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## Predictors of self-reported word-finding difficulties in glioma patients – a longitudinal study

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### ABSTRACT

**Background:** Word-finding difficulties are a common self-reported concern in glioma patients known to negatively affect social participation and life satisfaction. Discrepancies between self-reported difficulties and performance on objective tests have been reported, but studies are seldom conducted longitudinally.

**Aims:** The aim of the present study was to examine the occurrence of self-reported word-finding difficulties before and during the first year after glioma surgery. In addition, we investigated whether self-reported word-finding difficulties were predicted by standardized language tests and psychological distress.

**Methods and procedures:** Twenty-three patients with gliomas (grade 1–3) were assessed pre-surgery, at six and twelve months follow-up. Self-reported word-finding difficulties were addressed with the item *I am able to find the right word(s) to say what I mean*, from the Functional Assessment of Cancer Therapy – Brain (FACT-Br). Confrontation naming was tested with the Boston Naming Test (BNT), word production with a semantic fluency test and word knowledge with a vocabulary test. Self-reported measures of psychological distress were assessed with the Hospital Anxiety and Depression Scale (HADS). Ordinal regression models were used to examine predictors of self-reported word-finding difficulties.

**Outcomes and results:** Word-finding difficulties were reported by 68% of the patients pre-surgery, increasing to 90% and 85% at the following assessments. Significant changes were observed in the magnitude of reported concerns between pre-surgery assessment and six months follow-up. Regression analyses demonstrated that self-reported word-finding difficulties were predicted by psychological distress and vocabulary pre-surgery and vocabulary at six months follow-up, whereas confrontation naming and semantic fluency did not become significant in any of the assessments.

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**Conclusion:** Our results indicate that self-reported word-finding difficulties occurred in a high percentage of glioma patients throughout the first year of illness. Patients reported increased difficulties after surgery that were not predicted by confrontation naming or semantic fluency but by vocabulary performance. The results imply further that psychological distress is a factor that should be taken into account. Self-reported function is an important supplement to objective testing and can provide indications about mental health status and the patients' perspective on language related challenges in everyday life.

## Introduction

Gliomas are progressive brain tumors within the central nervous system (CNS). They are diffusive and infiltrative in nature and often located close to language, motor, and sensory areas of the brain (Duffau & Capelle, 2004). Traditionally, gliomas are classified as low-grade (LGG) or high-grade (HGG) depending on histopathological and molecular features (Louis et al., 2016). Higher grade indicates more invasive and aggressive features. Both tumor growth and treatment related factors may cause impairments in neurological, language and cognitive functions, with negative implications for quality of life (QoL; Allen & Loughan, 2018; Van Dyk et al., 2022).

Word-finding difficulties are among the most common concerns of glioma patients, with up to 60% reporting problems pre-surgery. Despite this, most patients demonstrate only mild difficulties on standardized language tests. In the majority of patients, objective performance is reported to decline immediately after resection followed by improvement to the pre-surgical level within the first months (Antonsson et al., 2018; Duffau et al., 2008; Finch & Copland, 2014). Less is known about the course of self-reported word-finding problems. Some authors have suggested that self-reported difficulties and objective performance show different patterns (Brownsett et al., 2019; Racine et al., 2015). Racine et al. (2015) demonstrated that 83% of the participants in their study reported new or continuous word-finding difficulties at seven months follow-up, even though no significant decline was found in objective performance. Since the subjective experience of functioning is recognized as a crucial aspect of well-being (Nicol et al., 2019), it seems relevant to investigate how self-reported word-finding difficulties in glioma patients evolve during the first year of illness.

Word-finding difficulties range from tip-of the tongue experiences to rarely retrieving the intended word, leading to slow and hesitant speech (Laine & Martin, 2006). One of the most used tests to assess word-finding difficulties in various patient groups is the Boston Naming Test (BNT; Bortnik et al., 2013; Kaplan et al., 1983). However, the test has been criticized for having low psychometric properties (Harry & Crowe, 2014). In glioma studies, there are indications that the BNT lacks sensitivity to detect patient-reported word-finding difficulties (Moojiman et al., 2021; Racine et al., 2015). Word knowledge, such as assessed by vocabulary tests, has shown to be an important factor that modulates word-finding performance, in that greater vocabulary facilitates better word retrieval. Several authors have therefore suggested that both tests of naming and word knowledge should be

included when assessing word-finding difficulties (Harry & Crowe, 2014; Kavé & Yafé, 2014).

