 stable dysphasics. Second assessment was carried out at varied intervals after the first, mean = 1.9 years. Standard deviations were not provided. All correlations between scores at first and second testing are significant at $p<0.01$ using Pearson's *r*. (Kertesz, 1979)

	Number of Pairs	**Means 1st Test.**	**Means 2nd Test**	**Pearson r (Test 1-2)**
Information Content	35	5.0	5.2	0.95
Fluency	35	5.5	5.3	0.93
Yes-no Questions	35	47.6	49.6	0.76
Auditory Word Recognition	35	41.1	40.5	0.85
Sequential Commands	35	51.1	49.2	0.90
Comprehension Total /10	35	7.1	7.0	0.88
Repetition	35	5.6	5.4	0.97
Object Naming	35	30.0	33.1	0.94
Word Fluency	35	5.1	6.3	0.89
Sentence Completion	35	6.2	5.9	0.88
Responsive Speech	35	5.5	5.6	0.96
Naming Total	35	4.7	5.1	0.96
Aphasia Quotient	35	55.4	55.5	0.97
Reading	30	6.3	6.3	0.92
Writing	24	5.3	5.7	0.95

3.3.3.7. Results (3): BNT scores before and after resective surgery

The BNT scores obtained by all patients who had resective surgery show significant improvement in the post-operative performance for word finding, as can be seen in Table 25. The BNT scores before and after resective surgery for the anomic and non-anomic groups, using a score of 48 or less to indicate anomia and 49 or more to indicate word finding ability within normal limits as described above, are shown in Table 26. The anomic group shows significant improvement after surgery while the non-anomic group does not show significant change in either direction.

Table 25: BNT scores before and after resection for all patients who had a dominant hemispheric tumour resected.

Number of Pairs	Maximal Score	Mean Pre-op (S.D)	Mean Post-op (S.D.)	Significance Level
38	60	38.8 (16.8)	42.4 (15.3)	0.022

Table 26: BNT scores before and after resection for patients with a dominant hemispheric tumour who were anomic (i.e. scored 48 or less) and non-anomic (i.e. scored 49 or more) prior to resection.

	Number of Pairs	Mean Pre-op (S.D.)	Mean Post-op (S.D.)	Significance Level
Anomic Group	24	30.5 (16.0)	36.0 (15.8)	0.028
Non-Anomic Group	14	52.9 (3.2)	53.5 (3.7)	0.391

Test time for the BNT was recorded for each patient. Patients who were anomic prior to resection took significantly less time to complete the test after surgery. The non-anomic group, whose mean test time was almost half that of the anomic group before resection, did not change their test time significantly at second assessment. The time differences for both groups are shown in Table 27.

Table 27: Time taken (in minutes) to complete the BNT by anomic (scored 48 or less before resection) and non-anomic patients (scored 49 or more before resection) before and after resective surgery.

	Number of Pairs	Mean Pre-op (S.D.)	Mean Post-op (S.D.)	Significance Level
Anomic Group	24	10.4 (6.6)	7.9 (4.3)	0.034
Non-Anomic Group	14	5.6 (2.8)	5.0 (2.5)	0.342

3.3.3.8. Results (4): Corticosteroid dosage

The majority of patients in the study were given Dexamethasone prior to initial assessment. Table 28 shows the mean steroid dosages/day of the dysphasic and non-dysphasic groups at the time of the pre-and post-resective language assessment. In both groups the dosage is significantly smaller at the time of the second assessment with many patients no longer receiving steroid treatment.

Table 28: Mean Dexamethasone dosage before and after resection for patients with a dominant hemisphere tumour who were dysphasic (i.e. obtained an AQ of less than 93.8 before surgery) and for those who were not dysphasic (i.e. obtained an AQ of 93.8 or higher) before surgery.

	Number of Pairs	Mean Total Dosage in mg at Test 1 (S.D.)	Mean Total Dosage in mg at Test 2 (S.D.)	Significance Level
Dysphasic Group	25	10.3 (6.1)	0.7 (1.5)	0.000
Non-Dysphasic Group	15	8.5 (7.1)	2.2 (3.6)	0.012

3.3.3.9. Discussion: resective surgery and language scores

The results presented above support the assumption that resective surgery will relieve pre-existing neurological symptoms and rarely create new signs of functional impairment (Cohadon, 1990). The language function of patients with a dominant hemisphere tumour presenting with dysphasia was shown to improve after resective surgery and patients with normal language did not have new language deficits as a consequence of resective surgery. Selection bias is not believed to have had a strong influence on post-resective test performance as the group comprised a consecutive series of patients rather than only cases likely to do well. The possible

influence on test performance of (a) steroid dosage and (b) the short length of time between language testing were taken into consideration and the fact that neither of these factors are likely to have had a major effect on scores at second assessment will be discussed below.

A course of steroids is usually started prior to surgery to improve brain function and to minimise the potential development of postoperative oedema and brain swelling. The dosage is gradually reduced in the days following surgery (Swash & Schwartz, 1989). One of the initial aims of the study was to measure the effects on language function of steroids as a treatment option. This was not possible as in virtually all cases the patients had already embarked on a course of steroids prior to initial assessment. In retrospect this has proved to be fortuitous as separating the effects of steroids from surgery would have been problematic. In many of the cases in the study steroids had probably effected an improvement in language function by the time of initial assessment. It does not necessarily follow, however, that the true extent of tumour-induced dysphasia was not identified in the study. Rather, once the effects of oedema were removed a more accurate picture possibly emerged of language impairment caused by the growth of the tumour itself. On second assessment the steroid dosage was significantly lower than at the time of the first, with some patients no longer receiving steroid treatment. The implication is that while steroids may have improved the pre-operative clinical picture they could not have contributed to the post-resective improvement in language function.

Six stable stroke patients were assessed twice using the WAB with seven days intervening; this matched the number of days between the two assessments of the majority of the patients in the study who had resective surgery. The written picture description score was higher on second assessment because of the change in one patient's performance who had misunderstood the instructions at first assessment and had therefore written substantially different amounts on the two occasions. Despite this there was no significant change in any of the subtest or summary scores on second assessment. Although significant change would be difficult to identify in such a small group it seems likely that any practice effect from a second language assessment occurring soon after the first was limited and that the observable improvement in language scores in the patients with a tumour was a direct consequence of the resective surgery.

3.3.4. Language Scores Before and After Resection of a Dominant Hemisphere Tumour (B):

3.3.4.1. Results: Tumour type and language scores before and after resection

Thirty nine of the 40 patients who had a tumour of the dominant hemisphere resected were categorised according to tumour neuropathology as confirmed by biopsy. Post-resective change in test scores was analysed for significance in each of the groups using paired t-test, $p<0.05$. Patients with a glioblastoma showed the greatest amount of post-surgical change; this is perhaps not too surprising as the subtest and summary scores for this group were the lowest at initial assessment with more room for subsequent improvement than in the mean scores of the other groups which were usually closer to ceiling at first assessment. The numbers of WAB test scores, including both subtest and summary scores, which showed significant improvement after resection in each of the groups of tumour types are shown in Table 29. Tumour type 4, low grade astrocytoma or oligodendroglioma, was not included in the analysis because of the small number of patients in this group who had a language assessment before and after resection (n=2). Table 30 demonstrates the change after resective surgery in mean Aphasia and Language Quotients of patients with the various tumour types. The number of patients with both a pre- and post-operative Language Quotient is smaller in three of the groups because right arm and hand weakness prevented several patients from completing the writing subtest. The test results obtained by patients with a glioblastoma will be discussed in some detail therefore the individual AQs obtained by the 14 patients in this group before and after resective surgery are presented in Table 31.

Table 29: Numbers of test scores which showed significant change using paired t-test after resection for patients with a tumour in the dominant hemisphere in each of the tumour type groups: Type 1 glioblastoma multiforme, Type 2 anaplastic astrocytoma or oligodendroglioma, Type 3 metastatic carcinoma and Type 5 meningioma (Type 4, low grade astrocytoma or oligodendroglioma, has not been included because only two patients had a language assessment after resection in this group).

	Type 1 (n=14)	**Type 2 (n=6)**	**Type 3 (n=7)**	**Type 5 (n=10)**
Number of WAB Tests Showing Significant Change	19	4	1	0

Table 30: Mean Aphasia and Language Quotients (AQ and LQ, respectively) before and after resective surgery for patients with a dominant hemisphere glioblastoma multiforme (Type 1), anaplastic astrocytoma or oligodendroglioma (Type 2), metastatic tumour (Type 3) or meningioma (Type 5). Type 4, low grade astrocytoma or oligodendroglioma, has not been included because of the small group size.

	Type 1	**Type 2**	**Type 3**	**Type 5**
Pre-op AQ (S.D.)	n=14 77.3 (17.8)	n=6 88.7 (7.7)	n=7 92.1 (6.9)	n=10 95.6 (2.9)
Post-op AQ (S.D.)	85.9 (14.6)	94.0 (3.0)	96.9 (2.3)	95.5 (4.0)
Significance Level	0.039	0.094	0.078	0.927
Pre-op LQ (S.D.)	n=13 68.4 (22.3)	n=6 83.9 (11.2)	n=5 87.9 (10.2)	n=7 91.7 (7.5)
Post-op LQ (S.D.)	82.2 (18.6)	93.0 (4.4)	94.8 (5.1)	91.7 (9.7)
Significance Level	0.012	0.043	0.183	0.996

Table 31:Aphasia Quotients (AQ) obtained by 14 patients with a glioblastoma before and after resective surgery.

Pre-op AQ	**Post-op AQ**
30.6	65.2
55.8	90.6
62.0	71.2
70.0	53.4
78.6	72.6
80.0	98.0
81.2	81.2
82.6	94.2

84.2	97.0
84.6	93.6
90.6	96.4
91.4	92.4
91.8	96.6
99.0	100.0

3.3.4.2. Discussion: The significance of tumour type

It was demonstrated earlier that patients with a glioblastoma tended to obtain lower scores for the WAB and BNT at initial assessment than patients with less malignant tumours. As with all tumour neuropathologies, the trend is towards improvement for the glioblastoma group as a whole after surgery yet the larger standard deviations of the glioblastoma group demonstrate a much wider range of individual performance. The prognostic significance of overall functional status as measured by the Karnovsky Index and WHO scale at the time of diagnosis has been described in previous studies (Cohadon, 1990; MRC Brain Tumour Working Party, 1990;Thomas, 1992). Identifying predictive features of language performance at initial diagnosis may be more difficult. The mean aphasia quotients of most of the tumour types after surgery are indistinguishable, suggesting that tumour neuropathology will give few clues as to the expected outcome after surgery. The patients in the glioblastoma group, however, present a slightly different picture; only this group still had a low aphasia quotient after resection as all other tumour groups, including the other rapidly growing tumours, made sufficient post-surgical gains in language scores to obtain a mean AQ within normal limits. Only one of the 14 patients in the glioblastoma group had an aphasia quotient which was within normal limits at initial assessment. The six patients who were within normal limits after resection had a mean AQ at initial assessment of 88.0 whereas the eight whose AQ was still below 93.7 after surgery had a mean AQ of 69.3 at first assessment. It may be the case, therefore, that a low language score at initial assessment in patients with a glioblastoma may indicate that the disease is sufficiently advanced to limit post-operative improvement. Larger patient numbers would help identify a possible critical stage at which poor pre-operative performance may be predictive of limited subsequent improvement; and might enable clearer distinctions to emerge between the language profiles of patients with other tumour neuropathologies.

3.3.4.3. The significance of patient age and gender

Correlations in this study between patient age and post-resective Aphasia or Language Quotient were found to be non-significant using Pearson's *r*. Similarly no relationship was identified between AQ or LQ after resective surgery and the gender of the patient.

3.3.5. Language Scores Before and After Biopsy in Patients with a Dominant Hemisphere Tumour

3.3.5.1.Introduction

While information concerning tumour size and location can be gleaned from CT and MR scans, biopsy and histopathological diagnosis establish tumour type and therefore influence decision making in the subsequent management of the disease. It was expected that language function would remain relatively unchanged by the procedure.

3.3.5.2. Method

Tumour samples were taken using the BRW stereotaxic system and CT imaging (Thomas & Nouby, 1990; Whittle & Gregor, 1991). Two to five specimens were obtained from one to three sites using a Sedan-Nashold biopsy needle. Tumours were classified according to the WHO system. All biopsies were performed under general anaesthetic. Patients were assessed using the WAB and BNT before biopsy and again before discharge home.

3.3.5.3. Patients

Sixteen patients had a second language assessment after biopsy. The characteristics of this group are as follows:

Table 32: Characteristics of patients with a dominant hemispheric tumour who had either biopsy or resective surgery:

	Biopsy (n=16)
Male Patients	11
Female Patients	5
Age Range	26 - 73 years
Mean Age	47.5 years (S.D. 15.8)
Median Age	49.5 years

Four patients did not have a language assessment after biopsy for the following reasons: two patients were too ill after biopsy for assessment and rapidly deteriorated after beginning radiotherapy; one patient was lost to follow-up: and one patient declined further intervention, including language assessment, from any hospital department after biopsy.

3.3.5.4. Time between assessments

Of the 16 patients ten had a second language assessment seven days or less after the pre-operative assessment. The remaining six patients had a longer gap between assessments for several different reasons. Table 33 shows the time between assessments for these six patients.

Table 33: Number of days between language assessments for six patients who had a biopsy of a tumour of the dominant hemisphere whose second assessment was eight days or more after the first.

Number of Days	8	9	11	14	45
Number of Patients	1	2	1	1	1

Two patients, one who was assessed nine days later and one 11 days later, had a complicated recovery period and re-assessment had to be deferred in both cases until the patients were able to comply with testing. The remaining four patients were discharged very soon after biopsy and were re-assessed as outpatients. The patient with the 45 day gap lived some distance away from the hospital and because of difficulties with transport agreed to be re-assessed when he returned to the hospital prior to beginning radiotherapy.

3.3.5.5. Results (1): WAB test scores before and after biopsy

The subtest and summary scores for the whole biopsy group are not significantly different on second assessment compared with first, as is shown in Tables 34 and 35. The patients in this group were separated into those who were dysphasic before biopsy and those whose language was within normal limits for the same reason and using the same criteria as for the resection group. Subtest and summary scores for both groups are shown in Tables 36 and 37, and 38 and 39 respectively. There is no significant change in either direction in the scores after biopsy using paired t-test apart from the score for object naming in the dysphasic group, which is significantly worse, and the Cortical Quotient in the non-dysphasic group, which is significantly better. The numbers are small in both groups and significant change may therefore be difficult to identify. Although the change is not statistically significant the trend in all of the tables from 34 to 39 is for the scores to be slightly worse after biopsy.

Table 34: WAB subtest scores before and after biopsy for all 16 patients who had a biopsy of a tumour of the dominant hemisphere.

Subtest	Number of pairs	Maximal Score	Mean Pre-op (S.D.)	Mean Post-op (S.D.)	Significance Level
Information Content	16	10	8.8 (2.1)	8.4 (2.9)	0.289
Fluency	16	10	8.9 (2.2)	8.6 (2.3)	0.104
Spontaneous Speech Total	16	20	17.6 (4.3)	17.1 (5.1)	0.188
Yes/no Questions	16	60	58.3 (4.1)	57.6 (4.9)	0.164
Auditory Word Recognition	16	60	56.9 (8.9)	55.6 (8.9)	0.216
Sequential Commands	16	80	65.1 (24.6)	61.2 (30.0)	0.220
Comprehension Total	16	20	18.0 (3.7)	17.5 (4.3)	0.171
Repetition	16	10	8.7 (2.6)	8.5 (2.9)	0.258
Object Naming	16	60	51.6 (16.8)	47.9 (20.4)	0.099
Word Fluency (a)	16	>20	14.1 (8.6)	13.4 (8.7)	0.664
Word Fluency (b)	16	20	13.4 (7.8)	12.9 (8.3)	0.734
Sentence Completion	16	10	9.1 (2.5)	8.7 (2.7)	0.089
Responsive Speech	16	10	9.3 (2.5)	9.1 (2.6)	0.333
Naming Total	16	10	8.3 (2.8)	7.9 (3.2)	0.190
Reading Paragraphs	15	40	31.3 (15.3)	33.5 (13.9)	0.195

Reading Commands	15	20	16.9 (7.0)	18.1 (5.2)	0.222
Reading Total	15	10	7.9 (3.8)	8.5 (3.3)	0.170
Written Picture Description	13	34	24.1 (13.6)	22.7 (14.4)	0.446
Writing Total	13	10	7.5 (3.5)	7.0 (3.9)	0.321

Table 35: WAB summary scores before and after biopsy for all 16 patients who had a biopsy of a tumour in the dominant hemisphere.

Summary Score	**Number of Pairs**	**Maximal Score**	**Mean Pre-op (S.D.)**	**Mean Post-op (S.D.)**	**Significance Level**
Aphasia Quotient	16	100	87.4 (22.4)	84.3 (25.8)	0.136
Language Quotient	13	100	83.8 (26.0)	82.2 (28.1)	0.493
Cortical Quotient	14	100	87.4 (20.2)	86.5 (23.7)	0.552

Table 36: WAB subtest scores before and after biopsy for patients who had a biopsy of a tumour of the dominant hemisphere and who were dysphasic (obtained an AQ of 93.7 or less) at initial assessment.

Subtest	**Number of pairs**	**Maximal Score**	**Mean Pre-op (S.D.)**	**Mean Post-op (S.D.)**	**Significance Level**
Information Content	5	10	6.6 (2.9)	5.6 (3.50	0.089
Fluency	5	10	6.6 (2.9)	6.2 (2.8)	0.178
Spontaneous Speech Total	5	20	13.2 (5.8)	11.8 (6.3)	0.080
Yes/no Questions	5	60	54.6 (6.1)	52.8 (6.9)	0.305

Auditory Word Recognition	5	60	50.0 (14.6)	46.0 (11.5)	0.242
Sequential Commands	5	80	35.0 (24.4)	23.6 (26.4)	0.202
Comprehension Total	5	20	13.9 (4.5)	12.2 (4.4)	0.200
Repetition	5	10	6.2 (3.8)	6.0 (4.1)	0.358
Object Naming	5	60	33.8 (21.8)	28.4 (25.1)	0.037
Word Fluency (a)	5	>20	3.0 (4.6)	3.6 (4.8)	0.426
Word Fluency (b)	5	20	3.0 (4.6)	3.6 (4.8)	0.426
Sentence Completion	5	10	7.2 (4.1)	6.2 (3.9)	0.189
Responsive Speech	5	10	7.6 (4.3)	7.2 (4.4)	0.374
Naming Total	5	10	5.2 (3.2)	4.6 (3.6)	0.088
Reading Paragraphs	4	40	9.5 (14.2)	17.5 (20.6)	0.223
Reading Commands	4	20	8.4 (9.8)	13.3 (9.20	0.224
Reading Total	4	10	2.6 (3.7)	4.7 (5.0)	0.174
Written Picture Description	4	34	7.1 (12.3)	6.0 (11.0)	0.215
Writing Total	4	10	3.2 (3.3)	2.8 (3.3)	0.129

Table 37: WAB summary scores before and after biopsy for patients who had a biopsy of a tumour of the dominant hemisphere and who were dysphasic (obtained an AQ of 93.7 or less) prior to initial assessment.

Summary Score	Number of Pairs	Maximal Score	Mean Pre-op (S.D.)	Mean Post-op (S.D.)	Significance Level
Aphasia Quotient	5	100	63.1 (28.5)	57.0 (30.5)	0.081
Language Quotient	4	100	52.3 (28.8)	52.1 (34.1)	0.867
Cortical Quotient	4	100	62.1 (23.9)	57.4 (29.0)	0.409

Table 38: WAB subtest scores before and after biopsy for patients who had a biopsy of a tumour of the dominant hemisphere whose language was within normal limits (obtained an AQ of 93.8 or higher) at initial assessment.

Subtest	Number of pairs	Maximal Score	Mean Pre-op (S.D.)	Mean Post-op (S.D.)	Significance Level
Information Content	11	10	9.7 (0.5)	9.7 (0.9)	1.000
Fluency	11	10	9.9 (0.3)	9.7 (0.9)	0.341
Spontaneous Speech Total	11	20	19.6 (0.5)	19.5 (1.8)	0.724
Yes/no Questions	11	60	60.0 (0.0)	59.7 (0.9)	0.341
Auditory Word Recognition	11	60	60.0 (0.0)	60.0 (0.0)	1.000
Sequential Commands	11	80	78.7 (3.1)	79.1 (3.0)	0.341
Comprehension Total	11	20	19.9 (0.3)	19.9 (0.3)	0.341
Repetition	11	10	9.9 (0.1)	9.6 (1.1)	0.407

Object Naming	11	60	59.7 (0.9)	56.7 (9.9)	0.345
Word Fluency (a)	11	>20	19.2 (3.5)	17.9 (5.9)	0.584
Word Fluency (b)	11	20	18.1 (2.2)	17.2 (5.4)	0.628
Sentence Completion	11	10	10.0 (0.0)	9.8 (0.6)	0.341
Responsive Speech	11	10	10.0 (0.0)	10.0 (0.0)	1.000
Naming Total	11	10	9.8 (0.3)	9.4 (1.5)	0.418
Reading Paragraphs	11	40	39.3 (2.4)	39.3 (2.4)	1.000
Reading Commands	11	20	20.0 (0.0)	19.9 (0.3)	0.341
Reading Total	11	10	9.9 (0.5)	9.8 (0.5)	0.341
Written Picture Description	9	34	31.7 (3.5)	30.1 (8.2)	0.569
Writing Total	9	10	9.4 (0.8)	8.9 (2.3)	0.477

Table 39: WAB summary scores before and after biopsy for patients who had a biopsy of a tumour in the dominant hemisphere whose language was within normal limits (obtained an AQ of 93.8 or higher) at initial assessment.

