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Research Report

The self and self-knowledge after frontal lobe neurosurgical lesions

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ABSTRACT

Background: Evidence suggests that damage to the frontal lobes can be associated with changes in cognitive and behavioral functioning and reduced awareness that such changes have occurred. In the current study, the Cognitive Awareness Model was used as a theoretical framework to explore knowledge of the self in people with acquired frontal lesions.
Methods: Fifteen individuals with focal frontal lobe lesions (FFL) and their nominated informants were compared with fifteen healthy matched control-informant dyads on questionnaire measures designed to assess awareness of difficulties. Questionnaires were adapted to ensure all enabled pre- and post-injury perspectives to be gained from both patient and informant, and to allow novel exploration of awareness of deficits from a third person perspective.
Results: Individuals with frontal lobe lesions showed adequate awareness of their post-surgery changes, which was substantiated by their informant report. Compared to the control group, the patient group was found to acknowledge more difficulties in current functioning. Perspective-taking ability was limited with both patients and controls being comparatively unreliable in assessing how they were perceived by others.
Conclusion: These results demonstrate that FLL patients are engaging in more atypical behaviors compared to healthy controls, but suggest that they are aware of and acknowledge these difficulties. The importance of obtaining multiple viewpoints when examining an individual's level of awareness and the clinical implications of this are discussed.

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1. Introduction

Damage to the frontal systems of the brain is often associated with impairment in mental functioning affecting multiple domains, including cognition, emotional processing and behavior (David, Bedford, Wiffen, & Gilleen, 2012). Prominent amongst such impairment may be changes in personality and social behaviour, consistently found following frontal lobe lesions (Adolphs, 2001; Stuss, Gallup, & Alexander, 2001), and noted by caregivers to be the factors most strongly associated with poor quality of life (Sterchx, Coolbrandt, Dierckx de Casterle et al., 2013). However, the report of behavior changes by patients and proxy (informant: caregiver or clinician) can vary. A general pattern emerges in which patients judge their functioning to be better than the judgement of proxies. This is often taken as evidence for a lack of awareness in the patient.

Awareness is a difficult term to conceptualize with reduced awareness and anosognosia frequently used as synonyms and overlap between them identified. Despite these terms often appearing interchangeably in the literature, argument exists for a distinction to be made between the two with variability noted in the hierarchical organization of these concepts and in turn assessment methods adopted (see Bertrand, Fischer, & Mograbi, 2020). The current paper conceptualizes awareness as self-knowledge about one's cognitive and functional capabilities and behaviors.

Despite repeated assertions linking impaired awareness with frontal lobe involvement (Stuss & Alexander, 2000; Stuss & Levine, 2002), there appears a relative dearth in empirical studies examining lack of awareness following frontal lobe damage specifically. Stuss and Alexander (2000) report on a small number of lesion and activation studies that suggest a critical role of the frontal lobes (particularly right frontal) may be for self-awareness. Spikman and van der Naalt (2010) compared self-awareness in TBI patients with frontal lobe lesions to TBI patients without frontal lobe lesions and found reduced awareness in the frontal lobe lesion group specifically. However, their findings were based on self-report only and the need to seek the judgement of other persons in the patient's life to corroborate self-evaluation was highlighted. Gregg, Arber, Ashkan et al. (2014) did compare patient-proxy ratings in patients with frontal tumors and patients with non-frontal tumors, but contrary to predictions found no significant difference between patient and relative ratings of personality and behavioral changes in either group. A review paper specifically exploring the impact of frontal lobe tumors and surgical treatment (Fang, Wang, & Jiang, 2016) acknowledges how frontal tumours can impair patients' self-awareness. However, of the five papers cited relating to awareness, only one (Hoerold, Pender, & Roberton, 2013) explored meta-cognitive awareness and involved both self- and proxy-report on patient functioning. It appears that the limited research that does exist focused on frontal lobe damage provides variable accounts with reports of both intact awareness and awareness deficit.

A range of cognitive and non-cognitive factors have been associated with the extent of awareness following brain injury. Common cognitive factors include executive and memory ability and intellectual functioning (Zimmerman, Mograbi, Hermes-Pereira, Fonseca, & Pritgatano, 2017), whereas non-cognitive associates include time since injury, injury severity and mood factors (Richardson, McKay, & Ponsford, 2015). Often allied to awareness, an important concept is that of emotional distress, with greater awareness often related to increased anxiety and depression symptomology (Geytenbeek, Fleming, Doig, & Ownsworth, 2017; Morton & Barker, 2010). However, despite a growing literature the nature of these relationships remains unclear.

From a clinical perspective, awareness deficits can be extremely debilitating, with unawareness predicting worse disability prognosis (Orfei et al., 2007) and less motivation for and compliance with treatment (David et al., 2012). In addition, unawareness has been noted to be associated with greater distress in relatives or caregivers (Turro-Garriga et al., 2013), and the benefits of gaining informant perspectives has been highlighted (Andrewes, Drummond, Rosenthal, Bucknill, & Andrewes, 2013).

Different theoretical accounts have been proposed that endeavour to explain the different processes underlying impaired self-awareness. Some explanations have emphasised the involvement of domain specific processes, suggesting that a lack of awareness is due to reduced perception of sensory input (e.g. diminished consciousness), a failure of executive control mechanisms (e.g. poor monitoring of current functioning; Cosentino, Metcalfe, Butterfield, & Stern, 2007) or impairments in aspects of memory function (Mograbi, Brown, & Morris, 2009; Lenzoni, Morris, & Mograbi, 2020). Other models link impaired self-awareness to comparator mechanisms, which suggest a disconnection between recently registered self-related information and previous self-knowledge (Agnew & Morris, 1998; Schacter, 1990).

The Cognitive Awareness Model (CAM; Morris & Hannesdottir, 2004; Morris & Mograbi, 2013) was adopted as a framework for the current study as it purports to account for unawareness following a range of conditions, including focal brain damage. It also allows different levels of awareness to be explored enabling investigation of the potential complexity of this phenomenon. In this model awareness is achieved through comparison of information concerning personal efficacy stored in a Personal Database (PDB) with incoming knowledge concerning task or activity performance monitored by comparator mechanisms. Lack of, or reduced awareness can be explained either by absence in acquisition of recent memories concerning performance, leading to a failure to recalibrate information stored in the PDB (mnemonic anosognosia) or due to difficulties monitoring or comparing the results of incoming information with that in the PBD (executive anosognosia; see Lenzoni et al., 2020; for recent review). This results in patients reverting to their strongest sense of self, which due to an inability to update self-knowledge is the more powerfully embedded sense of self that was stored prior to the lesion. Lenzoni et al. (2020) provide a review of the experimental work in support of this theory that compares patients' current behavioral ratings to informant ratings for past and current traits. However, it is possible to extend investigation to include patient ratings of their own past behavior, which can then be benchmarked by informant rating, who will corroborate past behaviour, thus allowing a more systematic investigation of the model's idea.