Word-finding difficulties may also relate to reduced linguistic processing speed (Antonsson et al., 2023; Moojiman et al., 2021). Everyday conversations require rapid exchange and processing of verbal information. Thus, even slight interruptions in the flow of communication may influence self-perceived performance (Antonsson et al., 2023). Tests of semantic fluency have shown to be sensitive to decline in glioma patients (Antonsson et al., 2018; Norrelgen et al., 2020; Satoer et al., 2014). Semantic fluency tests assess word production under time pressure. In addition to semantic knowledge, several cognitive functions are also involved in these tasks, e.g., the patients' ability to generate and follow a strategy, think flexibly and self-monitor their verbal production (Lezak et al., 2012). These "executive" aspects of verbal behavior may therefore relate to word-finding difficulties experienced in real life situations.

Another important factor shown to develop and maintain self-reported language and cognitive difficulties in cancer patients is psychological distress (Green et al., 2005). Åke et al. (2023) described negative feelings such as anger, insecurity, and anxiety in relation to language function three to five years after glioma diagnosis. Stress and frustration were especially related to word-finding difficulties, increasing in demanding situations.

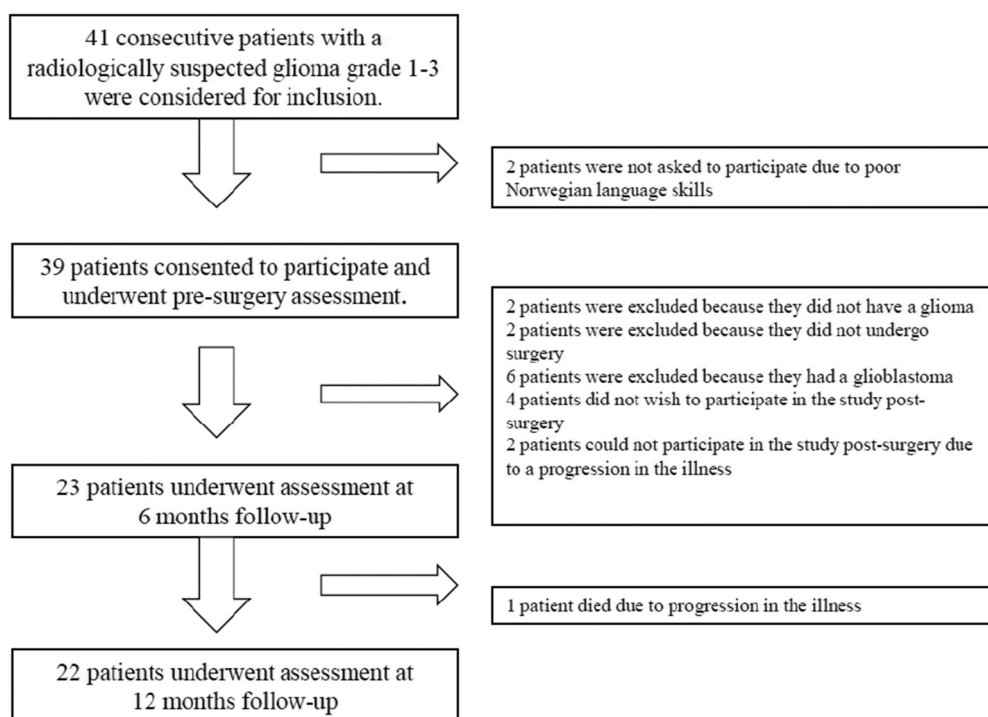
The clinical importance of self-reported difficulties is highlighted as they in turn have a negative effect on life satisfaction and participation in social roles (Ammanuel et al., 2022). Patients with brain tumors are known to experience poorer social functioning than other cancer patients (Aarons et al., 2011) and disturbed communication abilities are among the leading causes for withdrawal from social participation (Cubis et al., 2022). These barriers are reported to endure over time and have negative implications for QoL (Cubis, 2022; Ake et al., 2022). Self-reported word-finding difficulties are seldom explored systematically and longitudinally, while including several objective language measures and psychological distress.

Given an increased focus on patient-centered approaches in clinical practice (Dirven et al., 2018) and because language and word-finding are among the functional domains of major concern for patients (Gabel et al., 2019), this longitudinal study seeks to increase the understanding of how self-reported word-finding difficulties evolve over time and if they can be predicted by performance on objective tests and symptoms of psychological distress. The results will enable healthcare professionals to meet patients' concerns and improve counseling and care.