Summary Score	**Number of Pairs**	**Maximal Score**	**Mean Pre-op (S.D.)**	**Mean Post-op (S.D.)**	**Significance Level**
Aphasia Quotient	11	100	98.5 (1.0)	96.7 (9.1)	0.507
Language Quotient	9	100	97.7 (2.1)	95.5 (9.7)	0.512
Cortical Quotient	10	100	97.6 (1.4)	98.2 (1.0)	0.049

As comparisons of mean test scores may be misleading when such small numbers of patients are involved Table 40 shows the AQ obtained before and after biopsy for all 16 patients, in addition to patient age and tumour neuropathology. Three of the five patients who were classified as dysphasic before biopsy had highly malignant, invasive tumours. Of the other two, one had an inoperable metastatic tumour and his condition was poor because of symptoms from the primary lung carcinoma. The other patient's symptoms had been controlled by corticosteroids for many years; a reduction in the dosage before and after biopsy effected the rapid recurrence of dysphasia. The mean age of the 11 patients who were not dysphasic before biopsy is 42 years while the mean for the dysphasic group is 59.

Table 40: First and second AQ, age and tumour neuropathology for all patients who had a biopsy of a tumour of the dominant hemisphere.

	Age	Tumour Neuropathology	Pre-op AQ	Post-op AQ
S.P.	56	metastasis	100.0	99.6
A.A.	30	anaplastic astrocytoma	99.6	100.0
D.J.	57	metastasis	99.2	100.0
T.M.	65	oligodendro-glioma	99.2	99.6
J.C.	45	low grade astrocytoma	99.0	100.0
G.S.	26	anaplastic astrocytoma	98.2	96.8
N.G.	26	anaplastic astrocytoma	98.0	100.0
D.S.	27	oligodendro-glioma	97.8	99.4
W.W.	54	low grade astrocytoma	97.8	99.6
A.H.	46	glioblastoma multiforme	97.2	69.4
P.S.	33	low grade astrocytoma	97.0	98.8
J.O.	63	glioblastoma multiforme	93.2	94.2
W.R.	73	metastasis	84.4	79.8
A.M.	53	mixed oligo- astrocytoma	69.4	54.0
R.W.	67	glioblastoma multiforme	43.4	37.8
J.L.	39	anaplastic astrocytoma	25.0	19.0

The time taken to complete the WAB was recorded except in four patients who were unable to cope with writing, drawing or Raven's Progressive Matrices. There was no statistically significant change in test times. The non dysphasic group took less time to complete the WAB than the dysphasic group both before and after surgery. Test times for all biopsy patients and those of the dysphasic and non-dysphasic groups are shown in Table 41.

Table 41: WAB test times (in minutes) before and after biopsy for patients who had a biopsy of a tumour of the dominant hemisphere and for the groups who were dysphasic (obtained an AQ of 93.7 or less) and non-dysphasic (obtained an AQ of 93.8 or higher) at initial assessment.

	Number of Pairs	**Mean Pre-op Test Time (S.D.)**	**Mean Post-op Test Time (S.D)**	**Significance Level**
All Biopsy Patients	12	59.7 (30.0)	57.7 (31.4)	0.631
Dysphasic Group	4	98.3 (16.5)	91.5 ((33.2)	0.603
Non-Dysphasic Group	8	40.4 (5.1)	40.8 (9.9)	0.892

3.3.5.6. Results (2): BNT scores before and after biopsy

BNT scores for the biopsy group are shown in Tables 42 and 43. The entire biopsy group is shown in Table 42 while groups who were both anomic and non-anomic are shown in Table 43. The same cut-off point of 48 out of 60, which separated patients with and without word finding difficulty in the resective group, was used for the patients who had a biopsy. Significant change is shown in the group as a whole after biopsy and the scores for both anomic and non-anomic groups almost reach significance. The time taken to complete the BNT is shown in minutes for both groups in Table 44; the change after biopsy is non-significant in each case.

Table 42: BNT scores before and after biopsy for patients who had a biopsy of a tumour of the dominant hemisphere.

Number of Pairs	**Mean Pre-op (S.D.)**	**Mean Post-op (S.D.)**	**Significance Level**
12	47.6 (9.6)	51.0 (9.1)	0.016

Table 43: BNT scores before and after biopsy for patients who had a biopsy of a dominant hemispheric tumour who were anomic (obtained a BNT score of 48 or less) and non-anomic (obtained a BNT score of 49 or more out of 60) at initial assessment.

	Number of Pairs	**Mean Pre-op (S.D.)**	**Mean Post-op (S.D.)**	**Significance Level**
Anomic Group	6	39.7 (6.5)	44.8 (9.3)	0.063
Non-Anomic Group	6	55.5 (3.1)	57.2 (1.9)	0.054

Table 44: Time taken (in minutes) to complete the BNT before and after biopsy by patients who were anomic (scored 48 or less) and those who were non-anomic (scored 49 or more) before biopsy of a tumour in the dominant hemisphere.

	Number of Pairs	**Mean Pre-op (S.D.)**	**Mean Post-op (S.D.)**	**Significance Level**
Anomic Group	6	9.2 (5.6)	6.5 (4.0)	0.082
Non-Anomic Group	6	5.7 (3.3)	4.7 (2.9)	0.275

3.3.5.7. Discussion: Tumour biopsy and language test scores

The expectation was that a biopsy of a dominant hemisphere tumour might not be expected to effect an improvement in language performance but neither should there be a deterioration in function afterwards. The results obtained in this study partially support these hypotheses: with the exception of one BNT and two WAB scores there is no significant change in either direction after biopsy. Separating language scores which indicate language impairment and normal language at initial assessment permits closer inspection of the effect of biopsy on patients whose language could perhaps be described as more vulnerable and therefore potentially more susceptible to change. Despite this no statistically significant change was identified. There are, however, several problems with the interpretation of results.

On inspection, the trend in the non-dysphasic group is that a slight deterioration is evident in test scores after biopsy. This can be attributed to the performance of one patient, A.H., who refused further steroid treatment after biopsy. This patient's

AQ dropped by 27.8 points from 97.2 to 69.4 with associated reduction in subtest scores. Otherwise the lack of change in AQs before and after biopsy for the other patients in this group accords with the hypothesis that biopsy should not alter normal language function. The patients in the dysphasic biopsy group, on the other hand, demonstrated the most impaired language out of all subgroups in the study. The majority of subtest and all three summary scores demonstrate a decline in performance after biopsy with the sequential commands subtest showing a mean deterioration of 11.4 points and the mean AQ dropping by 7.9 points. Several similarities can be identified among the patients who were dysphasic before biopsy. Apart from two patients whose circumstances were described above the dysphasic group all had highly malignant tumours. Their mean age (59) is also greater than the non-dysphasic group's (42). The results suggest that the presence of dysphasia before biopsy, perhaps combined with increased tumour malignancy and older age, may predispose to further deterioration of language function after biopsy whereas language which is within normal limits before biopsy might still be normal afterwards.

At 16 the number of patients in the biopsy group is small. When the patients are divided into dysphasic and non-dysphasic groups the size of each group precludes reliable identification of either significant change in language scores after biopsy or meaningful correlations with other relevant variables.

3.3.6. Language Scores Before and After Radiotherapy in Patients with a Dominant Hemisphere Tumour

3.3.6.1. Introduction

A course of radiation therapy usually followed biopsy or surgical resection of malignant glioma except in cases of tumour recurrence where the patients had already been irradiated. Attempts were made to carry out an evaluation of the effects of radiotherapy on language by comparing postoperative language scores with post-radiotherapy scores.

3.3.6.2. Method

Dosage was between 54 and 60 Gy in fractions given over two to six weeks, in accordance with recommendations intended to minimise the later development of radiation-induced brain atrophy (MRC Brain Tumour Working Party, 1991; Fine, 1994). Language was assessed before the onset of radiotherapy using the WAB and BNT. Administration and scoring of the tests was as described above. A second

language assessment took place at the end of the prescribed course. Patients were contacted at least several weeks after the completion of radiation treatment to allow side effects such as fatigue to dissipate. The second assessment took place a mean of 187 days after the first.

3.3.6.3. Patients

Eleven patients, nine male and two female, who had either a biopsy or resection of a tumour of the dominant hemisphere agreed to return for a post-radiotherapy language assessment. Age range was 25 to 73 years, mean 44.5, median 38. The cohort comprised a wide variety of ages and tumour neuropathologies with no evident selection bias, as is shown in Table 45.

Table 45: Sex, age and tumour neuropathology of 11 patients who had a language assessment before and after radiotherapy.

Patient	Sex	Age	Tumour Neuropathology
D.B.	M	25	(L)frontal GBM
N.G.	M	26	(L)parieto-occipital anap. astrocytoma
D.S.	M	27	(L)parietal mixed oligo-astrocytoma
D.G.	M	29	(L)temporo-parietal anaplastic astrocytoma
A.A.	M	30	(L)thalamic anaplastic astrocytoma
R.S.	F	38	(L)temporal meningioma
P.S.	M	43	(L)parietal anaplastic astrocytoma
A.T.	F	48	(L)parietal metastasis
W.W.	M	54	(L)fronto-temporal low-grade astrocytoma
T.M.	M	65	(L)frontal oligodendroglioma
V.W.	M	73	(L)parietal GBM

3.3.6.4. Results

The post-biopsy or post-resection language scores were viewed as the initial assessment. The patient group was not subdivided into dysphasic and non-dysphasic groups on the basis of initial assessment scores as was done with previous groups; all language scores were within normal limits before radiotherapy started. Tables 46 and 47 show the WAB subtest and summary scores; Table 48 shows the time taken to complete the WAB on both occasions. There is no significant change in any of these results.

Table 46: WAB subtest scores before and after radiotherapy for 11 patients who were treated with radiotherapy after resective surgery or biopsy.

Subtest	Number of pairs	Maximal Score	Mean Pre-Radio (S.D.)	Mean Post-Radio (S.D.)	Significance Level
Information Content	11	10	9.7 (0.5)	9.6 (0.8)	0.588
Fluency	11	10	9.7 (0.7)	9.8 (0.6)	0.676
Spontaneous Speech Total	11	20	19.5 (0.8)	19.5 (1.3)	1.000
Yes/no Questions	11	60	59.7 (0.9)	60.0 (0.0)	0.341
Auditory Word Recognition	11	60	60.0 (0.0)	60.0 (0.0)	1.000
Sequential Commands	11	80	79.4 (1.6)	79.6 (1.2)	0.676
Comprehension Total	11	20	19.9 (0.2)	19.0 (0.1)	0.290
Repetition	11	10	9.6 (0.7)	9.7 (0.6)	0.414
Object Naming	11	60	58.9 (1.5)	59.7 (0.9)	0.082
Word Fluency (a)	11	>20	18.0 (3.9)	19.7 (6.2)	0.439
Word Fluency (b)	11	20	17.3 (3.2)	17.5 (3.6)	0.873
Sentence Completion	11	10	10.0 (0.0)	10.0 (0.0)	1.000
Responsive Speech	11	10	10 (0.0)	10 (0.0)	1.000
Naming Total	11	10	9.6 (0.4)	9.7 (0.4)	0.482
Reading Paragraphs	11	40	39.3 (2.4)	39.3 (2.4)	1.000

Reading Commands	11	20	19.9 (0.3)	19.9 (0.3)	1.000
Reading Total	11	10	9.8 (0.5)	9.8 (0.5)	1.000
Written Picture Description	10	34	31.7 (2.9)	31.9 (3.4)	0.807
Writing Total	10	10	9.4 (0.7)	9.4 (0.9)	0.823

Table 47: WAB summary scores before and after radiotherapy for all patients with a dominant hemispheric tumour who had radiotherapy after either biopsy or resective surgery.

Summary Score	**Number of Pairs**	**Maximal Score**	**Mean Pre-Radio (S.D.)**	**Mean Post-Radio (S.D.)**	**Significance Level**
Aphasia Quotient	11	100	97.3 (2.9)	97.6 (4.1)	0.693
Language Quotient	10	100	96.7 (3.3)	97.2 (4.0)	0.578
Cortical Quotient	11	100	96.6 (2.8)	97.2 (3.4)	0.441

Table 48: WAB test time (in minutes) before and after radiotherapy for all patients with a dominant hemispheric tumour who had radiotherapy after either biopsy or resective surgery.

Number of Pairs	**Mean time pre-radiotherapy (S.D.)**	**Mean time post-radiotherapy (S.D.)**	**Significance Level**
10	51.4 (13.9)	45.0 (7.8)	0.243

Ten patients completed the BNT before and after radiotherapy as an additional measure of word finding. The group was divided into anomic and non-anomic prior to radiotherapy using the same criterion as was described above. Scores for the BNT and time taken to complete the test are shown in Tables 49 and 50. The group

of six patients who were classified as anomic before beginning radiation treatment improved significantly on second assessment in both test score and test time.

Table 49: BNT scores before and after radiotherapy for patients who were anomic (scored 48 or less) and non-anomic (scored 49 or more) before beginning radiotherapy.

	Number of Pairs	**Mean pre-radiotherapy (S.D.)**	**Mean post-radiotherapy (S.D.)**	**Significance Level**
Anomic Group	6	45.8 (5.1)	49.5 (4.5)	0.050
Non-Anomic Group	4	57.5 (2.4)	56.5 (1.9)	0.423

Table 50: BNT test times (in minutes) before and after radiotherapy for patients who were anomic (scored 48 or less) and non-anomic (scored 49 or more) before beginning radiotherapy.

	Number of Pairs	**Mean pre-radiotherapy (S.D.)**	**Mean post-radiotherapy (S.D.)**	**Significance Level**
Anomic Group	6	10.8 (6.3)	5.7 (1.9)	0.046
Non-Anomic Group	4	4.8 (3.8)	2.8 (0.5)	0.343

3.3.6.5. Discussion: Radiotherapy and language test scores

Potential side effects of radiotherapy include necrosis in brain adjacent to the tumour site (Awwad, Cull & Gregor, 1990; Cohadon, 1990; Thomas, 1992) with associated irreversible cognitive impairments (Archibald et al, 1994). Recent stricter recommendations regarding maximum dosage of radiation may have reduced the incidence of radiation-related defects. The results obtained in this study show that radiotherapy does not seem to be detrimental to language and in the case of the BNT both test scores and test times show a significant improvement after treatment. However, it is possible that language testing might have occurred too early to detect delayed deterioration of function as most patients were assessed at approximately six months after initial assessment.

The WAB does not reflect the same degree of improvement as the BNT as all scores were almost at ceiling before radiotherapy. The patients in the radiotherapy

study obtained higher WAB test scores overall than any other group in the entire study. The cohort unfortunately comprised a select, non-representative group. Although more patients than are represented here agreed to take part in the study and cooperated with post operative assessment while still inpatients, they were often reluctant to come back to the hospital for further language assessment. Reasons for this reluctance included the physical distance involved, the patient deteriorating or developing new symptoms, or the patient feeling well and being wary of further tests in case problems emerged. The group of patients who did return for assessment after radiotherapy were generally physically well, in some cases well enough to return to work, and had few signs of language difficulties at the earlier post-operative assessment so that the prospect of reassessment was perhaps less threatening.

Although few reliable conclusions can be drawn from the test results of the radiotherapy study some interesting observations emerge. The group is disparate, comprising patients with meningioma, metastasis and low and high grade glioma, with patient ages ranging from 25 to 73 years. Despite the lack of homogeneity the very high scores which the patients obtained before radiotherapy quite unexpectedly persisted in each case after treatment, irrespective of tumour type or age, with statistically significant improvement identifiable in the mean BNT score. Radiotherapy may therefore have contributed to maintaining the language function of the patients with malignant tumours at a level within normal limits when they may otherwise have begun to relapse or deteriorate. Analysing the language scores of patients who were dysphasic before radiotherapy would provide a useful comparison.

It may ultimately not be possible to describe with certainty the effects of radiotherapy on language. Attempts to re-assess patients after radiotherapy subsequent to biopsy or resection may be subject to the same selection bias as in this study where the cohort comprises people whose overall functional status is good before radiotherapy and the actual benefits on function are difficult to identify.

3.3.7. Language Scores Before and After Chemotherapy in Patients with a Dominant Hemisphere Tumour

3.3.7.1. Introduction

Chemotherapy is the usual therapy in the event of recurrence of malignant glioma (Wilson, 1992; Fine, 1994). An attempt was made in this study at identifying the effects of chemotherapy on language function.

3.3.7.2. Method

Patients with malignant glioma received vincristine, BCNU and procarbazine in 5-weekly cycles. All patients had a language assessment using the WAB and BNT before beginning chemotherapy; attempts were made to reassess all patients before the third treatment, i.e. at approximately three months after the initial assessment. Administration and scoring of these tests was as described above.

3.3.7.3. Patients

Fourteen patients with a tumour of the dominant hemisphere were included in the study. All patients had previously had either biopsy or resective surgery and radiotherapy. Of the14, nine patients did not have a second language assessment. Three patients declined further assessment; two because they felt that they could not cope emotionally with further assessment and one for no stated reason. Six patients died during the course of their treatment, having steadily deteriorated from the time of the pre-chemotherapy assessment. Four of the five patients who had a second language assessment were male. The mean age of this subgroup was 38.4 years; the mean age of the entire group of 14 was 39.4 years.

3.3.7.4. Results

Statistical analysis using paired t-test revealed no significant change in any of the WAB subtest and summary scores after chemotherapy; this is not surprising with such a small cohort. The size of the cohort also precluded separation into pre-chemotherapy dysphasic and non-dysphasic groups. For the purpose of discussion of findings, patients' details, including age, tumour neuropathology and pre- and post-chemotherapy Aphasia Quotient are shown in Table 51. A # marks the patients who did not want further language testing; the other patients without a second AQ did not survive until the end of treatment.

Table 51: Sex, age, tumour neuropathology and Aphasia Quotient for 14 patients with a dominant hemispheric tumour before and after chemotherapy.

	Sex	**Age**	**Tumour Neuropathology**	**Pre-chemotherapy AQ**	**Post-chemotherapy AQ**
A.M.	M	53	(L)temporo-parietal oligo.	54.0	96.2
J.S.	M	39	(L)temporal anap.astro	71.8	50.0

S.T.	M	31	(L)parieto-occipital anap.astro.	91.0	95.6
L.Q.	F	33	(L)frontal GBM	97.0	88.0
S.C.	M	36	(L)fronto-parietal GBM	98.0	99.0
J.L.	M	39	(L)temporal anap.astro.	19.0	_
J.G.#	F	35	(L)temporal anap.astro.	90.4	_
J.O.	M	63	(L)parietal GBM	94.2	_
M.F.#	F	50	(L)frontal anap.astro.	95.2	_
R.M.	M	27	(L)temporal GBM	95.2	_
G.K.	M	24	(L)frontal GBM	96.4	_
G.S.	F	25	(L)frontal anap.astro.	96.8	_
E.A.#	F	33	(L)frontal anap.astro.	97.2	_
R.H.	M	63	(L)parietal GBM	99.0	_

3.3.7.5. Discussion: Chemotherapy and language test scores

Significant change or trends in language profiles after chemotherapy are not detectable in this study because of the small number of patients who survived long enough for a second language assessment. What is apparent, however, is that similar predictions may not be made from pre-chemotherapy language scores in these groups as in the resection and biopsy groups. Of the five patients who were assessed after chemotherapy one made a dramatic improvement in language function (A.M.), two showed slight improvement and the scores of the remaining two deteriorated. Excluding the patients who withdrew from the study, not one of the five patients who had language within normal limits at initial assessment survived until the end of treatment. In this group of patients, therefore, normal

language function before treatment may not provide any indication of the possible effect of chemotherapy on either language or indeed survival.

The chemotherapy group in this study comprised on average younger patients than in the resection or biopsy groups. While youth may be expected to indicate longer survival times in patients with brain tumours (Cohadon, 1990; MRC Brain Tumour Working Party, 1990; Vecht, 1993) most of the patients receiving chemotherapy in this study presented with tumour recurrence. Brain tumours are usually more malignant at recurrence than at initial presentation (Cohadon, 1990) which perhaps adds to their more unpredictable nature.

The patient who showed dramatic improvement in language function after chemotherapy had an oligodendroglioma. This single case supports the findings that chemotherapy has been shown to be an effective therapy in the treatment of this type of tumour (Whittle & Gregor, 1991; Cairncross, Macdonald, Ludwin et al, 1994). Chemotherapy may prove to have more application in the future management of gliomas when the results of clinical trials currently underway become available (Lindsay et al, 1991; Whittle & Gregor, 1991; Jennett & Lindsay, 1994).

3.4.The WAB and BNT in Patients with a Non-Dominant Hemisphere Intracranial Tumour

3.4.1.Introduction

Patients with a tumour of the right hemisphere were initially tested using the Right Hemisphere Language Battery (RHLB). This test was later replaced by the WAB for reasons given in chapter 4. The (BNT) was introduced three months after the beginning of the study to provide additional information on word finding ability in this group hence the smaller numbers of BNT scores in the cohort with tumours of the non-dominant hemisphere. Language scores before and after radiotherapy and chemotherapy are not described here. Five patients with a right hemisphere tumour were assessed after radiotherapy while eight participated in the chemotherapy study. Only three patients in each group were assessed using the WAB and language was within normal limits in each case. The remaining patients were assessed when the RHLB was still in use; test scores for these patients were found to be uninformative.

3.4.2. Method

Surgical methods for both biopsy and resection were as described above for patients with a tumour of the dominant hemisphere.

Administration and scoring of the WAB and BNT were as described above for patients with a dominant hemispheric tumour. Language assessment was carried out before and after resective surgery or biopsy

As above, analysis of test scores in the groups who had resection and biopsy was carried out using paired and unpaired t-test as appropriate.