A further postulation of the CAM model is that there are two potential routes to self-understanding, that is, a functional distinction exists between self-related semantic memory (appraisal of own abilities) versus general semantic memory (appraisal of other's abilities). It is suggested that it may be the special self-memory that is dysfunctional in patients who lack awareness, but that general semantic memory is intact (see Bertrand, Landeira-Fernadez, & Mograbi, 2016 for a concise review). Previous studies, using the CAM model as a theoretical guide, have suggested that the perspective through which information is presented could impact patient awareness of their own deficits. From this it has been surmised that perspective-taking could be the basis for other awareness and surrogate processes. This idea is based on findings that in some clinical populations unaware patients may be able to acknowledge deficits in others (Clare et al., 2012; Mograbi, Brown, Landeira-Fernandez, & Morris, 2014) or in themselves when exposed to evidence from a third person perspective (Fotopoulou, Rudd, Holmes, & Kopelman, 2009). This allows us to hypothesise that if patients have an intact general semantic memory, they will be able to identify that others rate them to behave in a certain way and this is despite the fact that they might not spontaneously report this behavior themselves. However, to date a paucity of work has explored this idea of a ‘surrogate self’. Varying methods have been adopted in past studies investigating the disassociation between self and other (non-self) evaluation, with vignettes and self-observation through video the most typically employed. Findings from these revealed that both patients and healthy controls overestimate the performance of the other person compared to themselves. To the best of the current authors' knowledge, estimating how others rate their own abilities has not before been examined nor has the idea of the surrogate self been looked at in conjunction with general levels of awareness (self-reported awareness) in the same sample.

The main objective of the current paper was to systematically investigate awareness in patients with acquired frontal lobe lesions (FLL group) using the CAM model as a theoretical guiding framework. This enabled:

1) Investigation into whether people with FLLs estimate their current abilities and behavior using pre-injury self-representations, rather than representations that have been updated to incorporate post-injury changes. A comparison between the FLL groups' level of awareness and that of a healthy control sample was also undertaken. Two hypotheses were formulated. Hypothesis 1 predicted that there would be a significant difference between the post-injury ratings of informants and people with frontal lesions, with informants rating FLL patients as more impaired. Proportionally smaller differences were predicted between the pre-injury ratings of FLL patients and informants. Hypothesis 2 predicted that the patients with FLL would show reduced awareness of current abilities with higher self-informant discrepancy scores based on post-injury ratings compared to healthy control dyads.
2) Exploration into whether people with FLLs develop a ‘surrogate’ understanding of the changes they have experienced in the domains of cognition and behavior. This was an exploratory investigation testing whether surrogate ratings differ from self-ratings allowing insight into whether participants are aware of how they are perceived by others (their nominated informant).

2. Materials and methods

We report how we determined our sample size, all data exclusions (if any), all inclusion/exclusion criteria, whether inclusion/exclusion criteria were established prior to data analysis, all manipulations, and all measures in the study.

2.1. *Sample*

Two groups of participants were included in this study. The first group comprised 15 adults with acquired frontal lobe lesions (following surgical resection of brain tumours), recruited from the joint neuro-oncology clinic at King's College Hospital, London. Five of the FLL group were retired, five were currently working, three had not returned to work following their treatment and two had taken early or medical retirement from work since their surgery. The second group comprised 15 neurologically healthy controls that acted as a comparison for the clinical group specifically matched for chronological age, gender ratio, years in education and pre-morbid IQ. Although controls were not matched 1:1 to patients, periodic analysis of patient group characteristics allowed us to target the recruitment of controls so that samples would be comparable on socio-demographic variables such as age, gender and education. This was in line with the procedure adopted by Hart, Whyte, Kim, and Vaccaro (2017). In the control group nine were currently working and six were retired. All participants lived independently in the community.

All participants were also asked to nominate a significant other with whom they had regular and meaningful contact. Importantly for the FLL group only, patients were required to identify a significant other who knew them both before tumour symptoms were apparent and subsequent to tumour resection, to allow them to rate both pre-and post-injury functional abilities. All informants were over the age of 18 years and the relationship between participants and informants are detailed in Table 1.

2.2. *Eligibility criteria*

All participants were required to be over 18 years of age at time of testing. The test procedures all involved verbal instructions in English, and as a consequence, participants were required to be fluent in English. In addition, it was ensured that both groups had full-scale IQ > 70, as measured using the abbreviated two subtest version of the Wechsler Abbreviated Scale of Intelligence (WASI-II; Wechsler, 2011a). It was ensured that all FLL participants had undergone surgery after

Table 1 – Participant demographics and sample characteristics.

	FLL group ($n = 15$)			Control group ($n = 15$)			Statistics		
	M	SD	Range	M	SD	Range	*t*	P	*d*
Gender ratio	4 Male: 11 Female			4 Male: 11 Female					
Age (Years)	54.85	12.03	31.0–71.9	52.32	13.78	29.1–73.4	.54	.596	.20
Years of education	12.60	2.67	10–16	13.27	1.87	11–16	–.79	.435	.29
TOPF (premorbid IQ)	97.07	10.07	82–117	100.33	9.83	83–119	–.89	.376	.33
Months since lesion resection	42.07	37.46	6–135	–	–	–	–	–	–
Informant (n)									
Partner/Spouse	9			11					
Parent	2			1					
Sibling	1			0					
Adult Child	2			3					
Other	1			0					

the age of 18 years and were at least six months post-surgery to reduce acute post-operative effects on cognitive functioning. All FLL participants received a Magnetic Resonance Imaging (MRI) or Computerised Tomography (CT) scan following tumour resection and before participation. The neurological histories and neuroimaging reports indicated damage predominantly to the frontal lobes. The method used by Rowe, Bullock, Polkey, and Morris (2001) was adopted to classify lesion location in terms of Brodmann areas (Brodmann, 1909). Brodmann encroachment was amalgamated into four main regions, defined anatomically as orbitofrontal (Brodmann areas 10, 11, 12 and 47); medial (Brodmann areas 8, 9, 24, 25 and 32), dorsolateral (Brodmann areas 44, 45 and 46) and premotor (possible bias and limitations that arise in this approach, e.g. due to advances in neuroimaging, are acknowledged, see Geyer, Weiss, Reiman et al., 2011 for review). Lesion data are summarised in Table 2. Study exclusion criteria included the following: the presence of additional neurological conditions, language impairment, uncorrected hearing or vision, a severe psychiatric disorder (e.g. schizophrenia, bipolar disorder, personality disorder), a primary diagnosis of substance abuse or history of autistic disorders or attention deficit hyperactivity disorder (ADHD) or those currently suffering from a depressive disorder.