## **Materials and methods**

### ***Participants***

Patients with a radiologically suspected glioma grade 1–3 referred to the Department of Neurology or the Department of Neurosurgery at Haukeland University Hospital, Bergen, Norway, were invited to participate. Between May 2018 and April 2021, 41 consecutive patients were considered for inclusion. Exclusion criteria were a prior record of neurological disease, severe psychiatric disorders and alcohol or substance abuse. If histological examination revealed



**Figure 1.** Flow chart describing patient selection.

a glioblastoma, the patient was excluded from further participation, due to likelihood of progression during the follow-up period. Non-native speakers of Norwegian were considered for participation and included if they used Norwegian in everyday life and their language abilities were sufficient to complete assessment. Patients with tumors in the right hemisphere were included ( $N = 4$ ) based on studies that have found mild post-surgical deficits with word-finding in the group (Antonsson et al., 2018; Papagno et al., 2012). In total, 23 patients returned for follow-up and were included in the current analyses (Figure 1). The sample included 13 (57%) women. The mean age was 42.3 years ( $SD$  14.1; range 21–70) and the mean education was 14.7 years ( $SD$  2.8; range 9–19). Four patients had a tumor in the right and 18 in the left hemisphere. One patient had bilateral tumors. Eight patients had a lesion within language eloquent brain areas in the left hemisphere. Histological examination revealed that 13 patients had a LGG (grade 1,  $N = 2$ , grade 2,  $N = 11$ ) and ten a HGG (grade 3). Epileptic seizures were the initial presentation of illness in 13 (57%) patients. Fourteen patients (61%) received adjuvant cancer therapy, i.e., chemotherapy and/or radiation therapy post-surgery. Demographic characteristics are presented in Table 1. All patients provided written informed consent. The study was approved by the Regional Committee for Medical Research Ethics (REK West, #2018/345) and conducted in accordance with the Declaration of Helsinki (World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects, 2013).

**Table 1.** Demographic and tumor characteristics.

Sex/age/ education	Handedness	Site of lesion	Location	Language- eloquent area	Histology	Seizures	Post-surgery treatment
F/24/16	L	L	Frontal	No	III A	Yes	RT+ TMZ
M/48/13	R	L	Frontal	No	II O	No	RT + PCV
M/21/12	R	L	Temporal	Yes	I G	Yes	No
M/48/10	R	R	Frontal		II O	Yes	No
M/35/12	R	R	Gyrus cinguli		III A	Yes	RT + TMZ
F/53/13	R	L	Frontal	No	III A	Yes	RT + TMZ
M/42/18,5	R	L	Frontal	No	II O	No	No
M/57/12	L	L	Temporal	No	I A	No	No
F/36/16	R	R	Parietal/occipital		III A	No	RT + TMZ
M/49/12	R	L	Frontal	No	III A	Yes	RT + TMZ
F/37/11	R	L	Frontal	No	II O	No	No
M/29/12	R	L	Hippocampus region	Yes	II A	Yes	RT + TMZ
F/47/14	R	L	Parietal	Yes	III O	Yes	RT + PCV
M/70/19	R	R	Frontal		II A	Yes	No
F/49/16	R	L	Temporal	Yes	III A	Yes	RT + TMZ
F/29/19	R	B	Frontal L, Parietal R	No	II A	No	No
F/27/17	R	L	Temporoparietal	Yes	II A	No	No
F/66/12	R	L	Insula/ FrontalTemporal	No	II O	No	RT + PCV
F/64/17	R	L	Temporal	Yes	II A	No	RT + PCV
F/41/16	R	L	Frontal/Basalganglia/ Thalamus	Yes	III O	Yes	RT + PCV
M/33/16	R	L	Temporoparietal	Yes	II O	Yes	No
F/21/15	R	L	Frontoparietal	No	III O	Yes	RT + PCV
F/47/18	R	L	Frontal	No	III A	No	RT + TMZ

Handedness/Site of lesion: R: right; L: left. Histology: A: astrocytoma; O: oligodendroglioma; G: ganglioglioma. Post-surgery treatment: RT: radiotherapy; TMZ: temozolomide; PCV: procarbazine

## Procedures

All included patients were assessed with neuropsychological tests and self-reported questionnaires. The assessments took place pre-surgery (T1), at approximately six (T2) and twelve months (T3) follow-up. The median interval between T1 and surgery was eight days (*range* 1–43). After surgery, the subsequent assessments occurred at 5.3 months (*range* 2.8–7.5, T2) and 12.1 months (*range* 11.2–19.2, T3). The variation in time intervals was inevitable due to Covid-19 restrictions during the study period. All assessments were administrated by the first author (EO), a speech-language pathologist, or the last author (EW), a clinical neuropsychologist. The patients underwent surgery with microsurgical techniques assisted with neuronavigation and intraoperative ultrasound to maximize safe resection. One patient underwent a biopsy due to the tumor's location, in another awake surgery with perioperative language mapping was performed.

Tumor location was assessed by a neuroradiologist using FLAIR images. T1-weighted and T2-weighted images were reviewed when FLAIR images were unavailable. The left hemisphere was considered dominant and further categorized as follows: (a) language eloquent areas (inferior frontal gyrus, subcentral gyrus, supra-marginal gyrus, angular gyrus, inferior, middle and superior temporal gyrus) and (b) non-language eloquent areas (precentral, middle and superior frontal gyrus, with no involvement of the inferior frontal gyrus; Naidich et al., 2001).