3.4.3. Patients

Thirty three patients with a tumour of the right hemisphere were assessed using the WAB. Characteristics of this group are shown in Table 52.

Table 52: Characteristics of 33 patients with a tumour of the right hemisphere.

	Male Patients (n=19)	**Female Patients** (n=14)
Age Range	20 - 73 years	18 - 75 years
Mean Age (S.D.)	48.2 years (15.8)	54.6 years (14.9)
Median Age	46 years	56 years

3.4.4. Patterns of Language Disorder at Initial Assessment

3.4.4.1.Results (1): WAB scores

WAB test scores are shown in Table 53. Two patients were emergency admissions with little time available for testing; the writing subtests were not completed in either case. A further patient was unwilling to undertake the writing subtests.

Although the mean AQ and LQ are both within normal limits (ie higher than 93.8), 21% and 36% of patients obtained an AQ and LQ respectively which was lower than 93.8. Most of the subtest mean scores are almost at ceiling although the scores for the written picture description and word fluency (a) and (b) demonstrate a wide range of test performance. Because of the variability in scores for word fluency the mean score obtained for word fluency (a) by patients with a tumour of the right hemisphere was compared with that of a group of 20 normal control subjects. (The control group is described in chapter 4). The normal controls obtained a significantly higher mean score than the tumour patients, as is shown in Table 54. A maximal score of 20 for word fluency is indicated in the WAB scoring system. As described above word fluency (a) in this study removes the ceiling and provides a record of the actual score obtained. In the control group 70% of subjects

scored higher than 20 while only 27% of the patients with a tumour of the right hemisphere did.

In his validation of the WAB, Kertesz (1979) included several test scores for ten normal, non-brain-damaged controls and 53 non-aphasic patients with right brain damage. For the purposes of comparison and subsequent discussion these scores are presented in Tables 55 and 55.

Table 53: WAB scores for all patients with a non-dominant hemisphere tumour at first assessment.

(Maximal score)	**Number of Patients**	**Mean**	**S.D.**	**Minimum Score**	**Maximum Score**
Information Content (10)	33	9.0	1.0	4.8	10.0
Fluency (10)	33	9.9	0.4	9.0	10.0
Spontaneous Speech Total (20)	33	18.9	1.2	16.0	20.0
Yes/no Questions (60)	33	59.6	0.9	57.0	60.0
Auditory Word Recognition (60)	33	59.9	0.3	59.0	60.0
Sequential Commands (80)	33	78.4	4.3	60.0	80.0
Comprehension Total (20)	33	19.8	0.4	18.0	20.0
Repetition (10)	33	9.8	0.3	8.8	10.0
Object Naming (60)	33	59.2	1.7	54.0	60.0
Word Fluency (a) (no maximal)	33	16.7	6.6	4.0	37.0
Word Fluency (b) (20)	33	15.4	4.3	4.0	20.0
Sentence Completion (10)	33	9.9	0.5	8.0	10.0

Responsive Speech (10)	33	9.9	0.4	8.0	10.0
Naming Total (10)	33	9.4	0.5	8.2	10.0
Reading Paragraphs (40)	33	37.7	4.0	26.0	40.0
Reading Commands (20)	33	19.9	0.6	16.5	20.0
Reading Total (10)	33	9.5	0.8	7.2	10.0
Written Picture Description (34)	30	28.1	7.7	8.0	34.0
Writing Total (10)	30	8.7	1.5	4.8	10.0
Aphasia Quotient (100)	33	96.0	3.1	88.8	100.0
Language Quotient (100)	30	94.0	5.3	81.4	100.0
Cortical Quotient (100)	31	93.5	4.3	84.7	100.0
Test Time (in minutes)	29	48.4	9.2	33.0	70.0

Table 54: Mean scores for the word fluency (a) subtest obtained by patients with a right hemisphere tumour at initial assessment (n=33) and a non-brain-damaged control group (n=20).

	Mean (S.D.)	**Significance Level**
Right hemisphere patients	16.7 (6.6)	
Normal controls	21.5 (5.2)	0.008

Table 55: Mean WAB test scores obtained by ten normal, non-brain-damaged controls and 53 non-aphasic patients with right brain damage during the validation of the WAB. Standard deviations are shown in brackets. (Kertesz, 1982).

	Information Content	**Fluency**	**Compre-hension**	**Repetition**	**Naming**
Normal Controls (n=10)	10.0 (0.0)	10.0 (0.0)	20.0 (0.0)	9.9 (0.1)	9.8 (0.1)
Right Brain Damaged Nonaphasics (n=53)	9.2 (1.4)	9.4 (1.3)	18.7 (2.1)	9.5 (0.5)	8.8 (1.4)

Table 56: Mean Aphasia Quotient obtained by ten normal, non-brain-damaged controls and 53 non-aphasic patients with right brain damage during the validation of the WAB. Standard deviations are shown in brackets. (Kertesz, 1982)

	Mean Aphasia Quotient
Normal Controls (n=10)	99.6 (0.3)
Right Brain Damaged Non-Aphasics (n=53)	92.9 (8.0)

3.4.4.2. Results (2): BNT scores

Forty seven patients with a tumour of the right hemisphere were assessed using the BNT. The mean BNT score for the 47 patients falls within the normal range for adults of this age group, ie a score range of 49 - 60 for normal adults aged from 40 to 60 years. Mean, median and standard deviation for the BNT are shown in Table 57.

Table 57: BNT scores obtained at initial assessment for 47 patients with a tumour of the right hemisphere.

	Mean (S.D.)	**Median**
BNT scores	50.7 (5.6)	52.0

3.4.5. Language Scores Before and After Resection of a Non-Dominant Hemisphere Tumour

3.4.5.1. Patients

Twenty six patients were assessed both before and after resective surgery. Two patients with right hemisphere tumours were not re-assessed after surgery: the condition of one patient deteriorated after surgery and the other patient was discharged from hospital before re-assessment and was reluctant to return for further testing. (Scores for patients who were assessed before and after biopsy will not be presented below as all four such patients scored almost at ceiling for all subtests on both occasions. The findings for this group are therefore unremarkable.)

Characteristics of the patient group with a tumour of the right hemisphere who had a language assesssment before and after resective surgery are shown in Table 58.

Table 58: Age and sex characteristics of 26 patients with a non-dominant hemispheric tumour who had a language assesment before and after resective surgery:

	Resection (n=26)
Male Patients	15
Female Patients	11
Age Range	27 - 78 years
Mean Age	55.0 years
Median Age	57.0 years

3.4.5.2. Days between assessments

Patients were reassessed within a week of initial assessment except in 11 cases, as shown in Table 59.

Table 59: Eleven patients who had resective surgery to remove a tumour of the non-dominant hemisphere whose second assessment took place longer than seven days after the first.

Number of Days	10	12	13	14	18	20	27	63
Number of Patients	2	2	2	1	1	1	1	1

Two patients who were discharged before a second assessment was possible were later seen as outpatients. The patient who was reassessed 63 days later was an elective admission whose surgery was postponed for several months. The remaining

patients were reassessed prior to discharge when they were deemed sufficiently able to cope with testing.

3.4.5.3. Results (3): WAB test scores before and after resective surgery

The change in scores after resective surgery for most of the subtests did not reach significance using paired t-test; scores which did show significant change after surgery are listed in Table 60. For the remaining WAB scores, although many were almost at ceiling at first assessment, the trend was for a slight improvement in performance.

Attempting to subdivide the patients with a tumour of the non-dominant hemisphere into dysphasic and non-dysphasic groups using the criteria described above was not appropriate as the AQ of most of the patients was comfortably within normal limits. From clinical observation it appeared that patients with a non-dominant hemisphere tumour occasionally performed badly in the writing tasks. The group was divided, therefore, into patients who scored 32 or more from a maximal 34 for the written picture description subtest and those who obtained 31 or less. No cut-off score is proposed in the test manual therefore 32 was chosen in an effort to identify even small degrees of post-operative change in written expressive language. Table 61 shows that patients with a right hemisphere tumour can in fact perform badly in a test of written expressive language: 15 patients scored 31 or less pre-operatively with the range of scores indicating severe deficits in some cases. Two patients did not complete the writing subtest after surgery. The post-operative improvement is not statistically significant.

Table 60: WAB test scores for patients with a non-dominant hemisphere brain tumour which showed significant improvement after resective surgery.

Subtest	**Number of pairs**	**Maximal Score**	**Mean 1st Assesst. (S.D.)**	**Mean 2nd Assesst. (S.D.)**	**Significance Level**
Information Content	26	10	9.1 (1.0)	9.3 (0.9)	0.016
Spontaneous Speech Total	26	20	19.0 (0.3)	19.2 (1.0)	0.016
Comprehension Total	26	20	19.8 (0.4)	19.9 (0.3)	0.033

Aphasia Quotient	25	100	96.3 (3.0)	97.1 (3.1)	0.012
Cortical Quotient	24	100	94.6 (3.7)	95.6 (3.7)	0.027

Table 61: Pre- and Post-op scores for written picture description obtained by patients who had a resected tumour of the right hemisphere who scored 31 or less out of a maximal 34 at initial assessment (n=15).

	Range	**Mean (S.D.)**	**Significance Level**
Pre-op	8 - 31	22.6 (8.6)	
Post-op	13 -34	27.0 (8.1)	0.076

3.4.5.4. Results (4): BNT scores before and after resective surgery

Thirty four patients with a right hemisphere tumour were assessed before and after resection using the BNT; the mean scores show statistically significant change on second assessment, as shown in Table 62.

Patients were were classified as anomic or non-anomic on the basis of scores obtained at initial assessment using the criteria described above. Mean scores are shown in Table 63. The non-anomic group shows statistically significant improvement after surgery; change in scores for the anomic group almost reaches significance although this group is too small to detect statistical change reliably.

Table 62: Mean BNT scores obtained by patients with a tumour of the non-dominant hemisphere before and after resection.

	Mean BNT Pre-op (S.D.)	**Mean BNT Post-op (S.D.)**	**Significance Level**
Resection Group (n=34)	52.1 (4.2)	53.2 (4.1)	0.003

Table 63: Mean BNT scores for patients with a tumour of the non-dominant hemisphere before and after resective surgery who were classified as anomic (scored 48 or less) or non-anomic (scored 49 or more) at initial assessment.

	Mean BNT Pre-op (S.D.)	**Mean BNT Post-op (S.D.)**	**Significance Level**
Anomic Group (n=4)	43.8 (4.7)	46.0 (3.4)	0.058
Non-Anomic Group (n=30)	53.2 (2.7)	54.1 (3.2)	0.016

3.4.5.5. Results (5): Corticosteroid dosage

All patients were treated with steroids prior to surgery; the mean mg dose was significantly smaller at the time of the post-op language assessment, as shown in Table 64.

Table 64: Mean mg dose Dexamethasone at the time of initial assessment (Time 1) and at post-surgical assessment (Time 2) for patients with a right hemispheric tumour (n=49).

	Mean mg dose (S.D.)	**Significance Level**
Time 1	8.3 (6.6)	
Time 2	1.7 (3.2)	0.000

3.4.5.6. Discussion: Language impairment in patients with a tumour of the non-dominant hemisphere

A wide range of standardised, validated assessments of language impairment after left hemisphere damage is available for both clinical and research use. Interest in communication impairments after damage to the non-dominant hemisphere has a relatively short history: the only published group of tests of right hemisphere language available for use during this study, the Right Hemisphere Language Battery, was ultimately rejected. It was replaced by the WAB, not only because the latter would provide uniformity in assessment methods in the study but also because previous studies have shown that errors of language processing and production may be a possible consequence of right hemisphere damage.

Mean AQ, CQ, spontaneous speech and auditory comprehension total scores of the WAB and the BNT mean score all show significant improvement after resection of right hemisphere tumours. Naming deficits arising from right hemisphere damage has previously been described in the literature (Gainotti et al, 1981; Joanette et al, 1983); spontaneous speech has also been shown to be affected by right hemisphere damage (Joanette et al, 1986; Sherratt & Penn, 1990; Bloom et al, 1992) as have impairments of auditory comprehension (DeRenzi & Vignolo, 1962; Swisher & Sarno, 1969). A relationship between impaired verbal fluency and damage to the right hemisphere has been demonstrated by previous studies (Joanette & Goulet, 1986; Joanette, Goulet & LeDorze, 1988). Although patients in this group did not show substantial post-operative change in word fluency(a) their performance at initial assessment differed significantly from that of a normal control group.

When the scores of the group of patients who obtained less than the maximal 34 for the written picture test are analysed it emerges that approximately 50% of the total group with right hemisphere tumours demonstrated writing impairments prior to surgery which ranged from mild to relatively severe. These results are unexpected as the few references in the literature attribute disorders of writing after right hemisphere damage more to visuoperceptual or visuospatial deficits than to impairments of language (Pimental & Kingsbury, 1989). The scores do not reflect the nature of the writing deficits, however. While the content of written language after damage to the left hemisphere shows obvious impairment in the form of a variety of word omissions, paragraphic errors and perseveration, the written language of patients with right hemispheric damage is characterised by few errors of a dysgraphic type but sparse output with little information content. Even when prompted patients are usually unable to initiate more production, suggesting that word processing is being impeded at some undefined level. Following surgery, with the same set of test instructions, the amount written can increase dramatically. (Samples of writing are shown in appendix I, pp162-165.) In contrast is the nature of verbal expressive language produced during the spontaneous speech subtests of the WAB. Output was often verbose and tangential at initial assessment with obvious improvement in the appropriateness of the amount produced after resective surgery. These features of communication impairment have been associated with right hemisphere abnormality in several other studies (Tompkins & Flowers, 1985; Roman et al, 1987; Sherratt & Penn, 1990).

Post-operative improvement of several language scores provides evidence of the possible presence at initial presentation of language dysfunction in patients with a

tumour of the right hemisphere. The possibility of a large practice effect influencing second assessment scores seems unlikely, as discussed above. Corticosteroids are also unlikely to have contributed to any post-operative changes as the dosage was lower at second assessment than at the first. The pattern of scores and change in scores does not appear to be attributable to a general dulling of mental functioning which is subsequently relieved by surgery.

Mean test scores at initial assessment often reflect little more than mild impairment. As with left hemisphere disease not all patients can be expected to demonstrate language deficits therefore the mean score will mask to some extent the test performance of patients who do in fact have problems with language.

In conclusion it appears that the right hemisphere may have a more substantial role in language processing than was previously thought. The limitations of the assessment tools available, however, prevent the comprehensive exploration necessary to correlate language deficits specifically with damage to the right hemisphere or to adequately describe the nature of the language disorders which may occur with right hemisphere abnormality.

CHAPTER 4

The Validity of the Right Hemisphere Language Battery in Patients with a Non-Dominant Hemisphere Tumour

4.1. Introduction

The main obstacles facing researchers and clinicians investigating the effects of damage to the right cerebral hemisphere on communication are that consequent language disorders cannot be qualified as being strictly aphasic in nature and that they are difficult to assess (Joanette,1990). The Right Hemisphere Language Battery (RHLB) (Bryan, 1989) was devised to provide a qualitative and quantitative assessment of right hemisphere communication impairment (Bryan,1989) and is currently the only available formal, standardised test of right hemisphere language and communication. The battery avoids the traditional aspects of language functioning explored by aphasia batteries such as auditory comprehension, verbal expression, reading comprehension and written expressive language. It focuses instead on areas which the right hemisphere is believed to influence such as lexical-semantic processing, high level language processing and prosody (Bryan, 1988; Bryan,1989; Brownell et al, 1990; Joanette, 1990).

Dysphasia has been identified in many patients with tumours in the left cerebral hemisphere (Miceli et al, 1981; Recht et al, 1989; Tandon et al, 1993; Thomas et al, 1995). The RHLB was initially used in this study to identify features of right hemisphere language impairment which might be present in patients with tumours in the right hemisphere.

Observation of the pattern of performance profiles obtained from the RHLB in the present study showed that it rarely seemed to reflect the clinical impression of the patient's functioning. Patients with large tumours, whose eye contact, facial expression and general social skills frequently appeared to be abnormal, often obtained normal scores while the scores of patients who appeared to be communicating adequately often suggested impairments. Patients whose attention

was poor tended to perform badly using the battery. It was often impossible, therefore, to identify the real cause of low test scores. Bryan (1988) describes much of the test data which was presumably used in the battery as published a year later. From her account it appears that the patients and controls in her study had language assessments in a "noisy hospital ward". It is worrying that the RHLB was validated using test scores which were possibly influenced by the distractions presented by such a test environment, especially in a group of brain damaged patients already prone to attentional deficits (Lezak, 1995).

When it emerged that the test scores obtained might be unreliable the small study described below was set up to determine whether the RHLB could (a) discriminate between the language function of a group of patients with right hemispheric tumours and a control group with no evidence of brain disease and (b) measure change in language function after right hemisphere neurosurgery.

4.2. Method

4.2.1. Resective Surgery and Biopsy

Neurosurgical techniques were as described in chapter 3 for patients with a tumour of the dominant hemisphere.

4.2.2. The Right Hemisphere Language Battery

The battery consists of six tests: two tests of metaphorical language, one of which uses pictures and the other written material; a test of ability to infer information; a test of comprehension of humorous material; a lexical semantic test and a test of the appropriate use of emphatic stress. There is also a discourse analysis rating scale which provides a more subjective score for communicative competence regarding social skills, turn-taking, appropriateness of output etc. The tests are purportedly designed and administered in such a way as to minimise the effects of potential non-verbal deficits, such as visual perceptual deficits and unilateral neglect, which can be incurred as a result of right hemisphere damage

(Bryan, 1989). Bryan (1989) describes the right hemisphere as having a supporting role in verbal memory and maintains that none of the tests is dependent on this function. Each of the tests begins with a practice item to ensure comprehension of the task. Raw scores are converted into T scores which, when plotted on a graph, provide the scorer with a profile of the patient's functioning.

The battery was originally validated using 30 patients with right hemisphere damage of vascular origin and a group of 10 patients described only as "non-vascular". The same numbers of patients with left hemisphere damage were recruited. Scores from 30 normal controls were also collected. No details are provided regarding the level of education or socioeconomic groupings in either the patient or control groups.

4.2.3.Subjects

Twenty consecutive patients with right hemisphere tumours who would undergo neurosurgery were included in the study. All were right handed. The group comprised 12 men and 8 women, mean age 52 years with a range of 33 to 71 years. Mean length of time spent in formal education was 11.7 years with modal socioeconomic grouping 3 (Office of Population Censuses and Surveys, 1980). All patients had a solitary intracranial tumour, 15 of which were gliomas, 3 metastases and 2 meningiomas. Fifteen of the patients had surgery to remove or debulk the tumour; the remaining five had a biopsy only. Exclusion criteria were as listed in chapter 3. Patients were assessed using the RHLB prior to surgery and again approximately one week after either biopsy or resection, before discharge home.

Twenty inpatients awaiting lumbar spinal surgery served as a control group for preoperative assessment. The 10 men and 10 women in this group had a mean age of 50 years, range 32 to 71 years. Mean number of years in formal education was 11.9 with modal socioeconomic grouping also 3. These subjects had no history of brain disease. The control subjects were only assessed preoperatively using the RHLB. Administration of the tests and the test environment were identical in both groups except that on completion of the RHLB each control subject was asked to

complete a questionnaire which was devised for the study relating to which tests they found easiest and which most taxing.

4.2.4. Statistical Methods

The statistical significance of the data obtained was evaluated using t-tests, paired and unpaired as appropriate.

4.3. Results (1): Patients vs Controls

Each of the 20 patients with a brain tumour had a solitary neoplasm. The locations of these tumours were evenly distributed in frontal, temporal and parietal lobes. Tumour volume, calculated from CT scans, varied from small and well-contained to extensively invading the majority of the right hemisphere. The pre-operative mean test scores of the right hemisphere tumour group (n=20) and those of the control group (n=20) are shown in Figure 1. As maximal scores differ the raw mean scores have been converted into percentages. The patients and controls do not differ significantly by t-test on any subtest although a significant difference does exist between the two groups in the mean scores for the Discourse Analysis Rating Scales. The ranges of scores (Table 1) are similar in both groups except for Emphatic Stress and Discourse Analysis. Several people in both patient and control groups apparently performed very badly in the Metaphor Picture, Inference and Humour tests.

Figure 1: Percentage mean scores obtained by the patient and control groups using the RHLB. Open columns show scores for 20 inpatients with right hemispheric brain tumours; shaded columns show scores for 20 inpatients awaiting lumbar spinal surgery

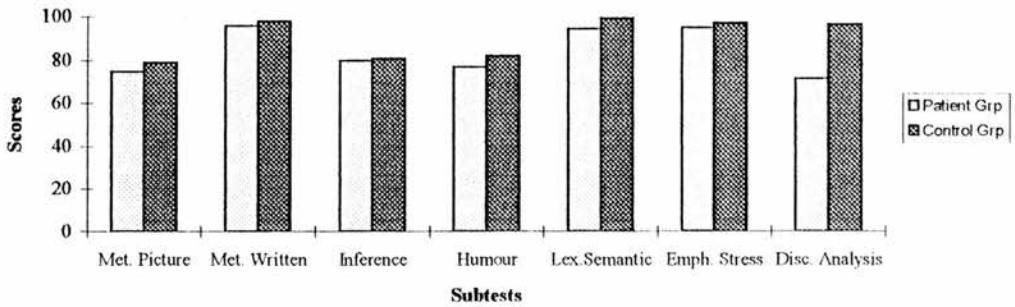


Table 1: Ranges of scores obtained by 20 patients with a dominant hemisphere tumour and 20 normal controls for the subtests of the RHLB.