2.3. *Administrative procedures*

Both verbal and written consent was obtained prior to study participation. Participants were seen for one testing session, with appropriate breaks given, and during which participants were administered a neuropsychological test battery and awareness questionnaires. All tasks were administered in a fixed order with the administration of the self-awareness measures and their novel surrogate versions separated by a short testing break, as well as completion of the memory and executive function measures. Informants, for both the FLL patients and controls, were simply required to complete two questionnaire measures. If the informant was present at the testing session, he/she was given the questionnaires to complete while waiting. If the informant did not accompany the participant to the testing session, a blank copy of the informant versions and a stamped addressed envelope were posted to the designated informant, with the expectation that they mail the completed questionnaires back to the primary researcher. The FLL patient group and their significant others completed pre- and post-injury versions of the awareness questionnaires. Controls and their informants provided only current ratings. All participants were offered a small honorarium for their participation. The study was approved by the

Table 2 – Frontal lobe lesion group characteristics and lesion aetiology.

Participant	Gender	Lesion location	Orbito frontal	Medial	Dorsolateral	Premotor	Tumour classification
1	F	Left		X		X	Oligodendroglioma Grade II*
2	F	Right		X		X	Meningioma Grade II
3	F	Right		X	X		Oligodendroglioma Grade III*
4	M	Right			X		Meningioma Grade II
5	F	Right			X		Meningioma Grade II
6	F	Left		X	X	X	Meningioma Grade I
7	M	Right		X	X		Glioblastoma Grade IV*
8	F	Bilateral	X	X	X		Meningioma Grade I
9	M	Left			X		Meningioma Simpson Grade II
10	M	Right			X		Oligodendroglioma Grade II
11	F	Left				X	Meningioma Grade II
12	F	Left	X	X	X		Malignant neoplasm, PNET
13	F	Left			X		Meningioma Grade III*
14	F	Left	X	X	X		Oligodendroglioma Grade III
15	F	Right	X	X	X	X	Astrocytoma Grade III**

*Underwent radiotherapy ** Underwent radiotherapy and chemotherapy.

relevant ethics committee (NHS London–Central Research Ethics Committee, REF: 17/LO/0531), the Research and Development Department at King's College London, and a local research governance committee of King's Health Partners. No part of the study procedures or analyses was pre-registered prior to the research being conducted.

2.4. *Background neuropsychological measures*

A battery of standardised tests was administered to all participants, measuring general intellectual functioning, verbal memory and executive function. The Test of Premorbid Functioning—UK version (TOPF-UK) (Wechsler, 2011b) was used to estimate premorbid ability; The two-subtest version of the Wechsler Abbreviated Scale of Intelligence (WASI-II; Wechsler, 2011a) was administered to calculate a full scale IQ on the basis of the Vocabulary and Matrix Reasoning subtests; The Logical Memory subtest from the WMS-IV (Wechsler, 2009) was used as a measure of auditory-verbal memory with both immediate and delayed recall trials; A test of mental flexibility known to be sensitive to the effects of frontal lobe damage was administered, namely the Brixton Spatial Anticipation Test (Burgess & Shallice, 1997) and the PHQ-9 (Spitzer, Kroenke, & Williams, 1999) and GAD-7 (Spitzer, Kroenke, Williams, & Lowe, 2006) were completed to assess current ratings of depression and anxiety symptoms respectively. The faux-pas task by Stone, Baron-Cohen, and Knight (1998) was also administered in order to assess participant's perspective-taking abilities, as this skill was required when completing the novel adapted 'surrogate' questionnaires.

2.5. *Measures of awareness*

Two questionnaire measures that aimed to assess changes (e.g. behavioral, cognitive, emotional, personality) often associated with frontal lobe damage were administered. Each questionnaire had four versions that followed the following format: Self rating of pre-injury functioning by the participant; Self rating of current post-injury functioning by the participant; Informant rating of pre-injury functioning of the participant; Informant rating of current post-injury functioning of the participant. Here, pre-injury refers to before symptoms of tumor diagnosis were apparent and post-injury refers to after tumor resection. The questionnaire measures used included:

2.5.1. *The Frontal Systems Behavior Scale (FrSBe; Grace & Malloy, 2001)*

This scale provides a brief, reliable and valid measure of three frontal systems behavioral syndromes: apathy, disinhibition and executive dysfunction. It quantifies behavioral change over time by including both baseline (retrospective) and current assessments of behavior. It includes a total score as well as scores on three subscales that correspond to the three frontal systems behavioral syndromes. The FrSBe already has ratings prior to and after injury/illness and includes both self-and informant rating version for both aspects. The FrSBe has been demonstrated to be sensitive to behavior change following focal frontal lesions and has acceptable psychometric properties (Grace & Malloy, 2001).

2.5.2. *The Dysexecutive Questionnaire-Revised (DEX-R; Simblett, Ring, & Bateman, 2016).*

This is a rating scale designed to sample everyday problems commonly associated with frontal systems dysfunction. It can be used as a measure of awareness by calculating the discrepancy score between self- and informant responses. It is designed to measure four areas of change: emotional or personality changes, motivational changes, behavioral changes and cognitive changes and comprises four subscales (Activating-Regulating functions, Behavioral-Emotional Self-Regulating functions, Executive Cognition functions, Meta-Cognitive functions). These are intended to link to Stuss' model of frontal lobe function. The DEX-R has two forms, Self and Informant, which contain the same items but phrased as appropriate and focus on current functioning. Further adaption was made for this study to create a pre-injury variant for both self and informant versions, in order to establish experimental procedures. There are currently no normative data available for the DEX-R. However, research into the psychometric properties of the DEX-R is being undertaken (Simblett, Ring, & Bateman, 2017).

2.5.3. *Scoring methods for the two questionnaire measures*

The DEX-R was scored using a 5-point rating scale regarding the frequency of a range of behaviors: 0 = never, 1 = occasionally, 2 = sometimes, 3 = fairly often, 4 = very often. The FrSBe was scored similarly, also adopting a 5-point scale: 1 = Almost never, 2 = Seldom, 3 = Sometimes, 4 = Frequently, 5 = Almost always. For both measures, individual item ratings are summed together and a higher total score indicates greater impairment.

The discrepancy score method is considered a sensitive measurement of deficit awareness following brain injury (Hart et al., 2003) and was therefore also adopted in the current study. Adapted discrepancy scores were calculated as used by Clare, Markoca, and Morris (2011) and in subsequent studies (Geytenbeek et al., 2017), whereby the difference between the two ratings (patient total score minus informant total score) was divided by the mean of the two ratings. This is proposed to prevent scaling effects (Geytenbeek et al., 2017). Discrepancy scores focused on current, post-lesion resection functioning only, with larger scores indicating more severe deficits of awareness. Negative scores indicate a consistent underestimation of deficit, whereas positive scores suggest an overestimation of impairment by the patient.