## Assessment

### *Self-reported word-finding difficulties*

The Functional Assessment of Cancer Therapy – Brain version 4 (FACT-Br; Weitzner et al., 1995) was administered. The questionnaire consists of four subscales measuring physical, emotional, social and functional well-being, in addition to a brain cancer specific subscale. For the current analysis, self-reported word-finding was evaluated with the item: *I am able to find the right word(s) to say what I mean* from the brain cancer subscale. Test-retest reliability for the brain cancer subscale in a larger sample has been reported ( $r = 0.66, p < 0.001$ ), which was considered sufficient by the authors (Weitzner et al., 1995). The answer categories range from 0 (not at all) to 4 (very much). A score of 0–1 was defined as serious difficulties, 2 as moderate difficulties, 3 as mild difficulties, and 4 as no difficulties.

### *Language assessment*

For measuring confrontation naming, the BNT was used. The test consists of 60 ink drawings that range in familiarity, the patient obtains one point for each correct answer. Semantic fluency was assessed with two conditions, *animals* and *male names* (Delis et al., 2001). The patient is asked to produce as many words as possible within 60 seconds for each condition. Word knowledge was assessed with the Vocabulary test (Wechsler, 2008). The test contains 42 words, listed in the order of difficulty. One or two points are given for an acceptable definition of each word's meaning, depending on accuracy and completeness.

### *Psychological distress*

Self-reported symptoms of psychological distress were assessed with the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983). The HADS is a screening instrument consisting of one subscale for anxiety and one for depression. Each subscale contains seven items, summing up to scores between 0–21 for each scale, with higher scores indicating more self-reported symptoms (Bjelland et al., 2002). In oncological settings, the HADS is one of the most commonly used questionnaires to identify distress in patients (Zigmond & Snaith, 1983). In the current study, the HADS total, a combined score for anxiety and depression, was used as a measure of symptoms of psychological distress according to recommendations as a good overall measure for distress (Singer et al., 2009).

## Statistical analysis

Descriptive statistics were used to characterize the sample. To explore if tumour- and treatment-related variables were associated with worsening or no change/improvement in self-reported word-finding difficulties between T1–T2 and T1–T3, Fisher's exact tests were used. The patients were categorised in groups according to the variables: tumour grade (LGG/HGG), site of lesion (left/right), localization within left hemisphere (language eloquent/non-eloquent), seizures (yes/no) and adjuvant cancer therapy (yes/no). Scores on objective tests between T1–T2 and T1–T3 were compared with Wilcoxon signed ranks tests. Group differences (language eloquent/non eloquent) on objective tests were

examined with Mann-Whitney U tests. Relationships between objective variables were checked with Spearman correlations. These analyses were performed in IBM SPSS Statistics for Windows (IBM Corp., Version 26.0. Armonk, NY.) and an alpha-level was set at  $p < 0.05$ . All further analyses were performed in R version 4.1.1. (R Foundation for Statistical Computing, Vienna, Austria).

To test changes in self-reported word-finding difficulties between T1–T2 and T1–T3, a cumulative link mixed-model using the `clmm` function from the ordinal R package (Christensen, 2018) was applied. The outcome variable vector included the assessment of self-reported word-finding at T1, along with post-surgery assessments at T2 and T3. Time (T) was included into the model as a fixed effect and the only predictor and treated as a categorical variable with three levels representing T1, T2 and T3. T1 was considered as the reference time point. A patient-level random intercept was included in the model to account for the repeated outcome measurements within patients.

To test the association of the BNT, Semantic fluency, Vocabulary and the HADS total with self-reported word-finding, ordinal regression models were used. This regression method was chosen due to the ordinal scale of self-reported word-finding difficulties as a dependent variable. Our initial analytical approach involved constructing univariable models, where only one predictor was included to assess its association with self-reported word-finding. Each potential predictor, i.e., BNT, Semantic Fluency, Vocabulary, and HADS total, was individually tested at each time point. Furthermore, predictors exhibiting significant associations with self-reported word-finding at any given time were included into the final ordinal regression model, referred to as the multivariable model. Collinearity among predictors in the multivariable model was checked using multicollinearity diagnostics by variance inflation factor (VIF). Multicollinearity was assumed if the VIF score was  $> 5$  (O'Brien, 2007). The univariable and multivariable models underwent testing for each time point independently, with the Bonferroni correction as  $p \leq 0.017$  applied to maintain the appropriate significance level. Due to the small sample size results below the  $p$ -level of 0.05 are additionally reported and discussed.

Ordinal regression analyses were performed using cumulative link models (`clm` function) of the ordinal R package (Christensen, 2018). To determine whether the proportional odds assumptions were met, a likelihood ratio test was performed. This assumption implies that the effects of the predictors are the same across all categories of the ordinal dependent variable (McCullagh, 1980). Results were shown with parameter estimates (log odds) and 95% confidence intervals (CIs). All regressions when required were re-analysed without outliers, which did not significantly affect the results.