	Met. Picture	**Met. Written**	**Inf.**	**Hum.**	**Lex-Sem.**	**Emph. Stress**	**Disc. Anal.**
Patients	0 - 10	8 - 10	6 - 12	3 - 10	15 - 20	7 - 10	7 - 44
Controls	1 - 10	8 - 10	7 - 12	1 - 10	19 - 20	8 - 10	35 - 44
Maximal Score	10	10	12	10	20	10	44

For three of the tests, Metaphor Picture, Inference and Humour, the ranges of scores for the 20 control subjects are wide, implying a variety of test performances among the control group. For the purposes of discussion later in the chapter it will be useful to see the raw scores obtained by the 20 control subjects in these three tests, as shown in Table 2.

Table 2: Raw scores obtained by 20 control subjects for the Metaphor Picture, Inference and Humour subtests of the RHLB.

Subject	Metaphor Picture	Inference	Humour
H.N.	4	7	8
W.H.	10	12	9
R.S.	10	11	10
J.M.	9	10	5
G.M.	4	10	1
J.P.	10	11	8
E.T.	10	10	9
W.F.	9	10	10
H.O.	10	7	8
L.D.	10	10	9
J.H.	10	9	10
G.J.	10	8	7
D.L.	10	9	10
D.G.	2	10	6
A.W.	10	11	10
S.I.	6	10	7
D.B.	9	11	10
E.S.	9	7	9
M.T.	4	10	9
J.L.	1	10	8
Maximal score	10	12	10

A breakdown of the control subjects' impressions regarding subtest difficulty as obtained from the questionnaire is shown in Table 3. Although the number of controls was 20, several choices were often made by the same subject in response to each question. Discourse Analysis is not included here as it is not a task-oriented subtest but a rating scale which is scored by the tester on completion of testing.

Table 3: Control subjects' responses to RHLB questionnaire:

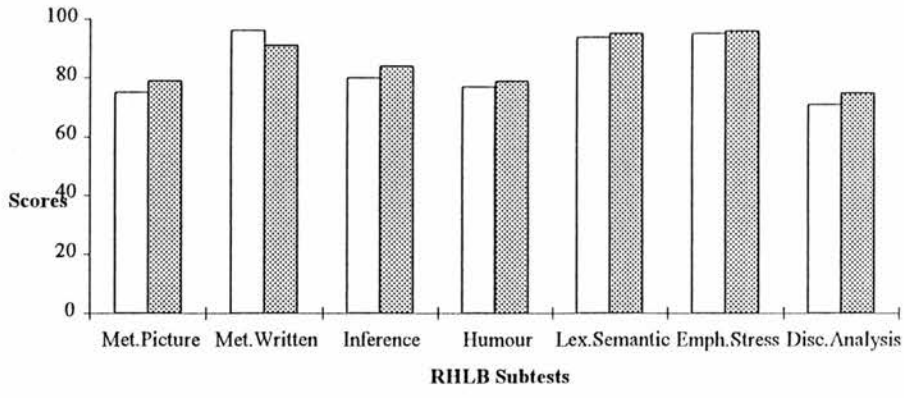
	Most Difficult Test	Least Difficult Test
Metaphor Picture	1	11
Metaphor Written	0	9
Inference	10	3
Humour	7	7
Lexical-Semantic	3	13
Emphatic Stress	3	8
None of the tests	2	3
All of the tests	0	0

4.4. Results (2): Patients' Scores Before and After Resection or Biopsy

Scores obtained by the 20 patients with brain tumours before and after neurosurgery are shown in Figure 2 where scores are again shown as percentages. At the second assessment none of the mean changes in scores differs significantly from zero by paired t-test.

Figure 2: Percentage mean subtest scores before and after either resection or biopsy. Open columns show the mean scores obtained before operation; shaded columns show the post-operative mean scores.

Figure 2



Combining the scores obtained by patients after both resection and biopsy may produce a false impression of the effects of neurosurgery on language as measured by the RHLB. It might be expected that resection could effect some functional improvement while biopsy is more likely to leave the clinical picture unchanged. When the scores of patients before and after biopsy and resective surgery are analysed separately it is demonstrated that, as anticipated, there is no statistically significant change after biopsy but neither is there any change after resection. The mean subtest scores are shown as percentages in Figures 3 and 4. Inspection of Figure 4 suggests that the lack of significant differences is not simply attributable to the small number of cases in the biopsy group.

Figure 3: Percentage mean RHLB subtest scores before and after surgery to remove or debulk the tumour. Pre-operative scores are shown by the open columns; shaded columns show post-operative scores.

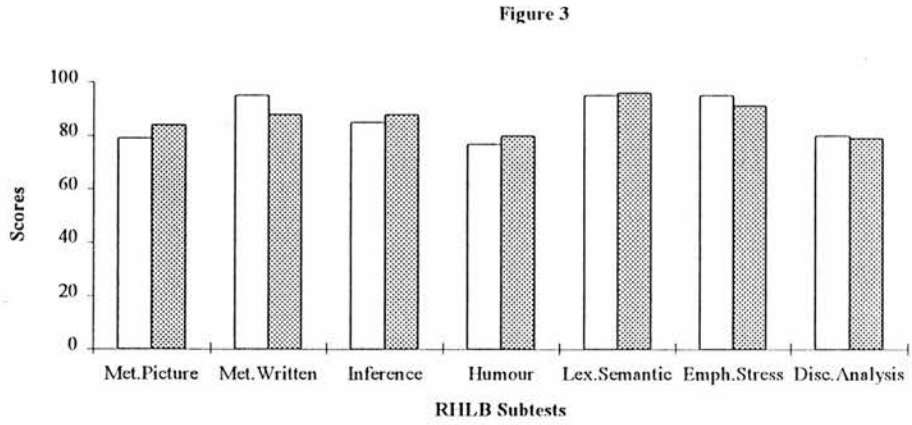
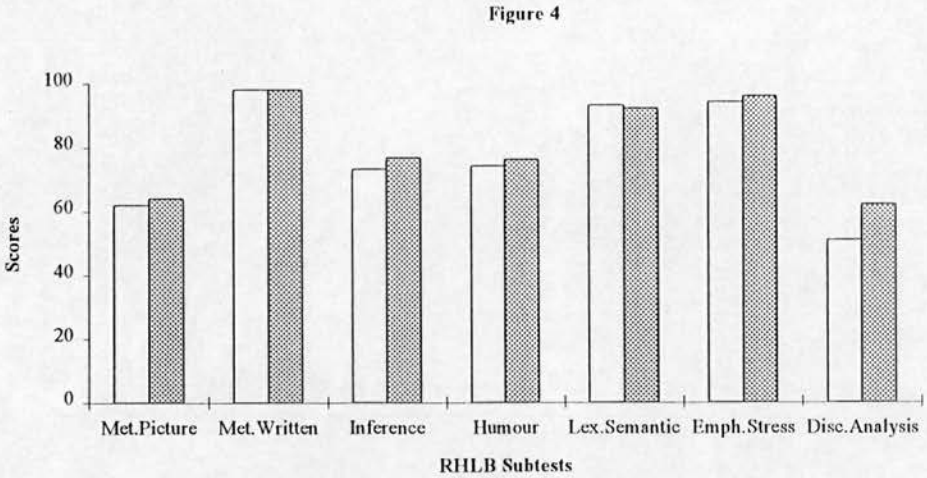


Figure 4: Percentage mean RHLB scores before and after biopsy. Pre-operative scores are shown by the open columns; shaded columns show post-operative scores.



Tumour size varied considerably within the patient group. The CT scans of four patients with very large right hemispheric tumours are shown in Figure 5.

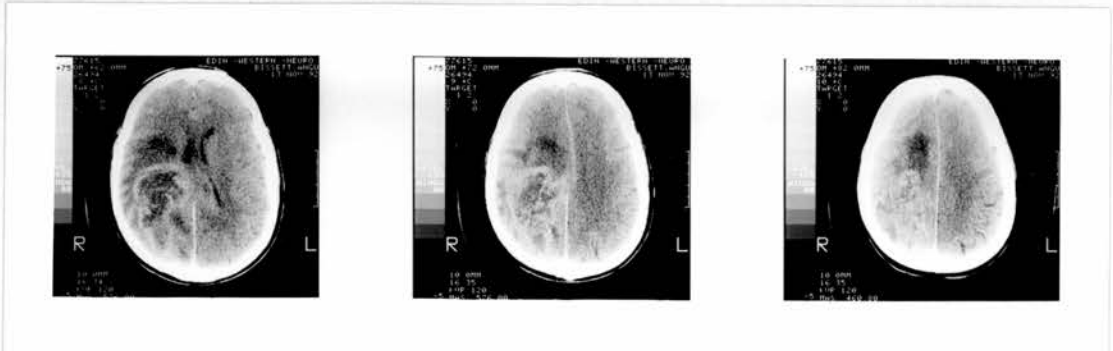
Figure 5: CT scans of four patients with large tumours of the non-dominant hemisphere.

(i)G.McG.

Right fronto-temporal anaplastic oligodendroglioma

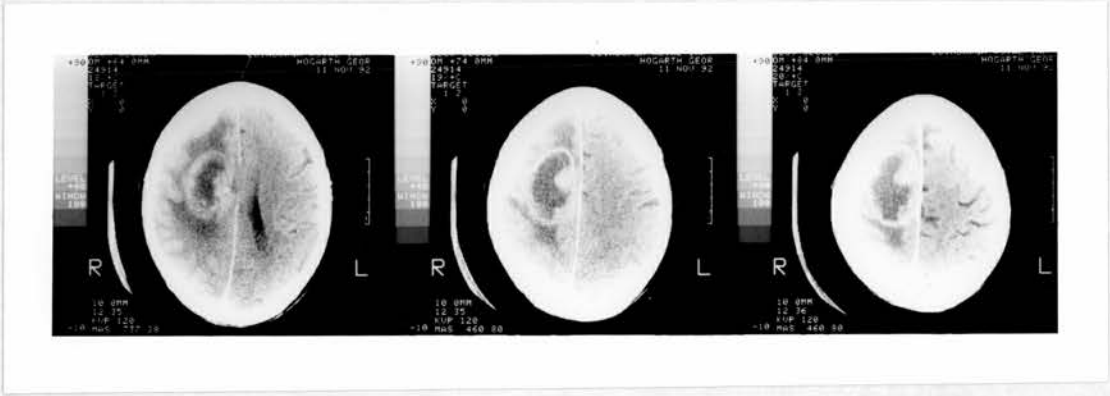
(ii)A.B.

Right temporal lobe glioblastoma multiforme



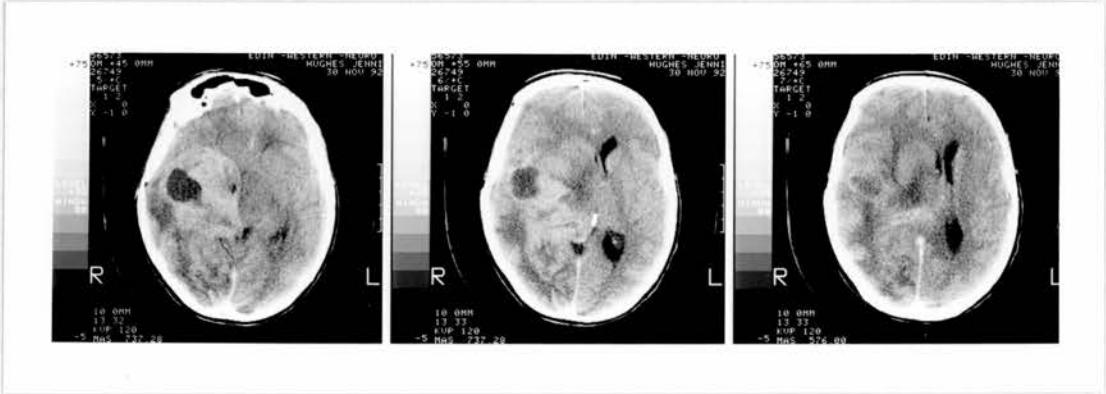
(iii)G.H.

Right temporal lobe glioblastoma multiforme



(iv)J.H.

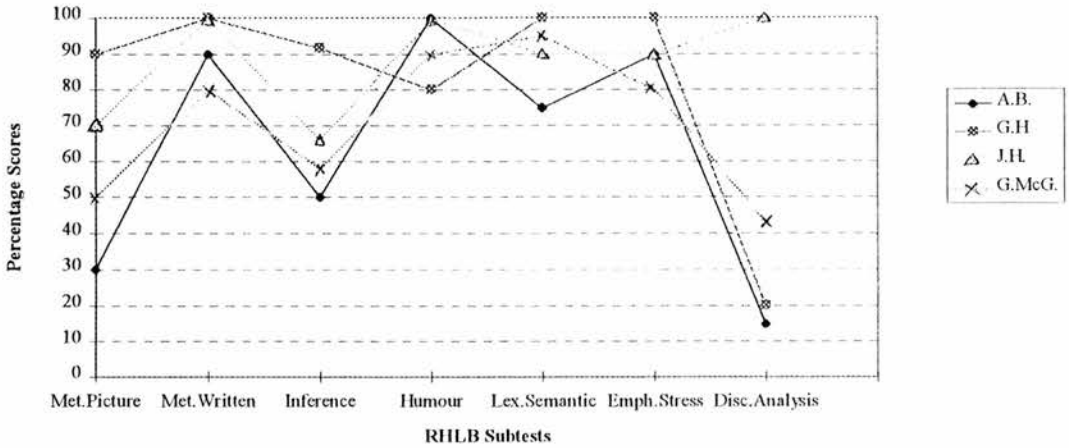
Right temporal lobe anaplastic astrocytoma



In each case the tumour has invaded extensively the right hemisphere and has caused marked peritumoural brain oedema and herniation of the brain tissues across the midline. The subtest scores obtained by the 4 patients are shown in Figure 6.

Figure 6: RHLB subtest scores obtained by G.McG., A.B., G.H. and J.H. Raw scores have again been converted into percentages because of the different maximal scores.

Figure 4



4.5. Discussion: The Right Hemisphere Language Battery in Patients with a Non-Dominant Hemisphere Tumour

The results obtained in this sudy indicate that the RHLB is an insensitive assessment tool for evaluating the language function of patients with right hemispheric tumours and for measuring change after treatment. Five main points have emerged from this study:

(1) The patient group in the study included many individuals with large, highly malignant neoplasms. General communication skills often appeared abnormal yet RHLB test scores frequently indicated normal performance. Figure 6 shows the scores, converted into percentages, of 4 people with extensive tumours. Three of the cases show communication impairment as identified by the Discourse Analysis Ratings Scales; apart from some variability in individual performances in the Metaphor Picture and Inference subtests there is little else to indicate functional deficit. The possibility that these tumours did not affect, at least in part, areas of the right hemisphere with a communicative role must be considered extremely unlikely. The mean scores of all 20 patients obtained prior to neurosurgery, when many were at their most impaired, did not differ from those of a control group with normal brain structure, function and metabolism (see Figure 1). The tumour patients in this study were all receiving steroid therapy prior to initial assessment. While this can

improve the clinical condition of patients with brain tumours (Whittle, 1992) it is unlikely that all signs of dysfunction would be removed. Patients in the main study with dominant hemisphere tumours were assessed using the WAB after similar duration and amounts of steroid therapy: language impairment was identified by the battery in almost 60% of cases. Although the Discourse Analysis Rating Scales do differentiate between the patient and control groups, this subtest differs from the others in the battery in that it requires subjective judgement to rate the patient and hence may be less reliable. We must therefore view with caution the sensitivity of a test of brain function which produces similar results in two groups of people with such widely differing brain status.

(2) The RHLB is unable to discriminate between the effects on language of two grossly different neurosurgical procedures: there is no significant change in scores after either biopsy or resection. The patient numbers are small although the larger group, which comprises fifteen patients who had resective surgery, is the one in which improvement might be expected after surgery. This is not identified by the RHLB. It is conceivable that there was no post-operative change although as the WAB demonstrates improvement after surgery in patients with tumours of the left hemisphere (chapter 3) it seems reasonable to expect some change after right hemisphere resection. The Discourse Analysis Rating Scales was the only RHLB component to identify differences in communication between the patient and control groups yet it did not identify post-resective change, as is seen in Figure 2.

(3) The range of subtest scores shows that people with normal brain function can perform extremely poorly on RHLB subtests, in particular the Metaphor Picture, Inference and Humour tests. Low intelligence was not considered to be a major factor in performance as subjects tended to obtain a low score in one or two subtests but rarely in more than two (for example, scores for H.N., G.M. and J.M. in Table 2). It seems likely, therefore, that a poor score can be obtained for reasons other than language impairment. Metaphor Picture was described by the controls as one of the most straightforward subtests. Only one person thought this test was "difficult" yet six out of the 20 controls scored 6 points or less from a possible 10.

Performance in this subtest can be seen to vary considerably among the four patients in Figure 6 whose percentage scores are evenly spread from 30 to 90. During administration of the tests the practice item was used in every case to ensure that the demands of the tests were fully understood by the subject so that misinterpretation of requirements should not have contributed to poor performance, although test illustrations were occasionally described as misleading.

Raw scores for the Inference test also reflect a sizeable range of ability among the normal controls with only one person gaining the full 12 points. An additional point of interest relating to this subtest is that the RHLB manual records that during the validation of the battery the group of 30 dysphasic patients, with a mean Aphasia Quotient of 63.8, obtained a mean Inference score of 10.46 while the normal control group only managed 9.16. Many subjects in the present study described the passages in the Inference test as "rambling" and "too long" with too much information to retain and claimed that it was often difficult to grasp what the the questions were referring to. The RHLB manual states that none of the tests is dependent on memory skills whereas the Inference test contains passages which are of the same word length as those widely used for recall in tests of verbal memory, e.g. Wechsler (1987).

The widest range of responses among the control group is found in the Humour test. Once again, understanding the requirements of the test was not a problem for any of the subjects although completing a joke by choosing the correct punchline from a choice of four did provoke some confusion.

(4) The raw scores obtained for each patient are converted to T scores to provide a communication profile. Interpreting the profiles is confusing as the T score distributions appear to have been based on the performances of combined heterogeneous groups (right hemisphere damaged, left hemisphere damaged and normal controls) which have been described only briefly in the test manual. This limits the utility of the scoring system in interpreting differences between subtests or patients and depicts normal performance as an uneven profile well above the defined T distribution mean of 50.

(5) Anderson et al (1990) showed that patients with brain tumours performed considerably better on neuropsychological testing than did stroke patients who were matched for size and location of lesion, suggesting that test batteries which were validated using mostly vascular patients may not be suitable for assessing tumour patients. Although post-resective improvement was not identified, the scores obtained in this study by controls and brain tumour patients for the Discourse Analysis Rating Scales demonstrate that differences do exist between the two groups. More work is required in this particular area in the future to produce a less subjective method of assessment.

4.6. Conclusion

Although communication deficits have previously been described in patients with right hemisphere damage, identifying and measuring impairments in patients with tumours of the right hemisphere has proved to be a difficult task. The RHLB does provide a profile of apparent language impairment but the real cause of poor performance may be non-linguistic in origin. Normal controls in this study found that some aspects of the battery tested their concentration span and memory. This would suggest that contrary to the author's claims the battery requires other visuospatial and attentional features of right hemisphere function to be largely intact before true language function can be assessed. The mean scores obtained by the patients in this study were higher than those of the patients used by Bryan in the validation of the battery. The adverse conditions under which Bryan's patients were assessed may have contributed to this difference.

The RHLB was initially used in the assessment of patients in the study but the findings described above question its validity both as a tool for establishing the presence of language disorders and for measuring change after surgery in patients with brain tumours.

CHAPTER 5

SPECT in Patients with an Intracranial Tumour

5.1. Introduction

Blood flow studies using single photon emission computerised tomography (SPECT) were carried out on a small patient cohort. The aim was to identify any relationships which might exist between language disorders and abnormal patterns of regional cerebral blood flow. Patients with either a left or right hemisphere tumour were included in an attempt to (a) identify similarities or inconsistencies between patterns of language disorders and localisation of lesion in dominant hemisphere stroke and (b) obtain any information on localisation of language in the right hemisphere as current knowledge is scant. A number of patients were scanned before surgery and again afterwards to identify any correlations between post-surgical improvements in language performance and changes in cerebral blood flow

5.2. Method

5.2.1. SPECT

SPECT scanning was carried out in the Royal Edinburgh Hospital and later in the Western General. In the former hospital a dedicated multi-detector scanner was used and in the latter a single headed rotating gamma camera; analysis of data was unaffected by the use of two different machines (Merrick, 1995, personal communication). Comparisons of blood flow before and after surgery were made in a way which did not depend on using the same machine for all patients, provided each patient was scanned using the same machine on both occasions. All patients were scanned in a resting state. SPECT scans were carried out as near to the time of their pre- and post-operative language assessment as possible. Language was assessed using the WAB and BNT, as described in chapter 3. All patients gave informed consent.

5.2.2. Patient Selection

As scanning initially required a journey to another hospital the first five patients had to be physically fit both to travel and to climb on to a bed with minimal assistance. Scanning facilities subsequently became available at the Western

General where the requirements for physical ability were not as stringent as the patient was transferred from one department to another within the same hospital. The patient's comprehension of language was required to be adequate to cope with instructions regarding the scanning procedure.

5.2.3. Statistical Analysis and Interpretation of Results

A quantitative, numerical analysis is often used to interpret SPECT images. Expert advice was that it would be very difficult to identify meaningful relationships between language scores and scan images represented by large series of numerals (Merrick, personal communication, 1995). It was suggested, therefore, that a protocol should be devised for rating size of abnormality on the basis of scan appearance. Images were rated independently and blindly by a radiologist, neurosurgeon and neuropsychologist who viewed each scan and decided if the area of abnormality was large, small or not visible. Pre- and post-operative scans were then compared to determine if the abnormal area was larger, smaller or unchanged. Agreement between the three raters on size of abnormal area was high. The scores allocated by each of the raters on the three point scales described above were averaged to give an overall score for each patient for (1) size of abnormal area before surgery and (2) change afterwards. Each patient's score was correlated with BNT and WAB summary scores using Pearson's *r*.