2.6. *Surrogate self-understanding of behavioral changes*

A novel questionnaire-based technique was adopted, focused on whether the participant with frontal lesion experiences a

Table 3 – Group differences on background neuropsychological measures

Variable	FLL group ($n = 15$)			Control group ($n = 15$)			Statistics		
	M	SD	Range	M	SD	Range	t	p	d
Vocabulary (SS)	8.80	2.57	5–14	10.33	2.64	7–18	−1.61	.118	.59
Matrix Reasoning (SS)	9.73	3.04	5–15	11.20	2.43	7–15	−1.46	.155	.53
FSIQ-2	95.53	13.17	74–124	104.13	12.02	85–129	−1.87	.072	.68
LM Immediate verbal recall (SS)	8.27	3.08	2–13	9.00	3.16	2–14	−.64	.525	.23
LM Delayed verbal recall (SS)	7.93	2.96	1–12	9.87	3.14	2–13	−1.74	.094	.64
Brixton (SS)(mv = 2)	5.08	2.63	1–10	6.60	.99	5–8	−2.09	.047*	.75
Faux Pas test (mv = 3)	18.50	1.38	16–20	19.20	.86	17–20	−1.61	.119	.61
Anxiety	5.60	4.55	0–19	1.73	2.02	0–7	3.01	.005*	1.09
Depression	6.07	4.23	0–18	3.07	2.71	0–9	2.31	.028*	.84

mv = missing values; Anxiety measured using GAD-7; Depression measured using PHQ-9; Vocabulary and Matrix Reasoning measured using WASI-II; Verbal recall measured using WMS-IV; FSIQ-2: Full Scale IQ-2 subtest estimate.

significant other person telling them they have particular symptoms that they may disavow. To measure this the FrSBe and DEX-R underwent a further wording adaption and participants were asked to rate the forms as if they were the informant in relation to current behavior only. An example of the wording is as follows: My partner/relative/friend thinks that I have difficulty expressing emotion. Participants were asked to rate how frequently they felt this occurs using the particular measure's rating scale and scoring method, described above. This aimed to assess participants' understanding of whether informants report behaviors of a type that is abnormal that they themselves do not think they engage in or do not view as abnormal.

2.7. *Data analysis*

The analysis used *t*-tests, repeated-measures analysis of variance and mixed-measures analysis of variance (ANOVA), mixed-measures analysis of covariance (ANCOVA) as well as intra-class correlation coefficients (ICC; absolute agreement, two-way mixed effects model, Koo & Li, 2016), performed using SPSS (version 26). Effect sizes were also calculated. Initial analysis for hypothesis 1 focused on the FLL group only because it required pre-illness and post-surgery comparison and did not therefore apply to the control group. All subsequent analyses focused on current functioning only, allowing comparison between the FLL group and controls.

3. Results

3.1. *Background neuropsychological measures*

Participants were tested on a range of neuropsychological measures reported to impact awareness following brain injury, with findings presented in Table 3. Significant differences were found between groups on the Brixton (a test of executive functioning), with the control group outperforming the FLL group. Anxiety and depression ratings were also found to significantly differ between the groups, with the FLL group reporting more symptoms than the control group. In addition, for each of these measures a moderate to high effect size was found suggesting high practical significance, with anxiety ratings between FFL patients and controls appearing of particular importance.

3.2. *Hypothesis 1: assessment of degree of awareness (DEX-R and FrSBE) in FLL group*

The data were approximately normally distributed and there were no obvious outliers allowing data to be analysed by means of two repeated measures 2 × 2 ANOVAs (one for the DEX-R ($n = 14$)[2] measure and another for the FrSBE ($n = 15$) measure), with Time (pre-versus post-surgery) and Rater (self versus informant) as the two within-subjects factors. For both the DEX-R and FrSBe measures, the analysis yielded a significant main effect of Time (DEX-R: $F(1, 13) = 41.87$, $P < .001$, partial $\eta^2 = .76$, $r = .76$; FrSBe: $F(1, 14) = 27.88$, $P < .001$, partial $\eta^2 = .66$, $r = .67$) with mean scores (presented in Table 4) suggesting that both patients and their informants rated an increase in difficulties for the patient following lesion resection compared to their prior functioning (Fig. 1 displays this visually). Across both measures, there was no significant main effect of Rater (DEX-R: $F(1, 13) = .018$, $P = .895$, partial $\eta^2 = .001$, $r = .01$; FrSBe: $F(1, 14) = .031$, $P = .863$, partial $\eta^2 = .002$, $r = .01$) nor was there an interaction between factors (DEX-R: $F(1, 13) = .490$, $P = .496$, partial $\eta^2 = .04$, $r = .04$; FrSBe: $F(1, 14) = .438$, $P = .519$, partial $\eta^2 = .03$, $r = .03$). The analysis was repeated splitting the measures into their relevant subscales to explore if either rater more or less readily identified change in any specific area of difficulty. In all cases, the results were comparable to the total score findings; a significant main effect of Time was found across all individual subscales ($P < .01$), whereas Rater and interaction factors were all non-significant (all Fs equal to or less than 1).

3.3. *Hypothesis 2: comparison of FLL and control groups' degree of awareness*

Contrary to predictions, independent samples *t*-tests found no significant differences ($P > .05$) between the two groups on the discrepancy between self-reported and informant-reported

[2] For one patient the informant version of the DEX-R was not returned and their data were excluded from these analyses.

Table 4 – Descriptive statistics for pre and post ratings by the FLL patients and their informants.

Measure	Time	Rater	Mean	SD	N	Measure	Time	Rater	Mean	SD	N
DEX-R	Pre	Self	22.14	16.29	14	**FrSBe**	Pre	Self	73.87	14.96	15
		Informant	18.07	12.04	14			Informant	72.80	18.97	15
	Post	Self	63.50	27.97	14		Post	Self	103.67	22.09	15
		Informant	65.79	35.49	14			Informant	107.33	33.72	15
A-R	Pre	Self	3.57	3.44	14	Apathy	Pre	Self	20.87	4.70	15
		Informant	2.57	2.44	14			Informant	20.67	6.59	15
	Post	Self	12.64	7.37	14		Post	Self	33.93	7.94	15
		Informant	13.43	7.78	14			Informant	33.33	10.23	15
B-E	Pre	Self	6.50	3.92	14	Disin	Pre	Self	24.93	6.10	15
		Informant	5.07	3.27	14			Informant	22.53	6.47	15
	Post	Self	13.64	6.42	14		Post	Self	31.53	8.45	15
		Informant	14.57	8.24	14			Informant	30.33	10.58	15
E-C	Pre	Self	4.93	5.87	14	Ex Dys	Pre	Self	28.67	7.23	15
		Informant	4.29	4.57	14			Informant	28.93	9.52	15
	Post	Self	20.50	10.28	14		Post	Self	38.20	9.56	15
		Informant	21.07	11.29	14			Informant	43.87	15.24	15
M-C	Pre	Self	6.57	5.05	14						
		Informant	5.64	4.52	14						
	Post	Self	15.29	7.33	14						
		Informant	14.36	9.53	14						

Note: A-R = Activating Regulating functions; B-E = Behavioral-Emotional Self-Regulating functions.
E-C = Executive-Cognition functions; M–C = Meta-Cognitive functions; Disin = Disinhibition.
Ex Dys = Executive Dysfunction.

