Short report: The moderating effect of estimated pre-morbid IQ on the relationship between neuropsychological status and subjective well-being after brain tumor

Running head: premorbid IQ and adjustment to brain tumor

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Abstract

Objective: People with brain tumor experience complex and distressing symptoms. Neuropsychological impairment is proposed to have a negative impact on subjective well-being; however, research is yet to examine the influence of estimated premorbid IQ on this relationship. This preliminary study investigated the moderating effect of estimated premorbid IQ on the relationship between global neuropsychological status (GNF) and depression and quality of life.

Methods: 73 adults (51% male) aged 21-65 years with primary brain tumor (52% benign) were administered a test battery assessing estimated premorbid IQ, GNF, depression (Depression Anxiety Stress Scales) and quality of life (Functional Assessment of Cancer Therapy; FACT).

Results: A series of two-way analysis of covariance (ANCOVA) controlling for education found a significant interaction between estimated premorbid IQ (low average to average vs high average) and GNF (low vs high) on levels of depression ($p < .05$) and FACT emotional well-being ($p < .05$). For these outcomes, individuals with high average estimated premorbid IQ and low GNF reported better well-being than those with low-average to average estimated premorbid IQ and low GNF. Higher GNF was related to greater functional well-being ($p < .01$) irrespective of estimated premorbid IQ.

Conclusion: The finding that higher premorbid cognitive ability buffers the effect of neuropsychological impairment on emotional well-being after brain tumor advances understanding of the role of cognitive reserve in adjustment to neurological disorders.

Key words: Brain tumor, neuropsychological impairment, emotional well-being, quality of life and cognitive reserve

Brain tumors are rare, but serious and chronic and they have the combined effects of brain injury and cancer. The worldwide incidence of malignant and benign tumors is 6.4/100 000 and 2.9/100 000 respectively [1]. Although brain tumors vary in their neuropathology and treatment, all forms pose a significant threat to people's functional status and subjective well-being [2,3]. People typically experience alarming symptoms (e.g., seizures, sensory loss) prior to diagnosis with uncertainty about their future outcome. Anxiety and depression has been reported in 30-50% of patients [3].

While neurological characteristics (e.g., tumor type, grade and treatment) are generally reliable predictors of survival and functional status [4-6] they are poor predictors of subjective well-being indicators, such as depression and quality of life [3,7]. Adjustment to brain tumor is influenced by an interplay of premorbid characteristics, neurological status and personal and social resources [3]. Theories of stress and coping have been applied to understand how people make sense of and cope with their illness [8,9]. However, cognitive impairments arising from brain tumor can compromise the adjustment process.

Neuropsychological testing is a common method to determine the impact of brain injury on everyday functioning [10]. Indeed, such results can be more sensitive to early tumor recurrence than imaging techniques [11]. Numerous studies have documented the effects of brain tumor on global cognitive functioning, processing speed, attention, memory, visuo-spatial skills, language and executive functioning [5,6,12]. However, research investigating the relationship between neuropsychological impairment and quality of life (QoL) has yielded mixed findings [3]. A possible explanation for these inconsistent results relates to the influence of premorbid cognitive ability or IQ [13]. Specifically, people with higher premorbid IQ may have greater capacity to cope with neuropsychological decline than those with low premorbid IQ.

The concept of cognitive reserve has been proposed to account for differences in functional outcomes of individuals with similar brain pathology in the context of head injury, stroke and dementia [13]. Cognitive reserve refers to the process of optimising performance by drawing upon one's neural networks to cope with increased task demands or to compensate for brain damage [13]. According to Jones et al. [14], cognitive reserve is “a feature of brain structure and/or function that modifies the relationship between injury or pathology and performance on neuropsychological tasks or clinical outcomes.” (p. 593). Cognitive reserve develops throughout life and is strongly influenced by environmental stimulation, including educational and occupational opportunities. Greater cognitive reserve (i.e., higher education, occupational status or premorbid IQ) is found to be a protective factor and enhance well-being in the context of dementia [15], head injury [16], psychopathology [17] and chemotherapy treatment for cancer [18]. However, the role of cognitive reserve in adjustment to brain tumor has yet to be investigated.