5.3. Results

5.3.1. Patients

The cohort comprised 16 patients, eight patients with a left and eight with a right hemisphere tumour. Patients' ages ranged from 27 to 71; eight patients were female and eight were male. Patients with a right hemisphere tumour were not included for analysis as the entire subgroup scored at or close to ceiling at both initial and post-operative language assessments. Three patients with a left hemisphere tumour did not have a post-operative scan; one patient's overall condition had deteriorated and the other two patients failed to attend.

5.3.2. Pre-operative SPECT and Language Scores

Correlations between the pre-operative AQ, LQ and BNT for the eight patients with a dominant hemisphere tumour and the scores allocated for size of abnormality were not significant using Pearson's *r* although the trend was in the direction of greater language impairment with a larger abnormal area. Table 1 shows language

scores at initial assessment and apparent size of brain abnormality. Each of the three raters allocated 2, 1 or 0 to each scan depending on whether the area of abnormality seemed respectively large, small or not visible. The mean rating for each scan is shown in Table 1. The LQ is missing for two patients who were unable to write because of limb weakness associated with the tumour.

Table 1: AQ, LQ and BNT and mean rating for size of area of abnormality allocated by three independent raters for eight patients with a left hemisphere tumour at initial assessment. (A rating of 2 = a large abnormal area, 1 = a small abnormal area and 0 = nothing visible.)

Patient	AQ (maximal score=100)	LQ (maximal score=100)	BNT (maximal score=60)	Mean Rating for Size of Abnormal Area
M.L.	55.8	42.3	3	1.7
S.C.	80.0		41	1.0
A.T.	99.4	98.7	44	1.0
W.F.	99.0		54	0.3
J.S.	97.2	96.3	48	1.0
J.G.	69.8	60.5	14	1.3
L.Q.	84.2	74.8	24	2.0
P.S.	97.0	98.1	45	2.0

5.3.3. Post-operative SPECT and Language Scores

Each of the three raters allocated 1, -1 or 0 to each scan depending on whether the area of abnormality seemed respectively larger, smaller or unchanged after surgery. The pre- and postoperative language scores and the mean rating for change in size of the abnormal area seen on the scan are shown in Table 2. The relationship between change in language score and change in size of abnormal area was found to be non-significant, although significance may be difficult to demonstrate in such a small group. There was no obvious trend in the results: one patient's language was seen to improve when the area of abnormality diminished (M.L), as might be expected; there was no change, however, in the size of the abnormal area in another patient whose language showed post-operative improvement (S.C.), as is shown in Table 2. (Pre- and post-operative scans and language scores for these two patients are shown in appendix III, pp171-175.)

Table 2: Pre-and post-operative AQ, LQ and BNT for five patients with a dominant hemisphere tumour. The mean rating allocated by three independent raters for perceived change in the size of the area of abnormality after resective surgery is also shown. (A rating of 1 implies that the abnormal area is larger after surgery, -1 that it is smaller and 0 that there is no change.)

Patient	1st AQ	2nd AQ	1st LQ	2nd LQ	1st BNT	2nd BNT	Mean Change in Size of Abnormal Area
M.L.	55.8	90.6	42.3	86.6	3	23	-0.7
S.C.	80.0	98.0	-	-	41	54	0
A.T.	99.4	99.2	98.7	99.4	44	50	-1
W.F.	99.0	99.4	-	-	54	56	1
J.S.	97.2	98.0	96.3	97.2	48	49	0.3

5.4. Discussion of Findings

The methods used in this study for interpreting SPECT scan images were subjective but were recommended as being potentially at least as informative as the more usual numerical analysis. Despite this, few conclusions have emerged from the results of this study. It is likely that very large patient numbers would be required to demonstrate systematic relationships between language functions and the areas of abnormality in the brain as shown by functional imaging, and to permit disentangling the various interrelated effects of tumour type, tumour location and blood flow abnormalities, all of which may influence the extent or nature of language dysfunction.

CHAPTER 6

Anxiety and Depression in Patients with a Dominant or Non-Dominant Hemisphere Tumour

6.1. Introduction

Little appears in the literature on mood changes in patients with brain tumours and results of studies of mood disorder in stroke are often contradictory. It was not clear, therefore, whether anxiety or depression could be expected to relate to performance during language testing either before surgery, or afterwards when the patient was usually fully aware of the diagnosis. Doubts also arose as to whether relationships could be found to exist between mood disturbances and side of lesion or patient gender, as has been suggested in stroke. Affective status was therefore measured at the time of each language assessment in an effort to investigate these possibilities.

6.2. Method

The Hospital Anxiety and Depression Scale (HAD) (Zigmond & Snaith, 1983) was used to evaluate mood. This comprises separate seven-item scales for anxiety and depression (see appendix II, p169-170 for HAD Scale and scoresheet). According to Zigmond and Snaith's guidelines a score of less than eight, between eight and ten and higher than ten on each scale were taken to indicate respectively the probable absence, the possible presence and the probable presence of mood disorder. Questionnaires were completed before and after biopsy, resective surgery, radiotherapy or chemotherapy at the time of language assessment.

Data was not recorded for patients whose language comprehension was too impaired to permit reliable completion of the scale. Where dyslexic difficulties prevailed each item was read aloud to the patient and where language difficulties were severe the HAD was not used. This was not thought likely to skew results greatly because of the small number of patients excluded. Occasionally the HAD was omitted for reasons of time in favour of a more complete language assessment. Several patients did not have a language assessment after treatment, as described in chapter 3. As post-operative HAD scores are also missing for these patients, group numbers below are often smaller in the descriptions of comparisons of scores before and after surgery than at initial assessment.

Scores were recorded for anxiety and depression. The total score for anxiety and depression was also computed in each case as an index of general mood disturbance.

The scores obtained at initial assessment were subtracted from those at the subsequent assessment to provide a change score.

Paired and unpaired t-tests, and Pearson *r* correlation coefficients, were used as appropriate.

6.3. Patients

One hundred and nine patients completed the HAD before either biopsy or resection; 94 completed a further HAD after surgery. Seventeen of these patients completed a third HAD after radiotherapy. Eighteen patients were assessed before beginning chemotherapy; post-chemotherapy HAD scores were obtained for eight patients.

Twenty control inpatients completed the HAD before and after lumbar spinal surgery to provide a measure of psychological reaction to surgery. This group is fully described in chapter 4.

6.4. Results: HAD Scores in Patients with Brain Tumours

As so little has been published on mood disturbances in patients with brain tumours it was hoped that an analysis of HAD scores might provide some insight into the emotions which accompany the disease. An overview of general findings relating to HAD scores in patients with brain tumours is presented first. An evaluation of relationships between mood scores and language function will follow.

Of the 109 patients who completed a HAD at initial assessment 56 had a left and 49 had a right hemisphere tumour. Four patients had tumours which could not be localised by hemisphere; their HAD scores were omitted from the analysis of HAD scores according to hemispheric location. The results in this section are grouped into three categories depending on whether the patient had surgery, chemotherapy or radiotherapy. HAD scores obtained at initial assessment are presented first in each case, followed by the changes in scores subsequent to the different methods of tumour treatment. In the surgery group the scores obtained after biopsy or resective surgery were analysed separately. Breakdown of results by gender and by side of lesion is presented as these factors are known to be associated with mood disturbance in other conditions such as stroke.

6.4.1. HAD Scores at Initial Assessment

Tables 1 and 2 show the means for anxiety and depression respectively for all patients before either resective surgery or biopsy. These scores are also represented in Figures 1 and 2. Also shown in the tables are the numbers of patients in the

tumour group as a whole and in patient subgroups who obtained a score indicating the probable absence (i.e. between 0 and 7), possible presence (i.e. between 8 and 10) or probable presence (i.e. 11 or higher) of anxiety or depression.

Table 1: Mean scores and numbers of patients (also shown in percentages) whose scores indicate probable absence, possible presence or probable presence of anxiety. (The scores of four patients have been omitted from the analysis according to side of lesion.)

	Mean (S.D.)	**Probable absence (% of total)**	**Possible presence (% of total)**	**Probable presence (% of total)**
Whole group (n=109)	8.3 (4.7)	55 (50%)	21 (19%)	33 (30%)
All left hemisphere (n=56)	8.7 (5.0)	28 (50%)	10 (18%)	18 (32%)
All right hemisphere (n=49)	7.9 (4.6)	26 (53%)	9 (18%)	14 (29%)
All male patients (n=62)	6.8 (4.0)	40 (65%)	13 (21%)	9 (15%)
All female patients (n=47)	10.3 (4.9)	15 (32%)	8 (17%)	24 (51%)
Male left hemisphere (n=33)	6.7 (3.8)	22 (67%)	8 (24%)	3 (9%)
Female left hemisphere (n=23)	11.7 (5.0)	6 (26%)	2 (9%)	15 (65%)
Male right hemisphere (n=28)	7.0 (4.4)	17 (61%)	5 (18%)	6 (21%)
Female right hemisphere (n=21)	9.0 (4.8)	9 (43%)	4 (19%)	8 (38%)

Table 2: Mean scores and numbers of patients (also shown in percentages) whose scores indicate probable absence, possible presence or probable presence of depression. (The scores of four patients have been omitted from the analysis according to side of lesion.)

	Mean (S.D.)	**Probable absence (% of total)**	**Possible presence (% of total)**	**Probable presence (% of total)**
Whole group (n=109)	5.6 (4.1)	72 (66%)	20 (18%)	17 (16%)
All left hemisphere (n=56)	6.0 (4.4)	36 (64%)	8 (14%)	12 (21%)
All right hemisphere (n=49)	5.2 (3.9)	34 (69%)	10 (21%)	5 (10%)
All male patients (n=62)	4.4 (3.8)	49 (79%)	6 (10%)	7 (11%)
All female patients (n=47)	7.3 (4.0)	23 (49%)	14 (30%)	10 (21%)
Male left hemisphere (n=33)	4.5 (4.1)	26 (79%)	2 (6%)	5 (15%)
Female left hemisphere (n=23)	8.2 (4.0)	10 (44%)	6 (26%)	7 (30%)
Male right hemisphere (n=28)	4.4 (3.5)	22 (79%)	4 (14%)	2 (7%)
Female right hemisphere (n=21)	6.2 (4.2)	12 (57%)	6 (29%)	3 (14%)

Figure 1: Mean scores for anxiety and depression obtained by all patients, male or female patients and patients with a left or right hemisphere tumour.

Figure 1

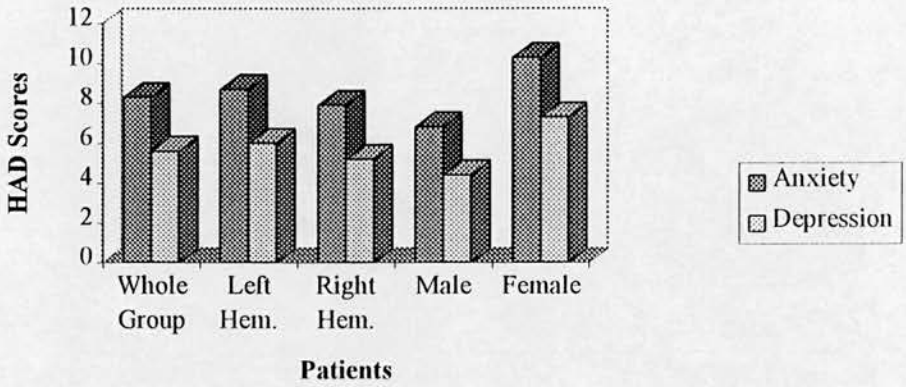
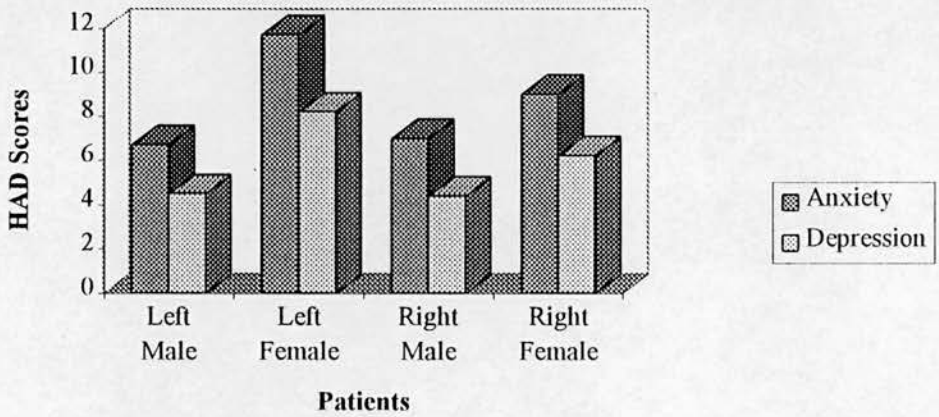


Figure 2: Mean scores for anxiety and depression obtained by male and female patients with a left or right hemisphere tumour.

Figure 2



6.4.1.1. HAD scores and side of lesion

The proportions of patients in each of the score categories for both anxiety and depression is similar for both left and right hemispheric tumours. The difference in scores between both groups is not statistically significant, as is shown in Table 3.

Table 3: Scores for anxiety, depression and HAD total obtained at initial assessment by patients with a tumour in the left or right hemisphere.

	Left (n=56) Mean (S.D.)	**Right (n=49) Mean (S.D.)**	**Significance Level**
Anxiety	8.7 (5.0)	7.9 (4.6)	0.355
Depression	6.0 (4.4)	5.2 (3.9)	0.317
Anxiety and Depression Total	14.7 (8.4)	13.0 (7.9)	0.290

6.4.1.2. HAD scores and patient gender

Differences were greater between the sexes: fewer of the female patients obtained scores which indicated the probable absence of either anxiety or depression. The group of female patients with a tumour of the left hemisphere contained the highest percentage of patients demonstrating possible or likely mood disturbance. Significant differences were identified by unpaired t-test between scores obtained at initial assessment by the 62 male and 47 female patients, irrespective of side of tumour, for anxiety, depression and total HAD scores, as shown in Table 4.

When HAD scores for male and female patients with a tumour of the same side are compared by unpaired t-test, the differences in scores at initial assessment for anxiety, depression and HAD total between males and females with a left sided tumour are highly significant (p=0.000, 0.001 and 0.000, respectively). The differences between male and female patients with a tumour of the right hemisphere do not reach significance for any HAD score.

Table 4: Scores for anxiety, depression and HAD total obtained at initial assessment by male and female patients with a brain tumour.

	Males (n=62) Mean (S.D.)	**Females (n=47) Mean (S.D.)**	**Significance Level**
Anxiety	6.8 (4.0)	10.3 (4.9)	0.000
Depression	4.4 (3.8)	7.3 (4.0)	0.000
Anxiety and Depression Total	11.2 (6.6)	17.6 (8.4)	0.000

6.4.2 HAD Scores Before and After Surgery

6.4.2.1. HAD scores and side of lesion

To identify possible change within each group, HAD scores before and after surgery were initially evaluated separately for patients with a left or right hemisphere tumour. Both groups demonstrated significantly reduced levels of both anxiety and depression after surgery: results are presented in Tables 5 and 6.

Table 5: Mean scores before and after surgery for anxiety, depression and HAD total for patients with a left hemispheric tumour (n=50).

	Pre-op Mean (S.D.)	**Post-op Mean (S.D.)**	**Significance Level**
Anxiety	8.7 (5.1)	5.7 (4.5)	0.000
Depression	5.7 (4.5)	4.0 (4.0)	0.001
Anxiety and Depression Total	14.5 (8.6)	9.7 (7.9)	0.000

Table 6: Mean scores before and after surgery for anxiety, depression and HAD total for patients with a right hemispheric tumour (n=44).

	Pre-op Mean (S.D.)	Post-op Mean (S.D.)	Significance Level
Anxiety	7.4 (4.4)	5.6 (4.2)	0.004
Depression	4.6 (3.6)	3.7 (2.9)	0.028
Anxiety and Depression Total	12.0 (7.4)	9.3 (6.3)	0.003

The extent of change in levels of anxiety or depression did not differ significantly by unpaired t-test between patients with a left or right hemisphere tumour.

6.4.2.2. HAD scores, patient gender and side of lesion

All patient groups showed significant reductions in levels of anxiety after surgery whereas only females with a left and males with a right hemisphere tumour obtained significantly lower post-operative scores for depression. Table 7 provides a summary of significant change after surgery within the four groups; mean HAD scores before and after surgery are shown in Table 8.

Table 7: Post-operative improvement in HAD scores in male and female patients with a left or right hemisphere tumour. * indicates statistically significant change.

	Anxiety	Depression	Total HAD Score
Males with a left sided tumour	*		*
Females with a left sided tumour	*	*	*
Males with a right sided tumour	*	*	*
Females with a right sided tumour	*		

Table 8: Pre- and post-operative mean HAD scores for patients with a left or right hemisphere tumour.

	Males-Left (n=31)	**Females-Left (n=19)**	**Males-Right (n=24)**	**Females-Right (n=19)**
Anxiety Pre-op (S.D.)	6.8 (3.9)	11.9 (5.3)	6.3 (3.7)	8.7 (5.0)
Anxiety Post-op (S.D.)	4.7 (3.6)	7.4 (5.4)	4.6 (3.4)	6.9 (4.9)
Significance Level	0.003	0.001	0.039	0.047
Depression Pre-op (S.D.)	4.3 (4.0)	8.2 (4.3)	3.8 (3.2)	5.7 (4.0)
Depression Post-op (S.D.)	3.7 (3.8)	4.4 (4.4)	2.7 (2.3)	5.0 (3.1)
Significance Level	0.225	0.001	0.031	0.339
HAD Total Pre-op (S.D.)	11.1 (6.5)	20.1 (8.9)	10.1 (5.8)	14.4 (8.6)
HAD Total Post-op (S.D.)	8.4 (6.8)	11.8 (9.1)	7.3 (4.8)	11.9 (7.2)
Significance Level	0.001	0.000	0.015	0.083

6.4.3. HAD Scores Obtained by the Control Group

The prospect of impending surgery alone was considered likely to be a significant factor in altering mood, irrespective of the disease process involved or likely prognosis. The 20 control subjects completed a pre- and post-operative HAD

to provide a measure of the effects on mood of a surgical procedure, the implications of which may be less distressing than surgery for a brain tumour.

The pre-surgery HAD scores obtained by the control group for anxiety and depression are shown in Tables 9 and 10 respectively. The mean scores and the percentages of subjects in the whole control group who fall within normal limits for both anxiety and depression are similar to those for the tumour group as a whole. The distinction which exists between male and female tumour patients is not apparent in the control group, although the size of the latter group is substantially smaller. HAD scores for male patients with a tumour of the left hemisphere were compared by unpaired t-test with those of the male control subjects as were male patients with a right sided tumour; scores for female patients with a left or right sided tumour respectively were compared separately with the scores obtained by the female controls. There was no significant difference in pre-operative HAD scores between any of the patient groups and the control subjects.

Table 9: Mean scores and numbers of control subjects (also shown in percentages) whose scores indicate probable absence, possible presence or probable presence of anxiety at initial assessment.

	Mean (S.D.)	**Probable absence (% of total)**	**Possible presence (% of total)**	**Probable presence (% of total)**
All control group (n=20)	7.9 (3.9)	10 (50%)	6 (30%)	4 (20%)
Male control group (n=10)	7.4 (3.1)	4 (40%)	4 (40%)	2 (20%)
Female control group (n=10)	8.3 (4.7)	6 (60%)	2 (20%)	2 (20%)

Table 10: Mean scores and numbers of control subjects (also shown in percentages) whose scores indicate probable absence, possible presence or probable presence of depression at initial assessment.

	Mean (S.D.)	**Probable absence (% of total)**	**Possible presence (% of total)**	**Probable presence (% of total)**
All control group (n=20)	5.6 (3.0)	14 (70%)	4 (20%)	2 (10%)
Male control group (n=10)	4.7 (3.2)	8 (80%)	1 (10%)	1 (10%)
Female control group (n=10)	6.5 (2.7)	6 (60%)	3 (30%)	1 (10%)

The HAD scores obtained by the control group after surgery did not show statistically significant change from the pre-operative scores. Pre-operative, post-operative and change HAD scores for the control group are shown in Table 11.

Table 11: Mean pre-operative, post-operative and change HAD scores obtained by 20 control subjects.

	All Controls (n=20) (S.D.)	**Male Controls (n=10) (S.D.)**	**Female Controls (n=10) (S.D.)**
Anxiety Pre-op	7.9 (3.9)	7.4 (3.1)	8.3 (4.7)
Anxiety Post-op	6.6 (3.3)	6.7 (4.3)	6.5 (2.2)
Significance Level	0.147	0.460	0.235
Depression Pre-op	5.6 (3.0)	4.7 (3.2)	6.5 (2.7)
Depression Post-op	5.1 (3.4)	4.5 (3.4)	5.7 (3.5)
Significance Level	0.428	0.735	0.494

HAD Total Pre-op	13.5 (6.4)	12.1 (5.7)	14.8 (7.0)
HAD Total Post-op	11.7 (6.1)	11.2 (7.4)	12.2 (4.8)
Significance Level	0.171	0.496	0.256
Anxiety Change Score	-1.3 (3.7)	-0.7 (2.9)	-1.8 (4.5)
Depression Change Score	-0.5 (2.8)	-0.2 (1.8)	-0.8 (3.6)
HAD Total Change Score	-1.8 (5.5)	-0.9 (4.0)	-2.6 (6.8)

There was no significant difference in any change HAD score between any of the patient groups and the control subjects.