## Results

### *Self-reported word-finding difficulties*

The total proportion of individuals reporting word-finding difficulties was 68% at T1, 90% at T2 and 85% at T3. Over time, changes between answer categories were observed and the percentage of patients reporting mild difficulties declined slightly (32%, 36% and 30% at T1, T2, T3, respectively), with a similar pattern for the group of patients reporting

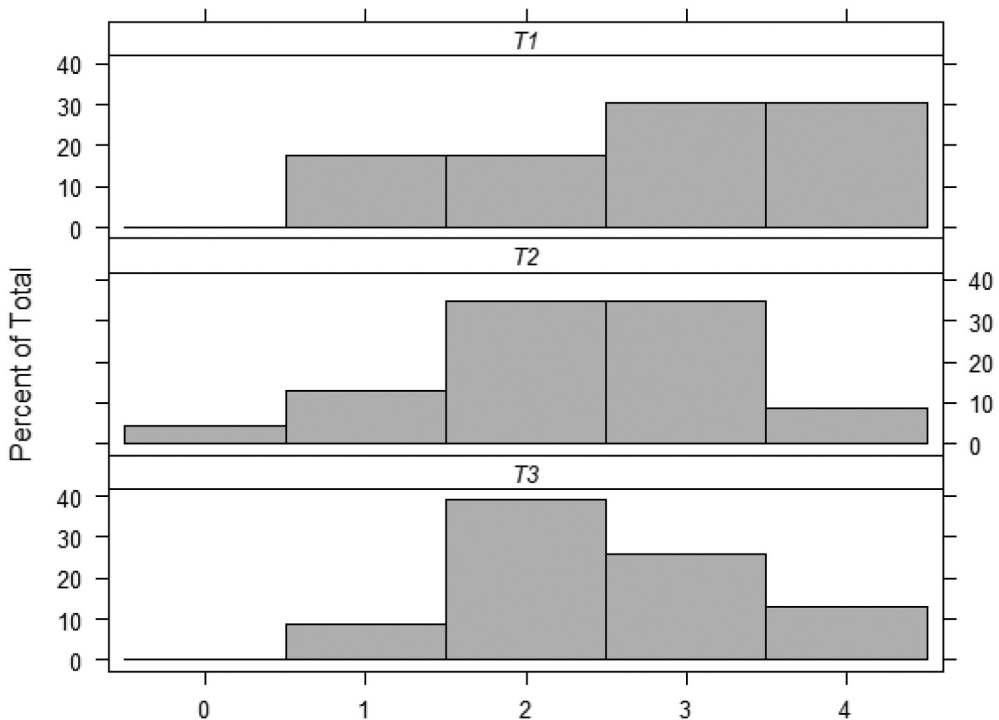


serious difficulties (18%, 18% and 10%; T1, T2, T3, respectively). The largest changes were seen in the group of patients reporting moderate difficulties increasing from 18% (T1) to 36% (T2) ending at 45% (T3; [Figure 2](#)). Between T1–T2, 48% of the patients reported worsening in word-finding, 37% reported no change and 15% reported improvement. Between T1–T3, 32% reported worsening, 53% reported no change and 16% reported improvement ([Figure 3](#)). Fisher's exact tests demonstrated no differences between groups based on tumor or treatment related factors (LGG/HGG; site of lesion: left/right; language eloquent area/language non-eloquent area; seizures: yes/no, adjuvant cancer therapy: yes/no) with regard to reporting worsening or no change/improvement of word-finding difficulties between T1–T2 (all  $p > 0.251$ ) or T1–T3 (all  $p > 0.316$ ).