This preliminary study investigated the moderating effect of estimated premorbid IQ on the relationship between neuropsychological functioning and depression and QoL after brain tumor. It was hypothesised that high average estimated premorbid IQ would buffer the effects of low global neuropsychological status on emotional status and QoL.

Methods

Participants

Seventy-three adults with brain tumor were recruited from metropolitan-based neurosurgery clinics and brain injury and cancer support services from 2008-2012. The sample included a subset of participants ($n = 28$) from a previous study [19]. Study inclusion criteria included: diagnosis of a primary brain tumor; aged 18-65 years; no pre-existing psychiatric, neurological or literacy disorder; adequate receptive and expressive English

language skills. An informal screen for aphasia during the pre-assessment interview identified two participants with expressive language difficulties who were excluded from the study.

Participants were aged 21-65 years ($M = 47.61$, $SD = 12.1$) and on average were diagnosed 2.94 years ($SD = 3.6$) ago. Education ranged from 8 to 19 years ($M = 12.9$, $SD = 2.7$).

Approximately half of the sample (52%) had been diagnosed with benign or low grade tumor (pituitary = 10, meningioma = 8, astrocytoma = 6, oligodendroglioma = 4, craniopharyngioma = 3, colloid cyst = 3, oligoastrocytoma = 2 and unspecified low grade glioma = 6). Malignant or high grade tumors (48%) included glioblastoma multiforme ($n = 17$), oligodendroglioma ($n = 8$), anaplastic astrocytoma ($n = 4$) and unspecified high grade glioma ($n = 2$). Most participants had received surgery as the primary treatment (79.5%) in isolation or combined with chemotherapy and/or radiation.

Measures and Procedure

Following ethical clearance and informed consent procedures participants completed an assessment battery lasting 1–1.5 hours. Participants were initially administered the Wechsler Test of Adult Reading [20], a word pronunciation test that provides a reliable estimate of premorbid IQ in the context of neurological disorder. Participants also completed standardised tests of attention, memory, visuo-spatial skills, language and executive function (Digit Span, Hopkins Verbal Learning Test [total recall and delayed recall], Rey Complex Figure [copy and 30-minutes recall], Trail Making Test [part A and B], and Verbal Fluency [total words]). Standardised scores (z -scores) were calculated using age-based norms (i.e., Digit Span and Rey Complex Figure) or age and education-based norms where available (i.e., Trail Making Test, Verbal Fluency, Hopkins Verbal Learning Test) [10, 21]. Based on the approach of Armstrong et al. [12] a composite score was calculated by summing and averaging the z -scores on each test. A principal components analysis found that test scores

loaded onto one factor ($\lambda = 3.10$, commonalities = .38-.75), labelled global neuropsychological function (GNF).

The Functional Assessment of Cancer Therapy (FACT) [22] includes physical, social, emotional, and functional well-being subscales that combine to form a general index (FACT-G). Higher scores reflect better QoL and scores ≥ 0.5 *SD* below the norms ($M = 80.1$, $SD = 18.1$) signify poor QoL [23].

The Depression Anxiety and Stress Scales (DASS) [24] depression scale assesses low mood over the past week. Scores >9 are considered clinically meaningful. The scale has good reliability and validity for the brain tumor population [25].

Results

The data were screened for missing values and checked for relevant assumptions. Participants' mean depression score was in the mild clinical range ($M = 11.34$, $SD = 9.9$) and the mean FACT-G score ($M = 71.87$, $SD = 18.3$) was approximately 0.5 *SD* lower than population norms [23]. The mean estimated premorbid IQ for the sample was 103.72 ($SD = 8.3$; range = 78-119). According to standard clinical categories, 12.3% were in the "low average" range (IQ = 80-89), 54.8% were in the "average" range (IQ = 90-109) and 32.9% were in the "high average" range (IQ = 110-119). Participants with malignant tumor demonstrated slightly poorer GNF than participants with benign tumor ($M = -0.91$, $SD = 0.94$ vs. $M = -0.61$, $SD = 0.90$), which was not significant ($t = -1.38$, $p = .17$). There were no significant differences in estimated premorbid IQ, depression and QoL according to tumor type ($p > .3$). Of the other potential covariates (i.e., age, gender, education, and chronicity), only education was significantly related to depression ($r = -.24$, $p < .05$), functional well-being and FACT-G ($r_s = .26$ -.27, $p < .05$) and was treated as a covariate.