6.4.4. HAD Scores in Biopsy versus Resective Surgery

The HAD scores of patients who had a tumour resected were compared with those who had a biopsy. The surgical procedure had been explained to patients prior to both language assessment and completion of the HAD questionnaire; it was thought that patients facing resective surgery might be more emotionally affected because of the associated longer period in hospital and greater risk of post-operative morbidity. Means and standard deviations were very similar for the resection and biopsy groups at both initial assessment and in the change scores, which were calculated by subtracting scores obtained at initial assessment from post-operative scores. These results are shown in Table 12.

Table 12: Mean pre-operative and post-operative change scores for anxiety and depression obtained by patients who had either resective surgery or biopsy.

	Anxiety (S.D.)	**Depression (S.D.)**
Pre-op score		
Resection mean (n=83)	8.3 (4.8)	5.6 (4.1)
Biopsy mean (n=23)	8.3 (4.6)	5.2 (4.0)
Level of Significance	0.963	0.671
Change score		
Resection mean (n=74)	-2.4 (4.1)	-1.5 (3.2)
Biopsy mean (n=19)	-2.1 (3.5)	-0.9 (3.1)
Level of Significance	0.677	0.468

HAD scores for both resection and biopsy groups were analysed by hemispheric location of the tumour. The biopsy group was substantially smaller than the resection group for both left and right hemisphere tumour groups: 11 and 38 respectively for the left hemisphere group and 8 and 35 for the right. There was no significant difference in HAD scores between resection and biopsy within left and right hemisphere groups at initial assessment or in change scores. Group numbers were considered too small for further subdivision by gender.

The tumour group was subdivided by surgical procedure and hemispheric location of the tumour and each subgroup was compared by unpaired t-test with the group of 20 control subjects. Patients with a tumour of the left hemisphere were categorised into biopsy and resection groups as were patients with a right sided tumour; the HAD scores for each of these four subgroups were compared separately with the scores obtained by the control group. There was no difference in pre-operative or change HAD scores between the means obtained by the control group and any of the four patient groups.

6.4.5. HAD Scores Before and After Radiotherapy

Seventeen patients who had previously had tumour resection or biopsy completed a HAD before and after radiotherapy. Means and standard deviations for anxiety and depression are shown in Tables 13 and 14 for the entire radiotherapy group. The group was analysed as a whole; subgroups contained too few patients for results to be considered meaningful. Percentages of patients with possible absence or possible presence of anxiety or depression are also shown. Within each group the majority of patients scored within normal limits for both anxiety and depression. A comparison by paired t-test of HAD scores before and after radiotherapy demonstrated a statistically significant reduction in anxiety, as shown in Table 15.

Table 13: Mean scores and numbers of patients (also shown in percentages) whose scores before beginning radiotherapy indicate probable absence, possible presence or probable presence of anxiety.

	Mean (S.D.)	**Probable absence (% of total)**	**Possible presence (% of total)**	**Probable presence (% of total)**
n=17	7.3 (4.8)	10 (59%)	3 (18%)	4 (24%)

Table 14: Mean scores and numbers of patients (also shown in percentages) whose scores before beginning radiotherapy indicate probable absence, possible presence or probable presence of depression.

	Mean (S.D.)	**Probable absence (% of total)**	**Possible presence (% of total)**	**Probable presence (% of total)**
n=17	3.1 (2.8)	16 (94%)	1 (6%)	0

Table 15: HAD scores for all patients before and after radiotherapy (n=17)

	Pre-radio Mean (S.D.)	Post-radio Mean (S.D.)	Significance Level
Anxiety	7.3 (4.8)	4.6 (3.1)	0.009
Depression	3.1 (2.8)	2.1 (2.5)	0.142
Anxiety and Depression Total	10.4 (6.5)	6.6 (4.5)	0.003

6.4.6. HAD Scores Before and After Chemotherapy

Eighteen patients completed a HAD questionnaire prior to beginning chemotherapy; each patient presented with tumour recurrence. Means, standard deviations and numbers of patients obtaining scores for anxiety and depression are shown in Tables 16 and 17. With the exception of the anxiety scores obtained by female patients the majority of patients in the whole chemotherapy group and each of the subgroups demonstrated scores for both anxiety and depression which can be described as falling within normal limits. Only eight of the initial eighteen patients completed a post-chemotherapy HAD; the other ten patients did not survive until the end of treatment. The group was analysed as a whole; subgroups contained too few patients for results to be considered meaningful. The differences in mean scores before and after treatment for both anxiety and depression were found to be not statistically significant, as is shown in Table 18.

Table 16: Mean scores and numbers of patients (also shown in percentages) whose scores before beginning chemotherapy indicate probable absence, possible presence or probable presence of anxiety.

	Mean (S.D.)	Probable absence (% of total)	Possible presence (% of total)	Probable presence (% of total)
n=18	6.9 (3.9)	10 (56%)	4 (22%)	4 (22%)

Table 17: Mean scores and numbers of patients (also shown in percentages) whose scores before beginning chemotherapy indicate probable absence, possible presence or probable presence of depression.

	Mean (S.D.)	**Probable absence (% of total)**	**Possible presence (% of total)**	**Probable presence (% of total)**
n=18	4.8 (4.3)	14 (79%)	2 (11%)	2 (11%)

Table 18: HAD scores for all patients before and after chemotherapy (n=8)

	Pre-chemo Mean (S.D.)	**Post-chemo Mean (S.D.)**	**Significance Level**
Anxiety	6.9 (4.2)	4.8 (3.4)	0.085
Depression	5.1 (3.5)	4.5 (4.4)	0.714
Anxiety and Depression Total	12.0 (6.7)	9.3 (7.0)	0.287

6.4.7. Anxiety, Depression and Language Scores

The patient cohort was analysed according to side of lesion and by gender. HAD scores were correlated with Aphasia Quotient, Language Quotient and Boston Naming Test obtained both pre- and post-operatively by patients with either a left or right sided tumour and then again separately for male and female patients. Scores were also analysed for smaller groups of patients categorised by both gender and side.

6.4.7.1. Side of lesion

In patients with a tumour of the dominant hemisphere (n=55, 52 and 49 for patients who had scores for HAD and AQ, BNT and LQ, respectively) there was no significant correlation between any language score and anxiety, depression or HAD total at initial assessment. A significant but low negative correlation was identified between depression and LQ at the post-operative assessment (r=-0.33; p=0.030). (Uncorrected significance levels are shown, without Bonferroni adjustment for number of comparisons made, as such adjustment is arguably excessively conservative in the context of an exploratory analysis such as this.)

In patients with a right hemisphere tumour (n=45, 31 and 29 for HAD and BNT, AQ and LQ) statistically significant relationships were identified at initial assessment between BNT and anxiety, depression and HAD total, and between LQ and both depression and HAD total. In each case a lower language score was related to a higher HAD score. Correlation coefficients and significance levels for these scores are shown in Table 19. Significant correlations did not exist between any of these scores at post-operative assessment although a low negative correlation was found between AQ and depression.

Table 19: Correlation coefficients and levels of significance between HAD scores and LQ and BNT obtained by patients with a right hemispheric tumour at initial assessment.

	Anxiety (p-value)	**Depression (p-value)**	**HAD Total (p-value)**
Language Quotient	_	-0.42 (0.023)	-0.41 (0.027)
BNT	-0.47 (0.001)	-0.54 (0.000)	-0.54 (0.000)

6.4.7.2. HAD and language scores in male and female patients

The only statistically significant relationship between HAD and language scores in the group of male patients (n=58, 52 and 48 for HAD and BNT, AQ and LQ, respectively) was an association between lower LQ and higher scores for depression at the post-operative assessment (r=-0.33; p=0.033). When the group of male patients was further categorised by side of lesion no relationship existed between any of the HAD or language scores for male patients with a tumour of the left hemisphere (n=33, 31 and 31 for HAD and AQ, LQ and BNT, respectively) at either the pre- or post-operative assessment. For male patients with a right sided tumour (n=25, 18 and 16 for HAD and BNT, AQ and LQ, respectively) significant negative correlations were identified between BNT and all three HAD scores at initial assessment, as shown in Table 20; and between AQ and depression at the post-operative assessment (r=-0.54; p=0.030).

Table 20: Correlation coefficients and levels of significance between BNT and HAD scores obtained by male patients with a right hemispheric tumour at initial assessment.

	Anxiety (p-value)	**Depression (p-value)**	**HAD Total (p-value)**
BNT	-0.45 (0.024)	-0.44 (0.028)	-0.50 (0.011)

The scores for female patients (n=42, 38 and 34 for HAD and BNT, AQ and LQ, respectively) at initial assessment demonstrated a significant relationship between higher scores for depression and lower AQ, LQ and BNT, as is shown in Table 21. No relationship was seen to exist between HAD and language scores for the female group at the post-operative assessment.

When the HAD and language scores obtained by the female patients are analysed by side of lesion no relationship of statistical significance can be identified at pre- or post-operative assessment for female patients with a tumour of the left hemisphere (n=22, 21 and 18 for HAD and AQ, BNT and LQ, respectively). Significant negative correlations exist between depression and LQ; and between BNT and anxiety, depression and HAD total at initial assessment in female patients with a right sided lesion (n=20, 13 and 13 for HAD and BNT, AQ and LQ, respectively), as are shown in Table 22. Table 23 shows the only significant correlations to be identified in the group of female patients with a right sided tumour at the post-operative assessment, i.e. between depression and AQ and LQ.

Table 21: Correlation coefficients and levels of significance between scores for depression and AQ, LQ and BNT obtained by female patients at initial assessment.

	Aphasia Quotient (p-value)	**Language Quotient (p-value)**	**BNT (p-value)**
Depression	-0.33 (0.042)	-0.36 (0.037)	-0.45 (0.003)

Table 22: Correlation coefficients and levels of significance between HAD and language scores obtained by female patients with a right sided tumour at initial assessment.

	Anxiety (p-value)	**Depression (p-value)**	**HAD Total (p-value)**
LQ	_	-0.56 (0.048)	_
BNT	-0.48 (0.031)	-0.61 (0.004)	-0.57 (0.009)

Table 23: Correlation coefficients and levels of significance between depression and language scores obtained by female patients with a right sided tumour at post-operative assessment.

	Aphasia Quotient (p-value)	**Language Quotient (p-value)**
Depression	-0.58 (0.048)	-0.61 (0.035)

Correlations of change scores (post-operative minus pre-operative) for AQ, LQ and BNT and anxiety, depression and the combined score for anxiety and depression were calculated for all patients with a tumour and separately for female and male patients and patients with a left or right hemisphere tumour. A significant relationship was identified between increase in LQ and reduction in depression in patients with a right hemisphere tumour (r= -0.51; p=0.008). No other relationships reached statistical significance.

6.5 Discussion: Mood Disturbance in Patients with an Intracranial Neoplasm

The primary aim of assessing mood was to identify any influence anxiety or depression might have on language performance in patients with a brain tumour. So little has been published on the emotional aspects of brain tumour, however, that relevant findings from this study on the presence of mood disorders, separate from any impact on language function, will also be discussed.

The main finding is that there is no identifiable relationship between HAD and language test scores obtained by patients with a dominant hemisphere tumour at initial assessment. The significant but low correlation which exists between the

Language Quotient and depression at the post-operative assessment disappears when the scores for males and females are analysed separately. It appears from correlational analysis of change scores in language tests with change in HAD scores that it is unlikely that improvements in language function in the group with a tumour of the left hemisphere were merely a consequence of post-operative reduction in levels of anxiety and depression.

Significant negative correlations are shown to exist at initial assessment between several of the language and HAD scores in patients with a right hemisphere tumour, suggesting the co-existence of higher levels of mood disturbance with poorer language test performance. This might not be attributable to the influence of mood on language function but to one, or a combination, of several factors: some of the significant results may be chance findings in view of the number of comparisons made; disturbances of language may influence mood; and a "third factor" (namely the existence of right hemisphere dysfunction) may influence both mood and aspects of language function. Also, a number of inconsistencies emerged. The results seem to suggest that a relationship exists pre-operatively in several of the patient subgroups between higher levels of both anxiety and depression and a lower BNT score but no similar association between the scores was identified at the post-operative assessment. A significant correlation was also identified between a lower Language Quotient and raised levels of depression at initial assessment in patients with a right hemisphere tumour and, although no relationship was found between the two scores at the post-operative assessment, where depression but not the LQ had improved significantly, a significant relationship was observed between the two change scores. No association was identified between depression and the Aphasia Quotient at the pre-operative assessment although the only difference between the two summary scores is the inclusion in the LQ of the reading and writing subtests. It was demonstrated in chapter 3 that almost half of the patients with a right sided tumour showed some degree of impairment in the written picture description, but not the reading, subtest. It is possible, therefore, that depression may have adversely affected scores for the written picture description subtest in the right hemisphere group although it seems implausible that mood should selectively influence such a specific aspect of language processing.

Stroke studies have found that patients with a left sided anterior lesion are often depressed while those with a right anterior lesion may be inappropriately cheerful and apathetic. From personal observation of casenotes patients in this study with a tumour of the right hemisphere had occasionally been diagnosed as depressed by their GP prior to admission or diagnosis of neoplasm. It is possible that diagnosis

had been influenced by observation of the signs of disordered non-verbal communication which often accompany right hemisphere disease, such as reduced facial expression, few alterations in intonation and poor eye contact, as there was no demonstrable difference in affective status as measured by the HAD between patients with a tumour of the left or right hemisphere. Analysis did not include an anterior - posterior distinction, however; tumours in the right hemisphere were not localised using the templates described in a previous chapter as it was considered unlikely that correlations with language scores would be identified.

The major differences in mood in this study were found between male and female patients but only for the patients with a left hemisphere tumour. The difference in both anxiety and depression scores between male and female patients with a right sided tumour did not reach significance. Although this supports Irle et al's claim (1994) that female patients with a brain tumour demonstrate greater levels of anxiety or depression than males, it is surprising that such disparity should exist between male and female patients with a tumour of the left hemisphere when HAD scores are relatively similar for those with a right hemisphere tumour and for the male and female subjects in the control group.

An unexpected finding of the study was that in general mean HAD scores obtained by patients with a brain tumour suggest remarkably little emotional disturbance, considering the severity of the medical condition. In few groups does the proportion of patients in the categories demonstrating possible or likely psychological disturbance exceed that in the category containing scores within normal limits. Comparisons with the surgical control group showed that there was no significant difference between the HAD scores obtained by any of the patient subgroups and the control subjects, either in initial or change scores, irrespective of gender, side of tumour or type of neurosurgery. Although group numbers were uneven and in some cases small enough to make statistical significance difficult to demonstrate, on inspection male patients with either a left or right sided tumour surprisingly obtained slightly lower mean scores for both anxiety and depression than the male controls. It has been estimated that between 9 and 19% of the general population could be diagnosed as "psychiatric" or borderline (Freeman, 1983). Although this is only a rough guide as much will depend on the measures used, the patients in this study appeared to be comparatively emotionally well-adjusted, especially considering that a proportion could be expected to have had some pre-existing depressive disorder. The nature of the forthcoming surgical procedure did not appear to influence levels of anxiety or depression within the tumour group as HAD scores were similar for patients who had either biopsy or tumour resection.

A plausible interpretation of these results is that the diagnosis of brain tumour was very recent at the time of both the pre- and post-operative HAD therefore emotions may not have had sufficient time to evolve. Irle et al (1994) showed that depressive states emerged in some patients either during radiotherapy or after they had gone home. Contrary to this are the relatively few chemotherapy patients in this study who obtained HAD scores suggestive of possible or likely mood disorders when their questionnaires were completed in the knowledge that the disease had recurred, some time after the initial diagnosis of brain tumour. Patients in the radiotherapy group with likely mood disorders were also in the minority, however this group comprised people who had few signs of disability and were described in chapter 3 as probably not a representative sample. Nearly all significant correlations between language and mood scores were negative (ie in the direction of more impaired language function being associated with greater mood disturbance), which clearly argues against an interpretation in terms of more impaired patients being less likely to experience or report mood disturbance as a result of reduced awareness or insight.

Response bias is a recognised problem with self-rating scales such as the HAD therefore it must be acknowledged that some patients may have opted for socially acceptable rather than accurate responses, possibly influencing reported levels of mood disturbance in the whole group or in subgroups of patients. Patients were usually very well prepared by medical and nursing staff in advance of treatment; it is likely that explanation and discussion would have contributed to a reduction in apprehension during the period as an inpatient. In general, however, the patients in this study appeared to demonstrate remarkable coping abilities with scores for anxiety and depression very often within normal limits. A recent study in the Department of Clinical Neurosciences found that emotional disturbance appeared to be less common among patients with intracranial neoplasm than in other cancer groups (Anderson, 1995) although much obviously depends on the assessment measures used. Where these differ comparisons between groups of patients in different studies may be unreliable. A link has been identified in studies of other cancer groups (Cella, Orofiamma, Holland et al, 1987; Kaasa, Malt, Hagen et al, 1993) between physical status and psychological distress. Persistent pain or physical disability was relatively uncommon among the patients in the present study. Further research is evidently required to clarify the nature and extent of emotional responses in patients with brain tumours.

CHAPTER 7

Significance of Main Findings and Implications for Future Research

7.1. Introduction

Analysis of the scores obtained at initial language assessment revealed that 58% of patients referred to the Department of Clinical Neurosciences were dysphasic prior to treatment of a tumour of the dominant hemisphere. Despite language disorders being equally common after stroke - Geschwind (1979) proposed that approximately 50% of patients may be dysphasic after a left hemisphere stroke - a sizeable difference exists in the amount which has been written about dysphasia as a result of the two conditions. Dysphasia in brain tumour has been largely neglected. Little is known of the pathophysiological mechanisms underlying tumour-induced dysphasia, despite the frequency with which this condition occurs and the distress it causes to both patient and family. In the few previous studies of language disorders as a result of brain tumour, researchers have relied on retrospective grading of language dysfunction using entries in medical case notes which were often several years old or subjective determination of the presence of language problems based on questioning the patients or their relatives. In the present study, assessing the language of a consecutive group of patients with brain tumours using objective, standardised assessments before and after treatment has enabled new conclusions to be drawn regarding the nature of language and communication disorders in patients with dominant and non-dominant hemisphere neoplasms. It is hoped that the main findings of this study will be clinically relevant and may stimulate further research.

7.2. Language Disorders in Patients with a Dominant Hemisphere Neoplasm

One of the main aims of the study was to identify and describe language disorders associated with dominant hemispheric brain tumours and to determine how closely they relate to the recognised clinical patterns of aphasia as derived from stroke studies. It was postulated that because of the different neuropathological processes differences might exist between language disorders as a result of stroke and brain tumour.

In general, language dysfunction in patients with a brain tumour was found to be relatively mild, even when the scores of patients who were categorised as dysphasic were analysed separately. On inspection the test performances of the stroke patients

in Kertesz's validation of the WAB were poorer than those of the patients in this study, supporting Anderson et al's (1990) finding that neuropsychological impairments, including language, tend to be more subtle in brain tumour than stroke. Language dysfunction associated with tumour has been described by Kertesz (1979) as largely anomic. While anomia was present in many of the patients in this study, the relatively low scores for the comprehension of complex sequential commands, reading comprehension and especially written picture description suggested the presence of a much broader range of language deficits.

An unexpected result of this study was that while relationships were identified between impairments of language and tumour location within the dominant hemisphere, the patterns of localisation which emerged were found to differ from those in stroke. For the group as a whole the pattern was one of a mixed dysphasia with specific syndromes such as Broca's or Wernicke's aphasia rarely evident in individual cases. Tumours sited in Broca's area produced impairments of all modalities of language, which is surprising as a vascular event in this territory of the frontal lobe is normally associated with deficits of expressive language but less so with deficits of language comprehension. Additionally surprising is the discovery that, while paraphasias, neologisms, jargon, and impaired auditory comprehension have been recognised as common sequelae to strokes in Wernicke's area for over a hundred years, tumours located in or near Wernicke's area were not associated with reduced performance in any of the language subtests of the WAB. It is possible, however, that a higher percentage of tumours in Wernicke's area were coincidentally of a lower grade or less extensive than those in Broca's.

A significant relationship was identified in the study between tumour type and degree of language impairment, with the most severely disordered language function found in patients with more highly malignant dominant hemisphere tumours such as glioblastoma multiforme. This supports an earlier finding by Hom and Reitan (1984) that patients with a rapidly growing intrinsic cerebral tumour demonstrate greater neuropsychological impairment than patients with either a low grade astrocytoma or oligodendroglioma. Although the language scores obtained by patients with a glioblastoma multiforme in the present study showed significant improvement after surgery, the mean Aphasia Quotient demonstrated persisting dysphasia, suggesting that destruction of cortex essential for language may have already occurred by the time of tumour resection. The combination of tumour type and location could not be analysed in this study for numerical reasons although it is possible that in a much larger cohort greater severity of language impairment may be shown to accompany a malignant tumour in or around the language zones.

7.2.1. Language Impairment and Treatment of Dominant Hemisphere Tumours

7.2.2.1. Resective surgery and biopsy

Neurosurgeons frequently face the problem of establishing a balance between prolonging life and improving its quality (Whittle, 1996), with particular difficulties inherent in deciding whether to excise a tumour from the dominant hemisphere. The main concerns are likely to be the risks of increasing the language difficulties of an already dysphasic patient or of introducing new deficits in a patient with previously normal language. One of the most important findings of this study is that dysphasia, irrespective of tumour type or location, will tend to improve significantly after resection. Just as important is the finding that language which is normal before resection can be expected to remain within normal limits after resective surgery. In this study one neurosurgeon carried out the majority of tumour resections therefore these results may be influenced by one individual's level of neurosurgical expertise. Similar studies carried out in a variety of neurosurgical units would demonstrate the extent to which these findings can be generalised.