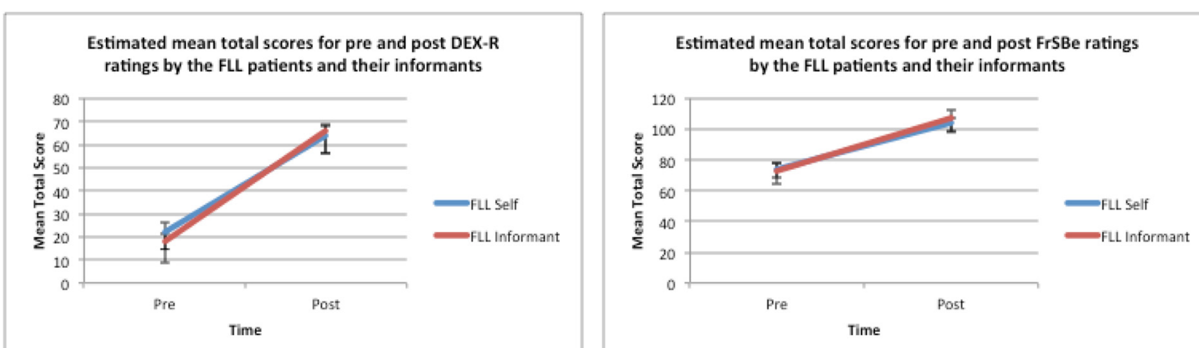

Fig. 1 – Graphs to show the estimated mean total scores (and Std. Error) for pre and post ratings by the FLL patients and their informants for both awareness measures.

Table 5 – Between group differences on post-surgery discrepancy scores.

Measure	Score Adapted discrepancy = self - informant/mean	FLL group			Control group			Statistics		
		M	SD	Range	M	SD	Range	t	P	*d*
DEX-R	Adapted Discrepancy total	.01	.74	−1.13–1.12	.14	.64	−.87–1.39	−.48	.636	.19
Subscales	A-R functions adapted discrepancy	−.15	.87	−2.00–1.30	.08	.69	−.86–1.33	−.81	.424	.29
	B-E functions adapted discrepancy	.02	.83	−1.45–1.43	.07	.67	−.93–1.79	−.19	.854	.07
	E-C adapted discrepancy	.01	.74	−1.25–1.27	.23	.87	−1.00–1.73	−.74	.464	.27
	M–C functions adapted discrepancy	.16	.92	−1.60–1.62	.15	.86	−1.33–1.69	.04	.966	.01
FrSBe	Adapted Discrepancy	−.01	.38	−.75–.58	.07	.26	−.39–.59	−.64	.530	.25
Subscales	Apathy adapted discrepancy	.04	.38	−.56–.74	−.04	.29	−.42–.60	.61	.548	.24
	Disinhibition adapted discrepancy	.05	.41	−.48–.95	.23	.29	−.30–.75	−1.29	.210	.51
	Executive Dysfunction adapted discrepancy	−.06	.40	−1.12–.47	.02	.29	−.48–.56	−.66	.515	.23

scores for total or by subscale for either measure (see Table 5). These findings inform that the FLL patient-informant discrepancies are comparable to those found in healthy control-dyads.

3.4. *Further exploratory analyses*

Contrary to a priori predictions, the findings from H1 and H2 inform us that FLL patient self-ratings appear in line with informant ratings, suggesting adequate awareness of abilities and that these self-informant discrepancies do not differ from controls. However, they do not allow a sense of whether patient ratings are elevated compared to a healthy comparison group. Given the current findings, and in opposition to a priori predictions had our previous hypotheses been supported, we can suppose that there will be a difference between the groups in the rated frequency of the frontal behaviors engaged in, with the FLL group reporting that they more frequently exhibit problem behaviors than the control group (which would be evidenced by higher mean scores on rating measures).

To allow us to explore how the FLL group appraised their current abilities compared to healthy controls a mixed 2 × 2 ANOVA was conducted with group (FLL or control) as the between-subjects factor and rater (self or informant) as the within-subjects factor. This test was adopted as it also allowed the inclusion of covariates. Significant between group differences were found for total and all subscale scores on both measures ($P < .01$), with mean scores suggesting that the FLL group reported engaging in more frontal behaviors than the control group (DEX-R self-total; FFL: $M = 63.50$, $SD = 27.97$; Control: $M = 32.47$, $SD = 15.62$; FrSBe self-total; FFL: $M = 103.67$, $SD = 22.09$; Control: $M = 82.13$, $SD = 17.99$). In keeping with previous findings, there was no significant main effect of rater nor was there an interaction between factors ($P > .05$).

A series of 2 × 2 mixed ANCOVAs were then conducted to examine the impact of three covariates (namely anxiety, depression and Brixton scores), as these were shown to differ between groups (and yielded large effect sizes). Overall, the inclusion of covariates did not change the pattern of results with significant group differences remaining and all other main effects and interactions yielding non-significant results across both total and the majority of subscale scores. There were however two exceptions: the covariates, anxiety and depression, had a significant relationship with participants' ratings on the Meta-Cognitive subscale of the DEX-R (anxiety: $F(1, 26) = 11.33$, $P = <.01$, partial $\eta^2 = .304$, $r = .30$; depression: $F(1, 26) = 8.36$, $P =<.01$, partial $\eta^2 = .24$, $r = .24$). However, the effect of group on participant ratings of Meta-Cognitive functioning became non-significant after controlling for the effects of anxiety ($F(1, 26) = 2.16$, $P = .154$, partial $\eta^2 = .08$, $r = .08$) and depression ($F(1, 26) = 3.94$, $P = .058$, partial $\eta^2 = .13$, $r = .13$). Comparative review of group means (non-adjusted and adjusted) suggests higher anxiety and depression ratings result in reduced reporting of frontal behaviors in the FFL group and increased reporting of frontal behaviors in the control sample. The same pattern was seen for the disinhibition subscale of the FrSBe. Both anxiety and depression were found to significantly relate to participants ratings on this subscale (anxiety: $F(1, 27) = 10.45$, $P = <.01$, partial $\eta^2 = .28$, $r = .28$; depression: $F(1, 27) = 10.06$, $P =<.01$, partial $\eta^2 = .27$, $r = .27$), however, the group difference failed to reach significance after controlling for the effects of these covariates (anxiety: $F(1, 27) = 1.81$, $P = .190$, partial $\eta^2 = .65$, $r = .06$ and depression: $F(1, 27) = 3.30$, $P = .080$, partial $\eta^2 = .11$, $r = .11$). Again, higher anxiety and depression ratings appeared to result in reduced reporting of frontal behaviors in the FFL groups and increased reporting of frontal behaviors in the control sample.