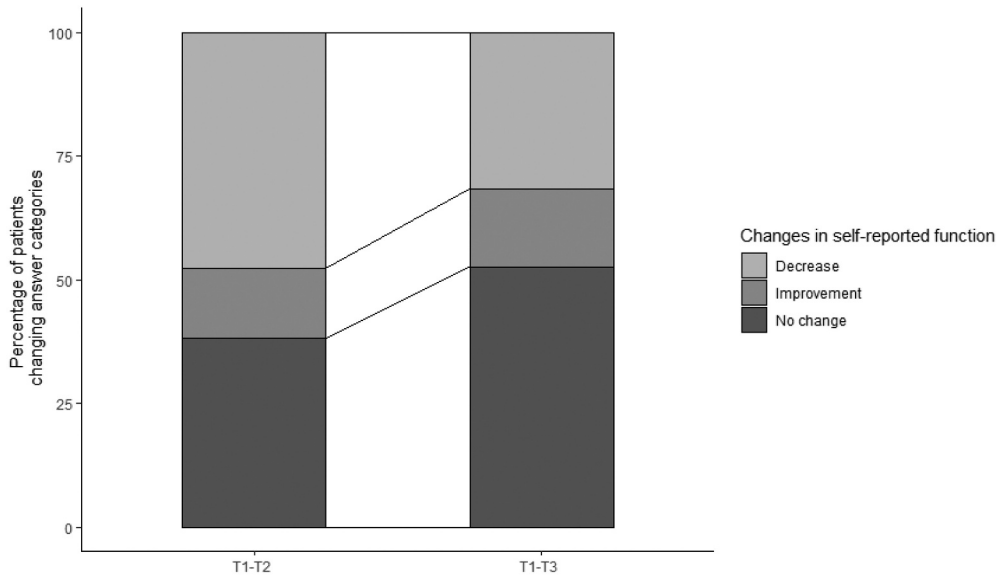
The mixed-model analysis (clmm) indicated a significant decrease of  $-1.33$  (95% CI:  $-2.613, -0.0502$ ,  $p = 0.042$ ) in the expected value of self-reported word-finding (more difficulties) on the log odds scale when comparing T1–T2. There was not a significant difference between T1–T3.

### Language assessment

Performance scores on all tests are shown in [Table 2](#). There were no significant changes in scores between T1–T2 and T1–T3 on the BNT or Vocabulary (Wilcoxon signed ranks tests all  $p > 0.111$ ). Scores on Semantic fluency decreased significantly



**Figure 2.** Histogram demonstrating proportions of patients reporting word-finding difficulties within each category; 0–1: serious difficulties, 2: moderate difficulties, 3: mild difficulties, 4: no difficulties; T1: pre-surgery, T2: 6 months follow-up, T3: 12 months follow-up.



**Figure 3.** Barplot demonstrating the percentage of patients changing answer categories on self-reported word-finding difficulties. T1: pre-surgery; T2: 6 months follow-up; T3: 12 months follow-up.

**Table 2.** Results on objective tests and measures of psychological distress.

	T1	T2	T3
	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>
<i>Language assessment</i>			
Boston Naming Test	49.3 (6.8)	46.6 (10.8)	48.3 (10.4)
Semantic fluency	43.1 (10.1)	38.6 (10.2)	41.7 (10.6)
Vocabulary	54.9 (8.9)	53 (9.7)	56.6 (7.9)
<i>Psychological distress</i>			
HADS-A	6 (5.5)	5.6 (3.9)	5.3 (4.1)
HADS-D	3 (2.6)	3.8 (2.7)	3.3 (3.1)
HADS total	9.1 (5.5)	9.2 (6.2)	8.6 (6)

T1: pre-surgery, T2: 6 months follow-up, T3: 12 months follow-up, *M*: mean, *SD*: standard deviation, HADS-A: Hospital Anxiety and Depression Scale – Anxiety, HADS-D: Hospital Anxiety and Depression Scale – Depression.

between T1–T2 (Wilcoxon signed ranks test  $p = .018$ ), no significant change was detected between T1–T3 ( $p = .404$ ). No differences between patients with tumors within or outside language eloquent areas of the left hemisphere were detected on any of the objective language variables (Mann Whitney U tests all  $p > 0.350$ ). Significant Spearman correlations between the BNT and Vocabulary were found at T1 ( $r = 0.697$ ,  $p = .001$ ), T2 ( $r = 0.545$ ,  $p = .013$ ) and T3 ( $r = 0.730$ ,  $p = .001$ ). Significant correlations between Semantic fluency and the BNT were found at T2 ( $r = 0.447$ ,  $p = .042$ ) and T3 ( $r = 0.470$ ,  $p = .036$ ). No significant correlations were found between Semantic fluency and Vocabulary.

## Psychological distress

Ratings of psychological distress are shown in [Table 2](#).

### *Predictors for self-reported word-finding difficulties*

The univariable ordinal regression showed significant associations between self-reported word-finding and Vocabulary ( $p = 0.017$ ) and the HADS total ( $p = 0.007$ ) at T1 ([Table 3](#)). The positive coefficients of Vocabulary indicated that higher values (better performance) were associated with higher ratings of self-reported word-finding (less difficulties). In contrast, the negative coefficient of the HADS total variable showed that higher HADS total values (more symptoms of psychological distress) were associated with lower self-reported word-finding (more difficulties). At T2, only Vocabulary had a significant association with self-reported word-finding ( $p = 0.002$ ). At T3, results did not reach significance at the Bonferroni-corrected level, but results on Vocabulary ( $p = 0.035$ ) and the HADS total ( $p = 0.020$ ) were below the  $p$ -level of 0.05.