Results showed that stereotactic biopsy is unlikely to induce dysphasia in patients whose language is normal before this procedure. The risks to language function are much less clear, however, when language deficits are present prior to biopsy. Significant change in test scores was difficult to demonstrate as the group of patients who were dysphasic before biopsy was small, despite comprising a third of the entire biopsy group. The trend, however, was for test scores to indicate poorer performance after biopsy. It is not known whether these results were influenced by features of the disease process common to the patient group which determined selection for biopsy and precluded resective surgery, or if the biopsy damaged an already vulnerable language system. A larger sample might permit the analysis of the influence of combinations of variables such as patient age, tumour neuropathology and degree of dysphasia.

In addition to supplementing current knowledge of the effects of dominant hemispheric tumours on language, and the potential risks and likely benefits of both biopsy and resective surgery as regards language function, the hope is that the above findings might enable medical and nursing staff to provide patients with more objective information prior to surgery.

7.2.2.2.Radiotherapy

The results obtained in this study showed that if language scores were normal before radiotherapy the tendency was for them to fall within normal limits after treatment. No further conclusions could be derived from the results as the patient group was subject to considerable selection bias. Patients in the radiotherapy group had already had two language assessments, one before and one after biopsy or resection. The patients who agreed to return as outpatients for a third assessment were typically tolerant, in good health and with few or no language difficulties either before or after radiotherapy. The effects of treatment might have been more apparent if a proportion of the cohort had been dysphasic before beginning radiotherapy. It is possible, however, that a future study would suffer from similar methodological obstacles as there are valid reasons why some patients may be unwilling to continue to participate in such a research project. Impaired language may deteriorate further subsequent to radiotherapy and might be accompanied by a more generalised decline in physical condition, or improvements may occur and patients might be unwilling to risk the discovery of new deficits.

7.2.2.3. Chemotherapy

Many of the patients in the study did not survive until the end of the course of chemotherapy therefore it was not possible to make statistically-based conclusions regarding the effects of chemotherapy on language function. This is not surprising: chemotherapy is normally used to treat brain tumours when they have recurred after radiotherapy. Deterioration at this stage is usually more rapid as tumours tend to be more aggressive at recurrence. Language test performance prior to beginning chemotherapy provided few clues as to those likely to survive until the time of the post-chemotherapy language assessment. A larger cohort would be required before any real changes in language function could be identified.

7.3. Language Disorders in Patients with a Non-Dominant Hemisphere Tumour

One of the most unexpected findings of this study is that approximately half of the patients with a right hemisphere tumour failed to obtain the maximal score for the written picture description subtest of the WAB. Although disorders of language processing were associated with right hemisphere abnormality in a few earlier studies, writing disorders following right hemisphere stroke have rarely been documented and have been attributed to sensory neglect (Pimental & Kingsbury, 1989). Limited output was the usual sign of impairment among the patients in the

present study, suggesting errors or difficulties in language processing rather than visuospatial, visuoperceptual or attentional deficits. In addition significant post-resective improvement was demonstrated in the auditory comprehension and verbal expression subtests of the WAB, indicating linguistic deficits present before resection which could reasonably be associated with the effects of the tumour. It is possible that such impairments could be attributed in part to pressure associated with tumour growth disabling remote eloquent areas of the left hemisphere. It is unlikely, however, that this fully explains the phenomenon as the majority of patients were receiving steroid therapy prior to initial assessment to reduce tumour-associated oedema. In addition the patterns of linguistic difficulties resulting from tumours in either hemisphere are inherently different, particularly regarding written expressive language.

What has emerged from this study is that impairments of language processing can in fact accompany right hemisphere tumours but that an aphasia battery in its entirety is not an appropriate tool with which to assess such patients. Nor is the currently available test of right hemisphere language sufficient, as was demonstrated in chapter 4. The conclusion therefore is that the right hemisphere may in fact play a larger role in language processing than was previously believed but that no suitable test of right hemisphere language and communication exists at the present time. This will be discussed more fully under implications for further research.

7.4. Mood Disorders in Patients with an Intracranial Neoplasm

It was considered likely that varying degrees of mood disturbance might be present in patients with brain tumours, which might in turn affect performance on language tests. On the basis of evidence from several stroke studies the expectation was that differences in levels of anxiety or depression would be linked to hemispheric location of the tumour, with depression more prevalent among patients with a tumour of the left hemisphere. No relationship was found to exist between low language scores and high HAD scores or vice versa, and no significant relationships were identified concerning hemispheric location of the tumour. Two main findings have arisen from the HAD scores obtained by the patients in this study, however. The first is that a significant difference was found between male and female patients in their levels of both anxiety and depression. This difference only existed between patients with a tumour of the left hemisphere. The pattern of correlations between language and HAD scores before and after surgery suggested that the presence of dysphasia did not influence levels of anxiety or depression systematically. It is not clear why one subgroup of patients should demonstrate

different patterns of mood disturbance from the other patients and controls in the study although some possible relevant factors were discussed in chapter 6.

The second, perhaps more important, finding is that in general HAD scores reflected remarkably low levels of anxiety and depression in patients with an intracranial neoplasm. While assessing patients soon after diagnosis may be considered to provide insufficient time for emotional responses to have evolved completely, patients in the chemotherapy group who had lived with their condition for some time also showed few signs of psychological distress. A separate study in the same department found that the level of mood disorder was lower among patients with a brain tumour than in other cancer groups (Anderson, 1995), although direct comparison with the present study is constrained by the use of different methods of assessment. Patients with pain or physical disability were identified in Anderson's study as being more prone to psychological distress. One possible explanation for the disparity among patients with a brain tumour and other cancer groups, therefore, is that, despite the prognosis often being poor, patients with a brain tumour who participated in the present study rarely suffered persistent pain or physical disability. This is an interesting area and would benefit from further research.

7.5. Implications for Future Research

7.5.1. Introduction

Few prospective studies have previously attempted to describe language disorders in patients with a brain tumour or to identify the likely effects of the various treatment options on language function. A number of the findings obtained in this study are therefore new and would be greatly strengthened by replication. Studies involving larger cohorts might clarify the likely effects of biopsy, radiotherapy or chemotherapy on language function as groups in this study were often too small or too selected to permit reliable conclusions to be formed. One of the main clinical applications of the study is that assessment of language function in patients with a brain tumour is highly desirable if not essential to optimise management. It was demonstrated that patterns of localisation of language function within the dominant hemisphere may differ in patients with a brain tumour from those inherent in the generally accepted models of language processing derived from stroke studies. In addition it seems likely from the findings that areas of the right hemisphere may have more involvement in verbal language skills than was previously understood. Assumptions based on current knowledge may therefore be

wrong and misleading. Comprehensive language assessment before resective surgery would provide an objective guide to the specific effects of the tumour on language function in individual cases, and language assessment before biopsy would enable medical and nursing staff to inform patients and their relatives of the potential risks to language function, especially in patients who are dysphasic before the procedure. A significant proportion of patients in this study with a dominant hemisphere tumour were dysphasic at initial presentation. Language impairments, however, were at times subtle and difficult to observe without formal assessment.

7.5.2. Towards Dedicated Tests

While it appears that language assessment is essential to optimal patient care before and after tumour surgery a substantial problem exists because of the current lack of suitable test materials. In an earlier chapter it was proposed that the WAB might lack the sensitivity required to fully assess the more subtle language deficits associated with dominant hemisphere tumours but, in the absence of a more suitable test battery, it proved in use to be an informative collection of tests as both initial problems and change were identified. On the other hand, the RHLB was shown to be an ineffective method of assessment in patients with a right hemisphere tumour. That control subjects with no brain damage often scored badly in various subtests, and that poor test performance could be interpreted as a sign of disordered communication, has considerable implications for clinicians using the battery with any patients, particularly as the RHLB is currently the only standardised test of right hemisphere communication.

Despite the significant improvement seen in several WAB subtests after surgery, WAB scores were generally high in the right hemisphere group. The implication is that specific linguistic deficits do occur after right hemisphere damage but that an aphasia battery is a limited tool for measuring deficits in this group. It is known that differences exist in the nature of language function in the two hemispheres and as the WAB was designed primarily as a test of language processing in the dominant hemisphere it does not enable more than a superficial evaluation of right hemisphere language. Furthermore, aphasia batteries do not cater well for the additional deficits of communication associated with right hemisphere damage, such as difficulties with abstract language, reduced facial expression and inappropriate eye contact. Because of such inadequacies in test materials and general lack of knowledge concerning these effects of right hemisphere dysfunction, patients in the present study presenting with disordered non-verbal communication were occasionally, from observation of casenotes, misdiagnosed as depressed. The obvious lack,

therefore, is in the availability of an effective method of assessing right hemisphere language and communication, a lack which exists for stroke patients as well as for those with a neoplasm.

Before an effective test battery can be developed a greater understanding of right hemisphere language and communication is clearly required. Two questions have arisen from the results of this study: does the right hemisphere have a larger role in language processing than was previously thought; and what is the nature and range of language and communication deficits which may accompany right hemisphere abnormality. The first priority would be to separate deficits of communication from the confounding influence of additional neuropsychological impairments by means of a comprehensive assessment of verbal and non-verbal memory, attention, visuoperceptual skills and a broad range of deficits of communication, including those which were identified in the present study using the WAB. A degree of inventiveness would be required to devise suitable tests where none currently exist. Initial assessment followed at an interval by a second assessment would permit an evaluation of the sensitivity of the individual subtests for both identifying deficits and measuring change. Assessment of a group of patients with right hemisphere stroke and a group with right hemisphere tumour would enable development of a selection of tests with wide application. Inclusion of a control group comprising patients with left hemisphere stroke or tumour would permit separation of impairments common to all patients with supratentorial stroke or tumour from those specifically associated with right hemisphere disease. A second control group comprising non-brain-damaged subjects would provide norms. Information regarding the localisation of language and communication functions within the right hemisphere would be derived from relationships between lesion location and test scores.

A follow-up study addressing these issues has been funded by the Scottish Office and is under way.

APPENDIX I

***Templates devised to localise tumours within the dominant hemisphere. Region 1 = frontal pole; region2 = temporal pole; region3 = occipital pole; region 4 = area of the frontal lobe containing Broca's area; region 5 = temporoparietal region containing Wernicke's area; region 6 = subcortical region.**

Sections 19 and 20

STUDIES OF SPEECH AND LANGUAGE FUNCTION

Department of Clinical Neurosciences, Western GeneralHospital, Edinburgh,, Scotland

The Department of Clinical Neurosciences is currently studying speech and language functions in certain patients. The aims of this study are to recognise and characterise such disorders and relate them to sites of brain damage, the specific cause of this damage, patient age and sex. These simple studies are performed by a qualified speech therapist and do not interfere or compromise your care and treatment either as an inpatient or outpatient. By carefully documenting speech and language functions the effects of various types of treatments on these functions can be precisely evaluated. Hopefully this will lead to improvements in understanding of brain disease and better patient management and care.

CONSENT FORM

I, ...

of .....
hereby consent to inclusion in the study of clinical speech and language function.

The nature of the study has been explained to me by Mr I R Whittle and I understand that should I later wish to withdraw from the study it will not compromise my treatment or care.

Signed Date

Witness Date

Writing Samples

(1) T.D., 54 year old male with a left temporoparietal anaplastic astrocytoma.

(a)Picture description and dictated sentence before resection

(Dictated sentence: *Pack my box with five dozen jugs of liquid veneer*)

Two Man and Man & woman having a picnic Boy flying his Kite Boy fishing,

Pack one P the five dozel of liquide vaneer

(b)Picture description after resection

Young man flying a Kite
2 people sailing the Boat
2 People having a picnic
Boy fishing
Boy playing beside water

Pack my Box with 5 Doz Jugs of liquid veneer.

(2) D.B., 25 year old male with a left frontal anaplastic astrocytoma.

(a)Dictated sentence before resection (D.B. was unable to attempt the picture description before resection)

Pack My Box With th 5 Dozen
Boxes of Liyid Nerves.

(b)Picture description and dictated sentence after resection

The Man is sitting Reading a Book
While the Lady Pours a cup of Tea.
The boy flies a kite over the
Lake. Someone is digging in the sand.
While to people Sail the Boat.
The scene is a holiday type
of Picture everyon is having a
good time enjoying themselves.

Pack my box with 5 Dozen jugs
of Liquid Veneer.

(3) J.A., 65 year old male with a right frontal meningioma

(a)Picture description before resection

Picnic scene in park, Man & Child & 2 Boys
sailing a yacht

(b)Picture description after resection

2. People in a sailing Boat.
1. Person flying a kite
1. Person fishing
2. ~~People~~ People having picnic
A Dog.
Bucket & Spade
Person in water (Could be swimming)
Car in garage, attached to log Cabin.
Flag flying.
Large tree, trees in background.

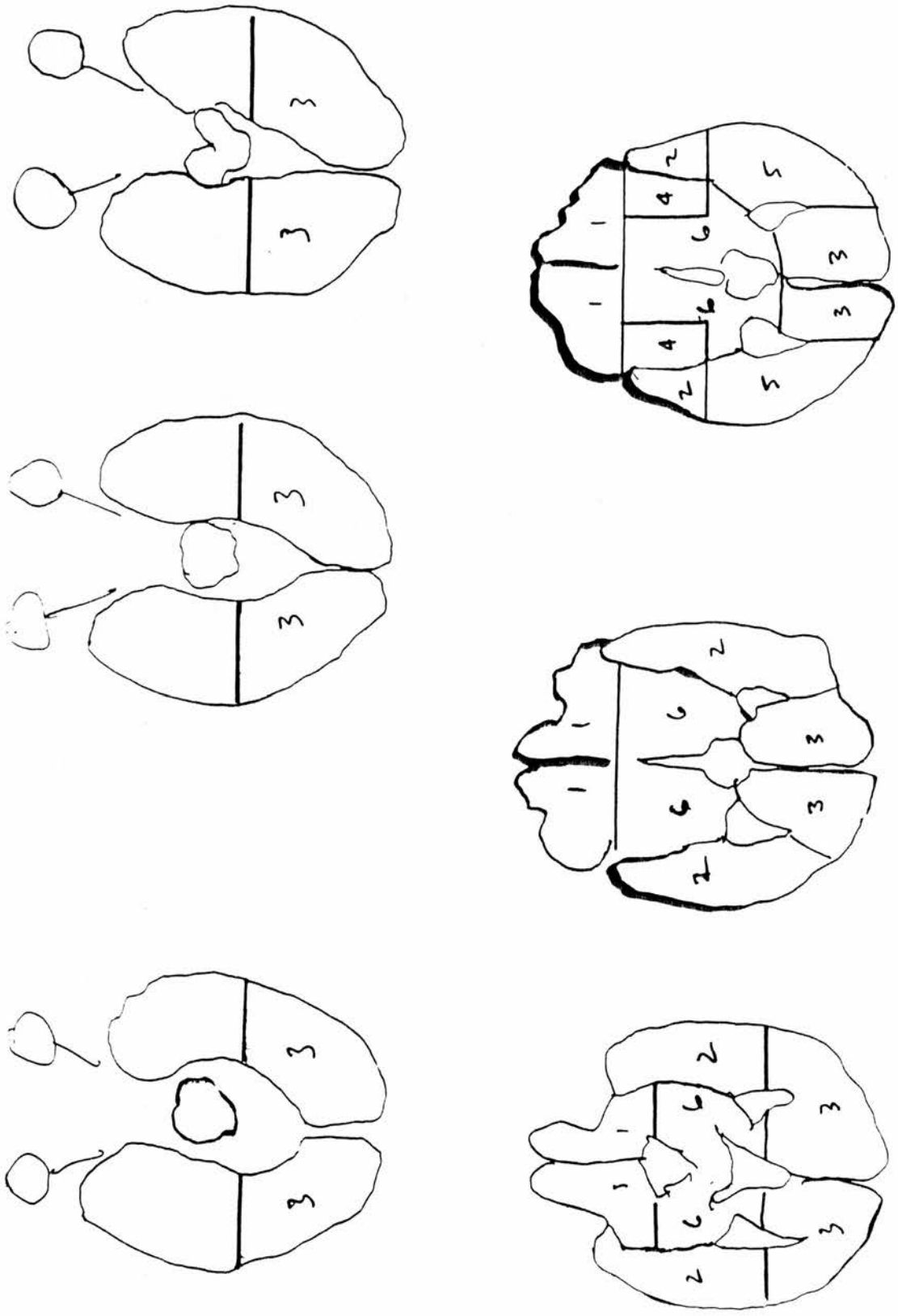
(4) A.M., 50 year pld male with a right frontal anaplastic astrocytoma

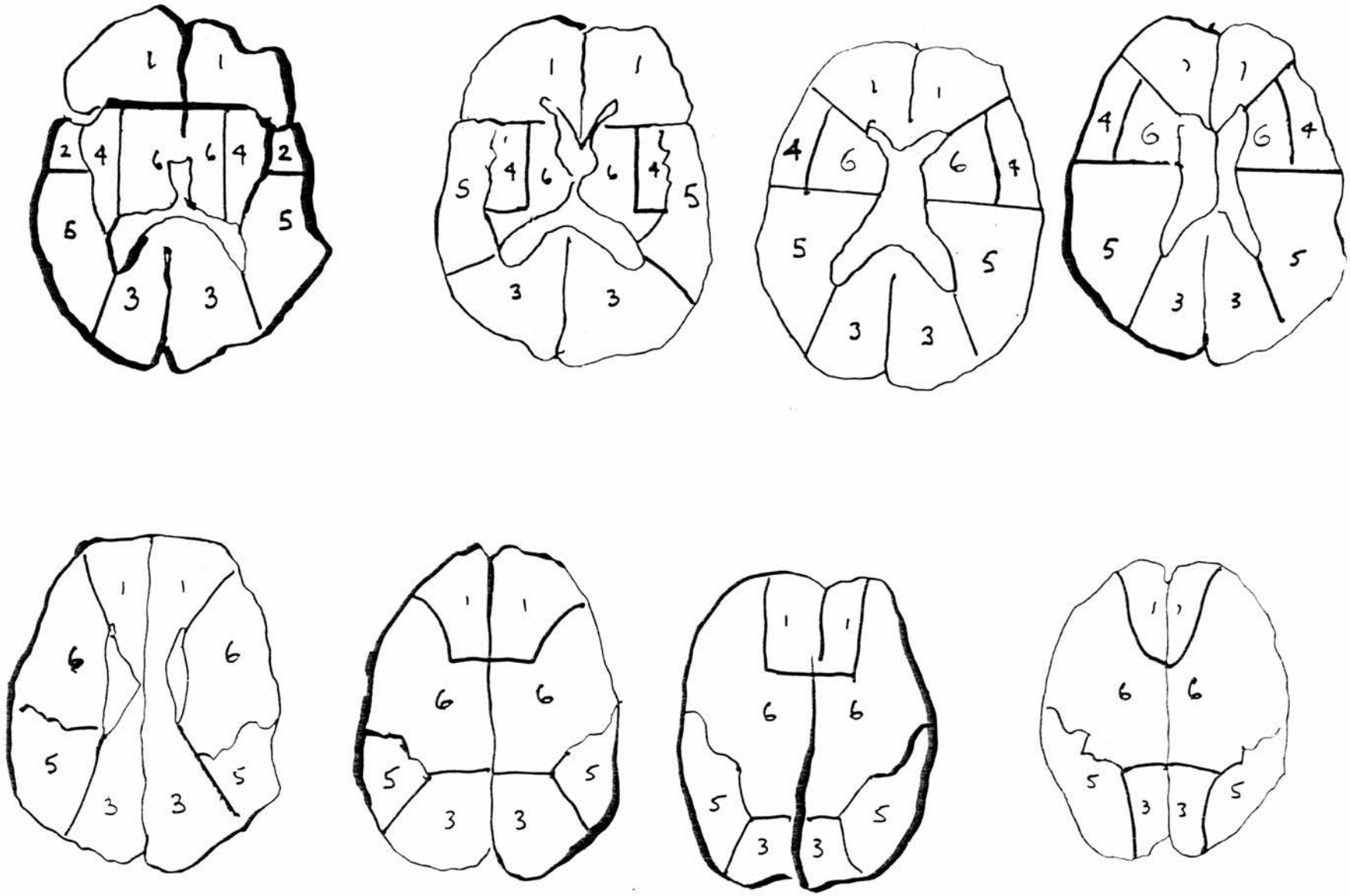
(a)Picture description before resection

GENERAL VIEW OF FAMILY AT SEASIDE, OBVIOUSLY ENJOYING THE WEATHER + POSSIBLY OUT IN FAMILY YACHT

(b)Picture description after resection

SCENE OF FAMILY AT SHORE - FATHER/SON FLYING KITE; MOTHER/DAUGHTER + OTHER SON ENJOYING PICNIC ON RUG. DOG ENJOYINNG HIMSELF; OTHER SON AT EDGE OF WATER, PROBABLY MAKING SANDCASTLES: OTHERS SAILING IN YACHT. TREES/HILLS IN DISTANCE. FLAG FLY ON MAST

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THE HANDEDNESS INVENTORY (LEZAK M D 1983)

NAME:		SEX:		AGE:	
INDICATE HAND PREFERENCE	ALWAYS LEFT	USUALLY LEFT	NO PREFERENCE	USUALLY RIGHT	ALWAYS RIGHT
1. To write a letter legibly					
2. To throw a ball to a target					
3. To play a game using a racquet					
4. At the top of a broom to sweep dust from the floor					
5. At the top of a shovel to move sand					
6. To hold a match when striking it					
7. To hold scissors to cut paper					
8. To hold thread to guide through the eye of a needle					
9. To deal playing cards					
10. To hammer a nail into wood					
11. To hold a toothbrush while cleaning teeth					
12. To unscrew the lid of a jar					

QUESTIONS:

a. Are either of your parents left-handed? If yes, which? _____

b. How many siblings of each sex do you have? Male _____ Female _____

c. How many of each sex are left-handed? Male _____ Female _____

d. Which eye do you use when using only one (eg. telescope, keyhole) _____

e. Have you ever suffered any severe head trauma?