Table 6 – ICCs explored the notion of surrogate awareness.

		DEX-R surrogate	FrSBe surrogate
FLL	Self	.91**	.91**
	Informant	.43	.32
Control	Self	.84**	.94**
	Informant	.45	.41

**P < .001.

3.5. *Agreement between self- and surrogate-ratings and informant- and surrogate-ratings of awareness of deficit: perspective-taking*

Although our initial hypothesis was unsupported and suggested that the FLL sample have adequate awareness, further analysis comparing surrogate-ratings with self- and informant ratings, although purely exploratory, was deemed valuable as enabled us to more explicitly investigate how participants perceived nominated informants to perceive them. This provided a novel measure of perspective-taking via surrogate analysis, regardless of objective awareness. Intraclass correlations (ICCs) were run to explore the associations and agreement between current self-ratings and surrogate ratings versus current informant ratings and surrogate ratings. ICCs are presented in Table 6. Both the DEX-R and the FrSBe achieved values in the range generally accepted to indicate moderate (.50–.75) to good (>.75) reliability, or in this case agreement, between self and surrogate ratings (Koo & Li, 2016). By comparison the agreement between informant ratings and surrogate ratings for both measures failed to reach significance. Inspection of the coefficients in Table 6 reveals moderate to strong agreement (.73–.89) between self and surrogate ratings, suggesting that participants believe their informants' perception of them is strongly aligned with their own experience. In contrast, the agreement between informant and surrogate ratings was consistently lower (.19–.29). These findings suggest that participants (both FLL patients and controls) do not appear to fully understand how their informants perceive them. Instead, they seem to think that informants view them similarly to how they view themselves.

Given previous findings suggesting a lack of discrepancy between self and informant ratings, it is somewhat surprising to find significant agreement between surrogate and self-ratings only. Although no significant difference in mean discrepancy scores was found, it was noted that the direction of the discrepancy scores within samples varied and mean analyses might have masked the impact of any differences in individual ratings. ICCs for the self and informant ratings on both measures confirmed weaker agreement between individual ratings (DEX-R: FLL: .44; Control: .48; FrSBe: FLL: .32; Control: .27). An 'unsigned' analysis was run on the self-informant discrepancy scores in order to examine whether patients were less 'accurate' overall than the controls. Independent t-tests on these unsigned discrepancy scores revealed no significant differences between groups on either the DEX-R ($t(27) = .47$, $P = .642$, $d = .17$) or FrSBe ($t(28) = 1.77$, $P = .087$, $d = .70$) measure. However, the FrSBe measure score yielded a large effect size, suggesting that a difference between the groups is detectable and with a slightly larger sample it may have reached significance.

3.6. Lesion analyses

Supplementary analyses were conducted to investigate the effects of laterality and location of lesions within the frontal lobe group on performance on the background neuropsychological battery and on level of awareness (self-informant discrepancy and surrogate) as assessed by both DEX-R and FrSBe measures. These analyses were purely exploratory, due to the small numbers in subgroups when splitting the sample, and offer preliminary findings, which may be helpful to direct future investigation. The method used by Rowe et al. (2001) and subsequently by Denmark et al. (2017) was adopted, where individuals who had an operation in a specific location were compared to the rest of the sample who did not have an operation in this region. For laterality analyses, unilateral left ($n = 7$) were compared with unilateral right hemisphere lesions ($n = 7$) (this excluded the one patient with a bilateral lesion). The groups significantly differed on verbal memory task performance (immediate recall: $t(12) = -2.89$, P=<.05, $d = 1.54$; delayed recall $t(12) = -2.99$, P=<.05, $d = 1.60$), on which patients with left hemisphere lesions performed worse than those with right hemisphere lesions and on depression scores ($t(12) =$.-2.45, P=<.05, $d = 1.31$), for which patients with right hemisphere lesions reported increased depression compared to patients with left hemisphere lesions. However, although it did not reach significance ($t(12) = 2.09$, $P = .058$, $d = 1.12$), the effect size suggested a trend for difference between subgroups based on time since lesion, with the right hemisphere group having less time since surgery, which likely impacts depression ratings. No significant effects of laterality were found on level of awareness (with all results consistent with previous findings).

For lesion location analyses dorsolateral lesions ($n = 12$) were compared with non-dorsolateral lesions ($n = 3$); medial lesions ($n = 9$) were compared to non-medial lesions ($n = 6$); orbitofrontal lesions ($n = 4$) were compared with non-orbitofrontal lesions ($n = 11$) and finally, premotor lesions ($n = 5$) were compared to non-premotor lesions ($n = 10$). No significant effects of lesion location were found on background measure performance (all P=>.05). When exploring level of awareness, a significant main effect of time was found across all four regions, comparable to prior analysis. Additionally, analysis revealed a significant effect of lesion localization for the Premotor group only. Across both measures, an interaction was found between Rater (self versus informant) and Localization (premotor versus non-premotor; DEX-R: $F(1, 12) = 6.19$, $P < .05$, partial $\eta^2 = .34$, $r = .34$; FrSBe: $F(1, 13) = 7.08$, $P < .05$, partial $\eta^2 = .35$, $r = .35$) with mean scores suggesting that within the premotor group patients rated themselves as more impaired than their informants both prior to and following lesion resection whereas within the non-premotor group the reverse was observed (informants reported more impairment than patients self-reported both prior to and following lesion resection). The analysis was repeated splitting the measures into their relevant subscales and within the premotor group an interaction between Rater and Localization was found across the Behavioral ($F(1, 12) = 8.44$, $P < .05$, partial $\eta^2 = .41$, $r = .41$) and Executive Function subscales of the DEX-R ($F(1, 12) = 6.26$, $P < .05$, partial $\eta^2 = .34$, $r = .34$) and the Disinhibition subscale of the FrSBe ($F(1, 13) = 6.61$, $P < .05$, partial $\eta^2 = .34$, $r = .34$). No significant effect of lesion localization was found on measures of surrogate awareness.

4. Discussion

In this study we explored self-awareness and perspective-taking in people with acquired frontal lobe lesions (FLL group). A combination of hypothesis testing and exploratory analyses were carried out using the CAM model as a theoretical guiding framework.