The multivariable ordinal regression showed that Vocabulary was significant at T2 ( $p = 0.002$ ). Results on the HADS total were below the  $p$ -level of 0.05 at T1 ( $p = 0.048$ ) and T3 ( $p = 0.049$ ) ([Table 3](#)). Multicollinearity was tested before entering Vocabulary and the HADS total into the multivariable models. Since all VIF values were below 1.3 no collinearity issues existed in the multivariable models ([Table 4](#)).

## Discussion

In this long-term follow-up study, we found that a large proportion of glioma patients reported word-finding difficulties within the first year of disease and that the magnitude of difficulties increased significantly between pre-surgery assessment and six months follow-up. This effect was no longer apparent after one year. A reason for this may be that self-reported function changes dynamically during the first year, showing a decrease in the first months after surgery and some improvement thereafter.

Our results are in line with Racine et al. (2015) although numbers vary slightly. Both studies indicate that self-reported word-finding difficulties occurred in a large proportion of patients pre-surgery (our study: 68%, Racine et al.: 63%) and that reported difficulties increased after resection (our study: 22%, Racine et al.: 25%). Findings regarding improvement differed in that Racine et al. found that 29% in their sample reported improvement at seven months follow-up, whereas this number was 15% in our sample. One explanation for the differences may be that Racine et al. obtained their answers during neuropsychological interviews and they had a different answer format. In our study, graded response categories ranging from “not at all” to “very much” were given. Graded response categories may enable the clinician to range concerns and address changes at follow-up. This is stressed by our results showing that the magnitude of difficulties increased significantly after surgery. Yet, we did not find significant differences between T1 and T3. These results suggest that patients report worsening during the first months after surgery followed by some improvement. The clinical significance and implication of these reports may vary between patients but the results underline the importance of addressing this topic at

**Table 3.** Results from univariable and multivariable regression analyses Univariable ordinal regression analysis.

Variables	T1		T2		T3	
	Estimate (p value)	95% CI	Estimate (p value)	95% CI	Estimate (p value)	95% CI
BNT	0.127 (0.057)	(-0.004, 0.286)	0.044 (0.215)	(-0.026, 0.121)	0.067 (0.111)	(-0.015, 0.161)
Semantic fluency	0.044 (0.276)	(-0.034, 0.128)	0.004 (0.266)	(-0.035, 0.127)	0.071 (0.087)	(-0.008, 0.158)
Vocabulary	0.126 (0.017)**	(0.02, 0.26)	1.643 (0.002)**	(0.054, 0.265)	0.337 (0.035)*	(0.008, 0.245)
HADS total	-0.221 (0.007)**	(-0.406, -0.059)	-0.067 (0.329)	(-0.212, 0.068)	-0.1763 (0.020)*	(-0.356, -0.026)
Multivariable ordinal regression analysis						
Vocabulary	0.087 (0.134)	(-0.001, 0.224)	Estimate (p value) 0.146 (0.002)**	95% CI (0.123, 0.263)	Estimate (p value) 0.093 (0.118)	95% CI (-0.001, 0.223)
HADS total	-0.174 (0.048)*	(-0.367, -0.026)	-0.025 (0.729)	(-0.170, 0.048)	-0.156 (0.049)*	(-0.338, -0.024)

BNT: Boston Naming Test, T1: pre-surgery, T2: 6 months follow-up, T3: 12 months follow-up, \*\* Results significant at Bonferroni-corrected level  $p \leq 0.017$ , \*  $p < 0.05$

**Table 4.** Results of multicollinearity diagnosis.

Time	Variables	VIF
T1	Vocabulary	1.180
T1	HADS total	1.180
T2	Vocabulary	1.089
T2	HADS total	1.089
T3	Vocabulary	1.258
T3	HADS total	1.258

VIF: Variance inflation factor, T1: pre-surgery, T2: 6 months follow-up, T3: 12 months follow-up

follow-up. Another issue that needs to be addressed is that using clinical interviews or single questions may be a source of bias as patients often refer to different concepts when describing difficulties, e.g., word finding difficulties may be reported as memory problems (Satoer et al., 2012). Multi-item scales could address this issue in future studies.

We found that lower performance on the Vocabulary test significantly predicted self-reported difficulties at the first two time points in the univariable regression models and was the only significant predictor at six months in the multivariable analysis. The BNT did not predict word-finding difficulties, but the scores were highly correlated with Vocabulary scores at all points in time. Correlations between the tests have been reported in earlier studies, suggesting a relationship between adequacy of word knowledge and naming performance (Thompson & Heaton, 1989). Our results are in line with studies which indicate that confrontation naming is not sufficient to detect the subtle language changes often reported by glioma patients (Moojiman et al., 2021; Racine et al., 2015; Satoer et al., 2012). Satoer et al. (2018) conducted a linguistic analysis of spontaneous speech in glioma patients and found deterioration of performance (e.g., more incomplete sentences, shorter utterances) during the first year of illness that did not correlate with performance on the BNT. Our study, along with others, suggests that clinicians should not draw conclusions about word-finding abilities solely based on confrontation naming performance, as other tests may be better aligned with difficulties experienced in everyday life.