APPENDIX II

HAD Scale

Name: Date:

Doctors are aware that emotions play an important part in most illnesses. If your doctor knows about these feelings he will be able to help you more.
This questionnaire is designed to help your doctor to know how you feel. Read each item and place a firm tick in the box opposite the reply which comes closest to how you have been feeling in the past week.
Don't take too long over your replies: your immediate reaction to each item will probably be more accurate than a long thought-out response.

Tick only one box in each section

I feel tense or 'wound up':
- Most of the time
- A lot of the time
- Time to time, Occasionally
- Not at all

I still enjoy the things I used to enjoy:
- Definitely as much
- Not quite so much
- Only a little
- Hardly at all

I get a sort of frightened feeling as if something awful is about to happen:
- Very definitely and quite badly
- Yes, but not too badly
- A little, but it doesn't worry me
- Not at all

I can laugh and see the funny side of things:
- As much as I always could
- Not quite so much now
- Definitely not so much now
- Not at all

Worrying thoughts go through my mind:
- A great deal of the time
- A lot of the time
- From time to time but not too often
- Only occasionally

I feel cheerful:
- Not at all
- Not often
- Sometimes
- Most of the time

I can sit at ease and feel relaxed:
- Definitely
- Usually
- Not often
- Not at all

I feel as if I am slowed down:
- Nearly all the time
- Very often
- Sometimes
- Not at all

I get a sort of frightened feeling like 'butterflies' in the stomach:
- Not at all
- Occasionally
- Quite often
- Very often

I have lost interest in my appearance:
- Definitely
- I don't take so much care as I should
- I may not take quite as much care
- I take just as much care as ever

I feel restless as if I have to be on the move:
- Very much indeed
- Quite a lot
- Not very much
- Not at all

I look forward with enjoyment to things:
- As much as ever I did
- Rather less than I used to
- Definitely less than I used to
- Hardly at all

I get sudden feelings of panic:
- Very often indeed
- Quite often
- Not very often
- Not at all

I can enjoy a good book or radio or TV programme:
- Often
- Sometimes
- Not often
- Very seldom

Do not write below this line

HAD Scale

Name: Date:

	A
	3
	2
	1
	0

	D
3	
2	
1	
0	

D	
0	
1	
2	
3	

	A
	0
	1
	2
	3

	A
	3
	2
	1
	0

	D
3	
2	
1	
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D	
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	A
	3
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D	
0	
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3	

D	
3	
2	
1	
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	A
	3
	2
	1
	0

	A
	0
	1
	2
	3

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3	

FOR HOSPITAL USE

Patients Name/No:

D(8-10) _____

A(8-10) _____

APPENDIX III

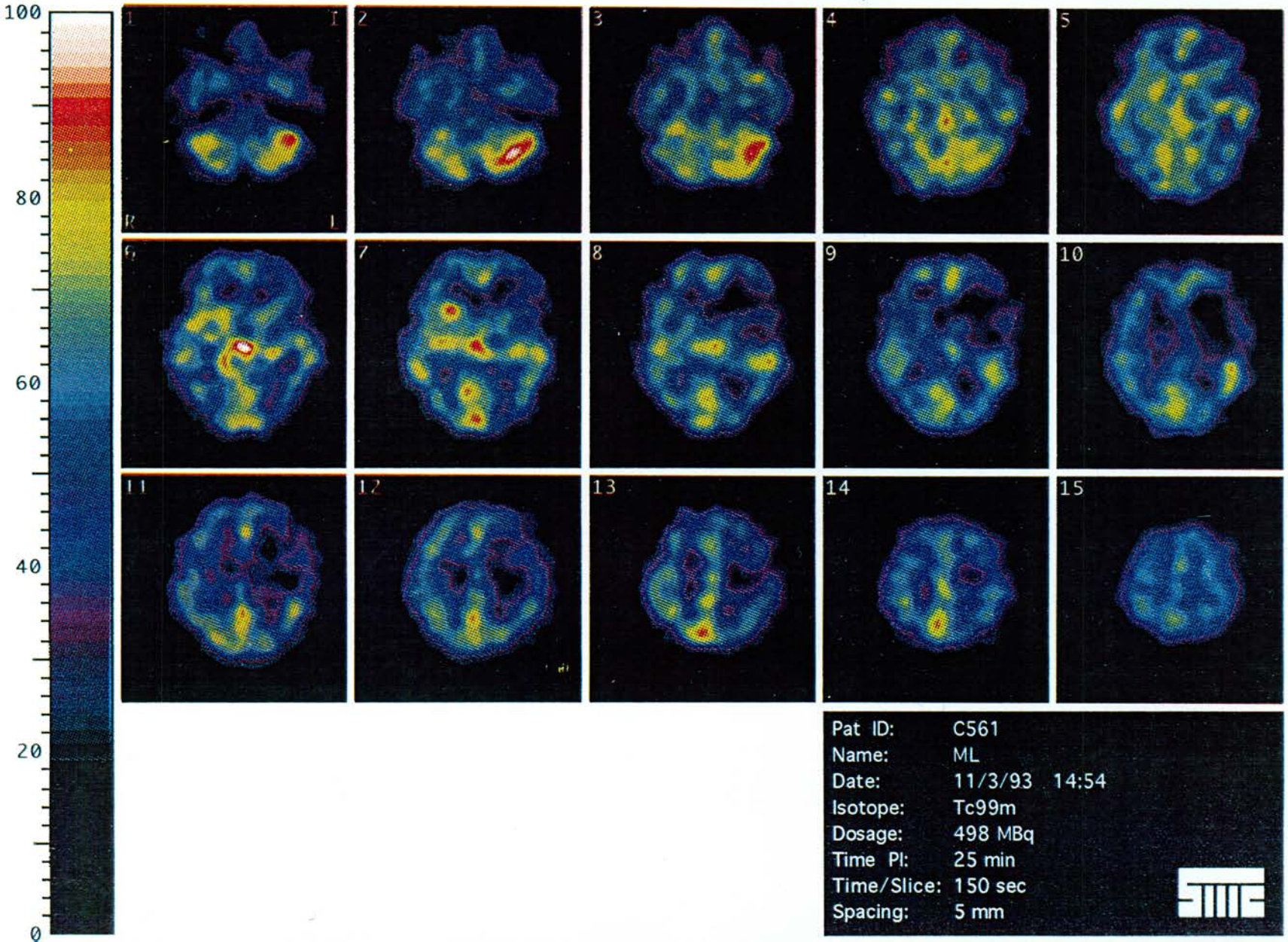
Pre and post-operative AQ, LQ, BNT and mean change in size of abnormal area on scan after surgery for M.L. and S.C.

Pre- and post-resection SPECT scans for M.L. are shown on pages 171 and 172. Pre- and post-operative AQ, LQ and BNT are shown below. Also given is the mean rating allocated by three independent raters for observed change in size of abnormal area after surgery. A score of 1 indicated that the abnormal area on the scan was larger after surgery, a score of -1 indicated that the area was smaller and a score of 0 implied no change.

Patient	1st AQ	2nd AQ	1st LQ	2nd LQ	1st BNT	2nd BNT	Mean Change in Size of Abnormal Area
M.L.	55.8	90.6	42.3	86.6	3	23	-0.7

Pre- and post-resection SPECT scans for S.C. are shown on pages 173 and 174. Pre- and post-operative AQ, LQ, BNT and mean change in size of abnormal area (as described above) are shown below. Although post-operative language scores are higher none of the raters observed any change in the size of the abnormal area on the scan.

Patient	1st AQ	2nd AQ	1st LQ	2nd LQ	1st BNT	2nd BNT	Mean Change in Size of Abnormal Area
S.C.	80.0	98.0	-	-	41	54	0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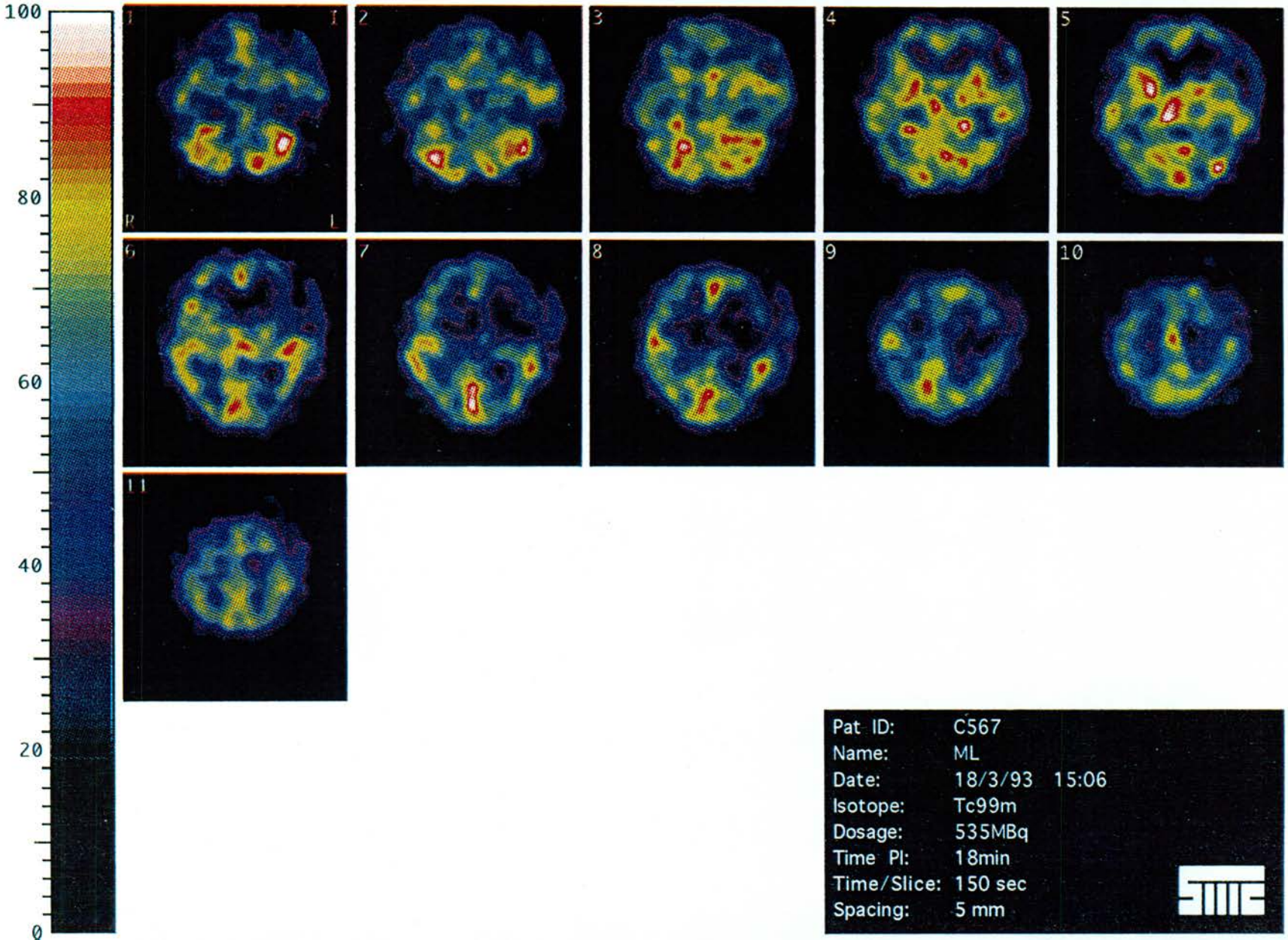
Pat ID: C561
Name: ML
Date: 11/3/93 14:54
Isotope: Tc99m
Dosage: 498 MBq
Time PI: 25 min
Time/Slice: 150 sec
Spacing: 5 mm

1 / 2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Pat ID: C567
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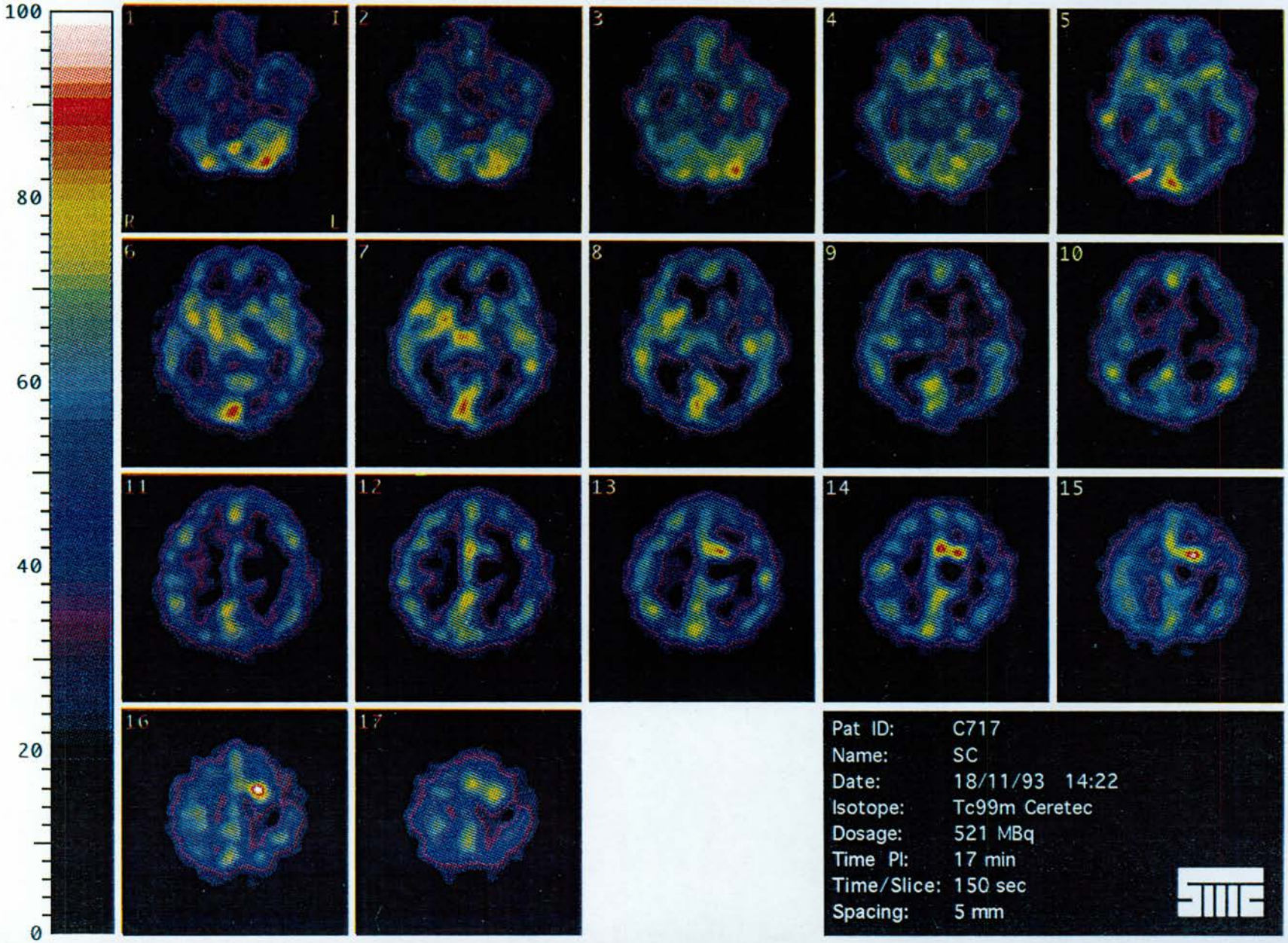
Isotope: Tc99m
Dosage: 535MBq
Time PI: 18min
Time/Slice: 150 sec
Spacing: 5 mm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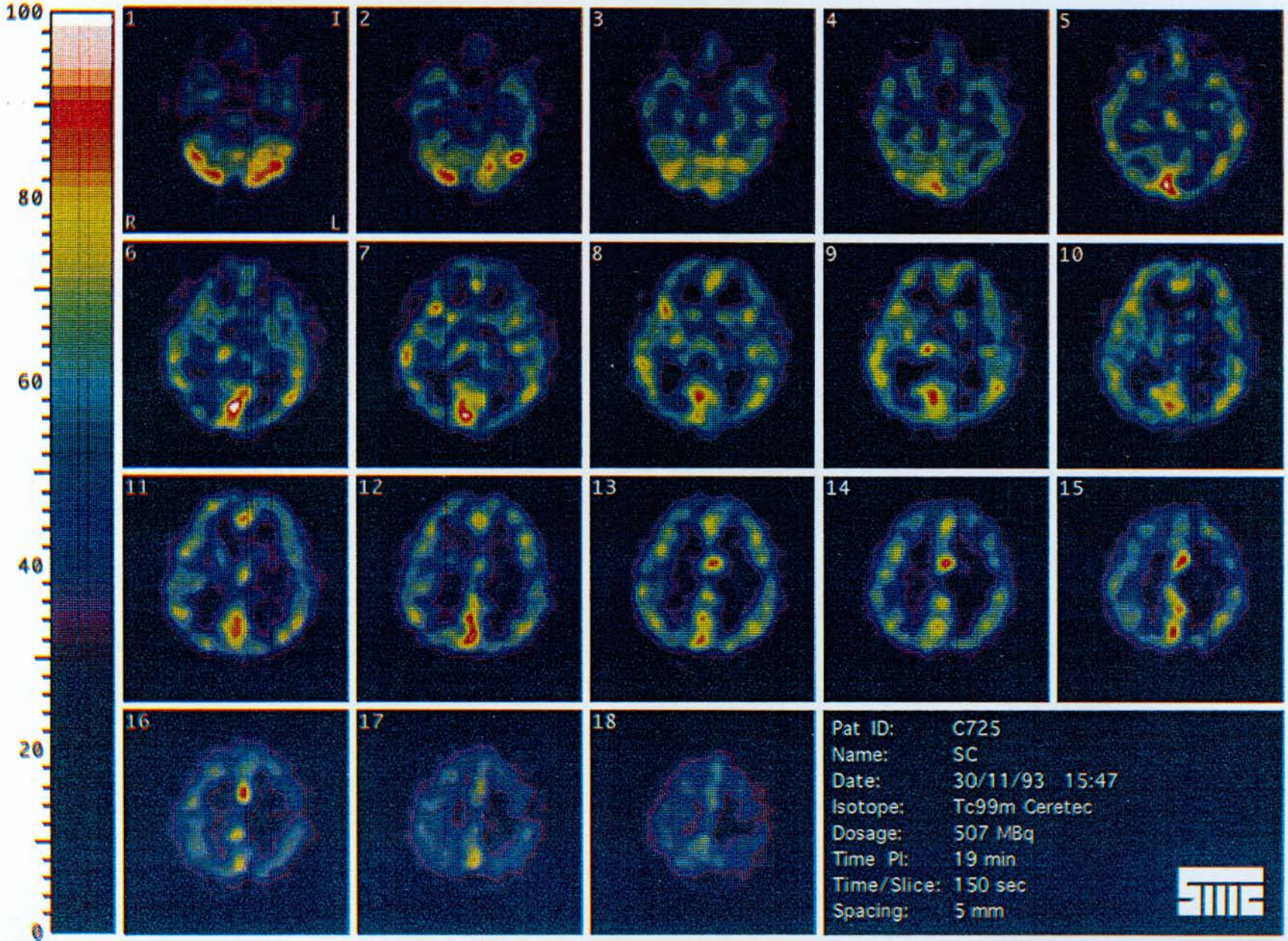
Pat ID: C717
Name: SC
Date: 18/11/93 14:22
Isotope: Tc99m Ceretec
Dosage: 521 MBq
Time PI: 17 min
Time/Slice: 150 sec
Spacing: 5 mm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18
Pat ID: C725
Name: SC
Date: 30/11/93 15:47
Isotope: Tc99m Ceretec
Dosage: 507 MBq
Time PI: 19 min
Time/Slice: 150 sec
Spacing: 5 mm

APPENDIX IV

Scientific Papers

Thomson A-M, Taylor R, Fraser D, Whittle I R. The utility of the Right Hemisphere Language Battery in patients with brain tumours. (In press: *European Journal of Disorders of Communication*)

Thomson A-M, Taylor R, Fraser D, Whittle I R. Stereotactic biopsy of dominant hemispheric non-polar tumours: a prospective study of its effects on language functions. (In preparation)

Published Abstracts

Thomson A-M, Taylor R, Fraser D, Whittle I R. (1994). Changes in language function following surgery for intracranial neoplasms: a prospective study. *British Journal of Neurosurgery,* Vol. 8, 263.

Whittle I R, Thomson A-M, Fraser D, Taylor R. (1994). Does stereotactic biopsy of dominant hemispheric glioma impair speech and language functions? *Acta Neurochirurgica*, Vol.129, Fasc.3-4.

Thomson A-M, Taylor R, Sellar R, Fraser D, Whittle I R. (1995). Anatomico-functional correlates of speech disorders in dominant hemisphere neoplasms: a prospective study. *Journal of Neurology, Neurosurgery and Psychiatry*, Vol. 58, 390.

Thomson A-M, Taylor R, Fraser D, Whittle I R. Is the Language Quotient a better way of scoring the Western Aphasia Battery (Kertesz 1982) in patients with a dominant hemispheric neoplasm? (In press: *British Journal of Neurosurgery*).

Thomson A-M, Taylor R, Fraser D, Whittle I R. (1996). Just how silent is the right hemisphere? *Journal of Neurology, Neurosurgery and Psychiatry*, Vol. 60, 244.

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