Our findings suggest that this specific patient group show adequate awareness with both patients with frontal lesions and informants who know them well acknowledging and reporting behavioral changes following surgery. It appears, therefore, that FLL patients are in fact able to update their self-representation to reflect current abilities. Although our findings did not support our a priori hypothesis, the results do highlight the sensitivity of the measures used in identifying change following surgery. This is particularly informative for the DEX-R measure, implying that the novel adaption and inclusion of the pre-injury questions (to elicit a comparative change score) adopted in this study was successful. Pre-injury ratings appear crucial for placing post-injury behaviors in context, marking the inclusion of the pre-illness ratings in the current project (a design specification to more systematically investigate the CAM models ideas) as warranted and important for future research.

Patient-informant discrepancies were also found to be comparable to those found in a demographically similar sample of healthy controls. In line with findings from previous studies with similar samples (Grace, Stout, & Malloy, 1999; Chiou, Chiaravalloti, Wylie, DeLuca, & Genova, 2016), further exploratory analyses found that the FFL group tended to rate themselves as more functionally impaired on a range of executive and frontal behaviors than a healthy control group. However, anxiety and depression scores (covariates known to differ between the groups) were found to impact participant ratings on two subscales (the Meta-Cognitive subscale of the DEX-R and the Disinhibition subscale of the FrSBe). For these subscales, increased anxiety and depression resulted in higher reports of frontal behaviors in the control group and lower reports of frontal behaviour in the patient group. The variability in directionality of mood and engagement in frontal behaviors is complicated by our small sample size and the diversity in sample characteristics (e.g. time since injury) and would benefit from closer attention in future research.

Taken together, these findings suggest that FFL patients are engaging in more atypical behaviors compared to healthy controls, but importantly and contrary to predictions, they are aware of and acknowledge these difficulties. Limited evidence exists comparing behavioral ratings and responses from individuals with frontal lobe lesions to typical control groups and as such this study marks a positive addition to the literature.

Interpretation of the above findings, however, could be impacted by the characteristics of the patient sample and participant proxy relationship. Factors that may influence differences in both participant and proxy response include the construct being measured, characteristics of the participant, characteristics of the proxy and the participant proxy relationship (Olino & Klein, 2015). In the current study, across both the patient and control groups, the relationship between participant and informant varied greatly. A failure to distinguish between different types of proxy has been implicated, and it can be argued that the depth and breadth of shared information is likely to vary dramatically dependent on this, which may impact the comparative observations required in assessment of awareness. Furthermore, the current study only assessed self-reported mood of patients and matched controls. It did not account for informant mood. However, discrepancy between caregivers' and patients' judgements could be influenced by the emotional state of former. It is possible that caregiver distress (elevated anxiety or depression symptoms) may impact their critical judgement when completing the required questionnaires. Although a brief verbal screening of caregiver (informant) distress was completed prior to study involvement (with all informants denying current concerns), the completion of formal measures was not undertaken. More formalised cognitive-behavioural pre-assessment of informants could be considered to strengthen future studies.

The current patient sample was recruited from an outpatient neuro-oncology clinic on the basis that they had frontal lobe lesions, rather than due to any reported behavioral or cognitive difficulties following their tumour resection. Studies that found awareness deficits using these measures (Bogod, Mateer, & Macdonald, 2003; Niemeier et al., 2014) have included samples recruited from hospital and rehabilitation settings where these difficulties may be more prominent. However, the prevalence of behavioral problems varies greatly across studies (13% in small studies to 34% in large studies) (Zwinkels et al., 2015). Additionally, previous studies that have found reduced awareness using these measures typically include samples comprised of survivors of ABI (Hart et al., 2017; Morton & Barker, 2010). These samples are often associated with larger lesions and more likely diffuse damage, distinct from the current cohort where precise neurosurgical techniques were used to remove the tumours. Prigatano (2010) posits that diffuse bilateral brain aetiology is more likely to produce awareness deficits than unilateral lesions, as such the severity of the injury in our studied patient group may not be large enough to impact awareness.

Supplementary analyses within the FFL group also indicated a significant effect of lesion localisation when comparing patients with lesions in the premotor and non-premotor regions specifically. One possible explanation for this may relate to the function associated with this brain region. Lesions in the premotor area impair planning of complex motor functions. Patients will likely be aware of their limitations and will therefore modify their behaviour accordingly to bypass any personal challenges with motor function experienced. Essentially, they may avoid performing complex motor functions that they know they are not able and instead perform a less complex task that they know they can. The informant is not aware of this conscious behaviour adaption because all they perceive is the motor function they see, as they are not privy to the patient's personal experience. The reports of reduced awareness by patients with lesions in the non-premotor group suggests that different frontal brain structures or regions are more related to representations of the self and awareness. However, further exploration with larger sample sizes of individuals with FFL, and with more focused samples with regards to lesion type (e.g. site, size and severity) is warranted to answer questions regarding how reports of self-awareness fit with theoretical accounts regarding fractionation of the frontal system, structures and regions (Stuss & Levine, 2002).

Our second research question explored another assertion of the CAM model: that a distinction exists between memory records for self- and other-appraisal. Despite no objective awareness deficits in the current sample, the inclusion of our surrogate analysis offered a novel methodological take on perspective-taking by explicitly asking participants to rate how they perceived nominated informants to perceive them. Findings revealed that neither FLL nor control participants were reliable in assessing how their informants perceived them, suggesting limited perspective-taking in both groups. It is possible that this is an artefact of the testing procedure. Although the self and surrogate questionnaires were not administered in the same testing block (separated by a testing break), all testing happened over one session and this may have caused difficulties in switching perspectives (from self-perspective (‘I act without thinking’) to surrogate (‘My partner thinks that I act without thinking’). The fact that no group (FLL versus control) difference was found on a task that provides a measure of perspective-taking (faux-pas task) suggests that neither group had difficulty with this skill and should minimise these concerns. However, future analyses may wish to more stringently assess perspective-taking ability (e.g. the cognitive demands with regards to Theory of Mind) and investigate its mediation effect. Our novel methodology offered a new angle on the potentially differing views of patients and family members. The psychosocial changes that can follow neurosurgery are noted to cause particular distress to relatives or caregivers (Andrewes et al., 2013). It has also been suggested that incongruence in how patients and family members perceive each other and willingness to change these self-perceptions are factors that could possibly impact on recovery or rehabilitation outcome (Ownsworth & Clare, 2006). Whereas previous studies have not investigated the idea of the surrogate self and self-reported awareness in the same sample, the current study has focused on this aspect. Improving our understanding of patient/carer self-perceptions could better support and encourage patient and carer communication, so appears to hold clinical relevance marking this investigation as a positive contribution to the literature.