Semantic fluency performance showed a significant decline between pre-surgery assessment and six months follow-up. This is in line with earlier studies showing that semantic fluency is sensitive to deterioration after glioma surgery (Antonsson et al., 2018, 2023; Norrelgen et al., 2020; Satoer et al., 2014). Given the importance of temporal demands in day-to-day communication, it was surprising that our results did not demonstrate a relation between semantic fluency and self-reported word-finding difficulties. Performance on semantic fluency relies on the integrity of both linguistic and executive abilities. Our results may suggest that the deterioration observed in the sample was more strongly linked to difficulties in executive function rather than word production, but it was not within the scope of the study to investigate that in more detail.

Symptoms of psychological distress were reported with slightly changing patterns during the study period. Symptoms of anxiety were higher than symptoms of depression, a pattern commonly reported (Bunevicius et al., 2013; Noll et al., 2017; Pranckeviciene et al., 2017). Anxiety levels were highest at the first assessment and most likely related to the upcoming surgery. Twelve months later the levels had declined but were still higher than symptoms of depression. This may indicate that living in constant awareness of

possible tumor progression can maintain elevated levels of anxiety. The relationship between self-reported cognitive concerns and emotional and mental symptoms is well documented (Gehring et al., 2015; Green et al., 2005; Hutchinson et al., 2012; Pullens et al., 2010). Many studies investigating self-reported language difficulties in glioma patients have not included measures of psychological distress but focused on relations between subjective and objective measures of language function (Brownsett et al., 2019; Moojiman et al., 2021; Racine et al., 2015; Satoer et al., 2012). In our study, the HADS total seemed an important predictor for word-finding difficulties before surgery. At follow-up, the results did not outlast the Bonferroni-correction. The results are nevertheless noteworthy since the univariable and multivariable regression analysis demonstrated that psychological distress had  $p$ -levels below 0.05 one year after surgery. Hence, the inclusion of psychological distress in assessments regarding language function seems valuable. Psychological distress has been reported to generate over-reporting of subjective difficulties (Gehring et al., 2015) and our results could mirror that.

In a study of the subjective experience of word-finding difficulties in patients with aphasia after stroke, Fama et al. (2022) found numerous negative feelings, such as frustration, sadness and embarrassment, associated with self-reported word-finding difficulties. Further, these concerns were reported to negatively impact the ability to connect and communicate with family and friends. Our results imply a persistent relation between symptoms of psychological distress and self-reported word-finding difficulties. This substantiates the suggestion that psychological distress and mental health should be addressed routinely during treatment and follow-up, as symptoms of distress often remain undetected and untreated in glioma patients (Carlson et al., 2004).

We acknowledge the limitations of our study. The small sample size limited our possibilities to include additional predictors in the regression analyses and generalize our results. We chose to focus on a single self-reported function in glioma patients, word-finding difficulties, which is a limited perspective in a patient group with a complex symptom burden (Armstrong et al., 2015). How multiple symptoms interfere with each other and impact functional status is still poorly understood (Röttgering et al., 2023). We argue that since word-finding difficulties are a prominent concern for patients, it is worthwhile to investigate them explicitly and increase focus on this topic. We recognize that other symptoms, e.g., fatigue, disturbed sleep and pain may have been interrelated with both psychological distress and the language variables investigated in our study. In addition, tumor related factors may have had an impact on the results. This remains to be addressed in future studies. Secondly, we acknowledge that communication is dependent on complex, interactive cognitive processes, among them executive functions, attention and processing speed which were outside the scope of this study. These cognitive functions may have influenced both results on objective tests, self-reported word-finding difficulties, and levels of psychological distress.

## Conclusion

This study demonstrates that acknowledging the patients' perspective on functioning is an important aspect of glioma treatment. Between 68%–90% of the sample reported mild to moderate word-finding difficulties at one or more assessments. Changes were observed between follow-ups in that the magnitude of reported

difficulties increased significantly after surgery. Predictors of word-finding shifted from including both Vocabulary scores and psychological distress in the univariable analyses, while Vocabulary remained the only significant predictor in the multivariable analyses. Psychological distress seemed an important factor, but the results did not remain significant after correcting for multiple testing. The BNT and Semantic fluency did not predict self-reported word-finding difficulties. The results indicate that these tests should not be used as sole measures of word-finding as they do not always mirror the difficulties experienced by the patients. The results suggest further that assessing self-reported concerns and psychological distress could be a valuable supplement to objective language testing in glioma patients, and that routine assessment may be beneficial to evaluate changes during the course of disease. Future research should seek to identify if and how self-reported word-finding difficulties affect life participation, social engagement and return to work, all important aspects of QoL.

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