4.1. *Limitations*

This study is not without limitation and should be noted when interpreting the results. Although our sample size was in keeping with previous investigations (Chiou et al., 2016; Larson & Perlstein, 2009) and relatively large considering the specific patient group recruited, it is still possible that a larger sample may uncover more behavioral variability, provide the opportunity to conduct appropriate subgroup analyses, as well as allow further exploration of factors suspected to impact the outcome (e.g. mood variables). When comparing patients and controls on variables believed to impact awareness and perspective-taking, only executive function and emotional distress ratings were found to significantly differ between the groups. However, even for variables in which no significant differences were found between the groups, it should be highlighted that effect sizes were moderate to large, suggesting that larger samples would lead to greater differences between the patient and control groups cognitive profile.

As research has highlighted frontal circuits and regions as potentially key in awareness, our targeted population appeared apt to test our theories, given the location of their post-surgical lesions. Although it can be helpful to limit the focus of research to a specific patient group, especially given the heterogeneity in clinical presentation following different types of injury, doing so does mean that the findings may not be generalizable to the wider population. Due to the relatively stringent eligibility criteria, the applicability to individuals with psychiatric histories or those with more diffuse injuries is unknown. Furthermore, there was variability within the patient sample in terms of the amount of post-surgery treatment that individuals had or indeed were receiving. This may have impacted on both self and informant ratings in terms of how 'well' patients were perceived to be recovering. It is conceivable, therefore, that these results would not generalize if these group variations were taken into account.

Another caveat for interpreting these results is the fact that the psychometric properties of the FrSBe instrument have not been as thoroughly studied in healthy samples as they have in those with neurological impairment. Therefore, caution should be applied when interpreting the between samples comparison made. However, as we did not employ the standard T-scores for the FrSBe measure, instead using raw score data to allow us to compare our novel adaption (surrogate version) to the pre- and post-versions, this may not be such a heavy criticism.

Although a limitation more generally when using these self-proxy measurement instruments, it may still have impacted the current study; It is not possible to validate reports from patients or informants to inform whether informant or indeed patient reports are more veridical. Further research is necessary to establish the best way of validating the measurement of pre-injury status in this sample. As we were asking participants to rate themselves pre-any symptoms of the tumour, it is possible that this was difficult to pinpoint temporally and that participants may have rated pre-surgery (which we can presume likely involved some symptoms) as opposed to pre-illness (pre-symptoms). With the patients themselves difficulties with this are less likely as the questionnaires were completed with the researcher and reminders were given when required focusing patients appropriately. However, nominated informants of the FLL group, in the majority of cases, completed their questionnaires remotely and therefore their understanding of the temporal element of the task instructions cannot be confirmed. Additionally, the ratings of pre-illness functioning were completed retrospectively. Therefore, post-surgery factors may have distorted ratings of pre-illness functioning. However, of note is that self and informant ratings of pre-illness functioning were comparable, which suggests that the retrospective rating was in fact an effective and reliable approach in this sample at least.

4.2. *Future directions*

Reflecting on the results and limitations presented above, there appear a number of avenues for future consideration emerging from this research. Replicating our results with a slightly larger sample in order to further corroborate our substantial effects sizes, increase power and improve our ability to draw meaningful and generalisable conclusions is deemed valuable. Increasing the sample would also allow further exploration into the impact of more diffuse versus more focal lesions, adding to this field of exploration (Ham et al., 2014; Stuss, 1991). Although the relationship between participant and informant was relatively well matched between the FLL and control groups, it has been noted that the way an individual is perceived can depend on patient–proxy relationship. It may be insightful to further control for that in future studies as it may impact on the amount of time the two individuals spend together and in turn the range of situations in which they observe each other and interact. Furthermore, assessing personality factors and sample characteristics that may bias perception and motivation, e.g. mood and self-efficacy ratings may offer more information on the factors mediating ratings and awareness of atypical behaviors. Finally, repeating the study with a TBI sample, for which behavioral challenges are more typically reported, may provide interesting insights and we could predict that a TBI sample may indeed show less awareness.

4.3. *Clinical implications*

Understanding the emotional, behavioral and psychosocial changes that may follow neurosurgery is important for the clinical management of these patients. A key finding of this study is that patients with FLLs seem relatively aware of behavioral changes in themselves. However, this does not mean that they are ready or willing to accept these changes and therefore the struggle with rehabilitation is still how to manage this altered sense of self that people experience (Bamm, Rosenbaum, Wilkins, Stratford, & Mahlberg, 2015). Not feeling like they are the person they once were (altered sense of self, marked by updating sense of self) implies that a potential helpful focus of rehabilitation should be to support patients to understand and accept the 'current them' and what this entails for their recovery journeys and future (Baker, Rickard, Tamplin, & Roddy, 2015). However, attention should be paid to the level of emotional distress reported or witnessed in both patients and carers, if using interventions to improve awareness. In addition, a potential strength of research into awareness more generally is the inclusion of the views and opinions of family members. Both patients and their significant others experience extraordinary stress during both diagnosis and treatment (Ownsworth, Goadby, & Chambers, 2015) yet the views and experiences of next of kin are sparsely reported in the literature. Our inclusion of investigation into the surrogate in the current study, offered a novel angle on the potentially differing views of patients and family members. Better understanding the experiences of both patients and their significant others to direct appropriate intervention and care plans may support the recovery process for both parties.

5. Conclusion

The current study aimed to expand our understanding of the level of awareness within a group of patients who have frontal lobe lesions following tumour resection. Taken together, the results appear to suggest that FLL patients have adequate awareness into their post-surgery changes and that they acknowledge more difficulties than controls, which is substantiated by informant report. Ultimately, results of this study support the need to gain information from multiple raters when examining an individual's level of awareness. Including both self- and significant others' ratings are particularly important and valuable in the assessment of functioning, as this may allow a shared understanding between all parties about the others' experiences.

Author contributions

Laura Brown: Conceptualization, Methodology, Investigation, Formal analysis, Writing-Original Draft Preparation, Writing-Reviewing and Editing; **Jessica Fish:** Conceptualization, Methodology, Writing-Review and Editing, Supervision; **Daniel Mograbi:** Conceptualization, Methodology, Writing-Review and Editing, Supervision; **Keyoumars Ashkan:** Methodology, Writing-Review and editing, Supervision, Resources; **Robin Morris:** Conceptualization, Methodology, Writing-Review and editing, Supervision, Resources.

Data sharing statement

The conditions of ethics approval do not permit public archiving of anonymized study data. Readers seeking access to the data should contact the corresponding author (LB). Access will be granted to named individuals in accordance with ethical procedures governing the reuse of sensitive data.

Open practices

Datasets generated during and/or analysed during the current study are not publicly available but are available for anonymized review from the corresponding author (LB) on request.

Submission declaration

All authors approve this work and declare that it has not been previously published nor is it under consideration for publication elsewhere.

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Declaration of competing interest

None.

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