The interactive effects of estimated premorbid IQ and GNF were examined using analysis of covariance (ANCOVA). Dichotomous variables were created using a median split for GNF (i.e., low GNF $z \leq -.68$ and high GNF $z > -.68$) and standard clinical categories for estimated premorbid IQ (i.e., “low average to average” [80-109] and “high average” [110-119]). Significant interactions were evident for depression and FACT emotional well-being ($p < .05$) (see Table 1). Figure 1 shows that participants with high average estimated premorbid IQ and low GNF had lower depression and better emotional well-being than those with low average to average estimated premorbid IQ and low GNF. There were no significant interactions or main effects for physical well-being, social well-being or global QoL ($p > .05$); however, there was a significant main effect of GNF for functional well-being ($p = .002$) with a medium to large effect size ($\eta^2 = .13$).

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Discussion

Consistent with cognitive reserve theory [13, 14] this study found that high average estimated premorbid IQ supported individuals with lower neuropsychological functioning to maintain better emotional well-being after brain tumor. The findings suggest that these individuals were able to draw upon their pre-existing cognitive capacity to cope with the neuropsychological effects. A buffering effect was evident for depression and general emotional well-being (e.g., sadness, worry and hope), but not for global quality of life or the physical, social and functional well-being domains. Participants with high GNF reported better functional well-being (e.g., ability to work and enjoy life) than those with low GNF, irrespective of their estimated premorbid IQ.

A possible explanation for the buffering effect of high average estimated premorbid IQ for emotional well-being relates to the link between IQ and social resources such as socioeconomic status (SES). Although SES was not measured, pre-existing social resources are unlikely to fully account for the protective effects of premorbid IQ because education level was controlled for. Higher estimated premorbid IQ has also been found to promote more active coping strategies after brain injury [16]. While neuropsychological impairment can compromise coping skills [26], greater cognitive reserve may support people to manage the emotional impact of a neurological disorder. People with higher premorbid IQ may have better health literacy and be able to access and consume health-related information and services more effectively [27]. Furthermore, they may draw upon pre-existing resources (e.g., optimism and resilience) to cope with stressors associated with brain tumor. In support of this proposition, higher IQ has been found to be protective of psychopathology [17], and personality characteristics are known to influence long-term psychological adjustment to cancer [28]. With further understanding of the mechanisms underlying the buffering effect of cognitive reserve, there may be scope to harness or strengthen personal resources of individuals with brain tumour through psychosocial interventions.

Various limitations of this study need to be recognised, particularly those related to sample characteristics and measurement issues. First, due to the relatively small sample and heterogeneous tumor characteristics caution is needed in generalising these findings to the broader brain tumor population. Further research is needed to determine whether the buffering effect of high average IQ for emotional well-being is evident in more homogeneous brain tumour samples (e.g., people with low grade glioma). Second, estimated premorbid IQ was used as a single proxy indicator of cognitive reserve in this study. Although education level has been more widely used, Jones et al. [14] note that large age cohort differences exist in average level of educational attainment. An advantage of using estimated premorbid IQ

(i.e., word pronunciation) as a moderator is that this proxy indicator of cognitive reserve is associated with broader life experiences than formal education. While many older adults might have had less opportunity to complete high school and/or post-secondary education, they could increase their cognitive reserve and IQ through other mentally stimulating activities. In general, different proxy indicators have been used in prior research (e.g., educational attainment, occupation, intracranial volume) and a multiple-indicator method has been advocated for measuring the hypothetical construct of cognitive reserve [14]. Third, GNF was classified as ‘high’ or ‘low’ relative to the current sample rather than clinical cut-offs and this composite score was only partially adjusted for the effects of education. Neuropsychological data from controls matched on age, education and gender would strengthen future studies. Fourth, although participants were screened for aphasia as part of the pre-assessment interview, the lack of formal diagnosis and standardised screening test for aphasia is a further limitation.

Overall, these findings extend the growing body of literature indicating that psychosocial resources buffer the impact of negative life events on psychological well-being. This study’s novel contribution was identifying the moderating influence of estimated premorbid IQ on the relationship between neuropsychological impairment and emotional well-being, which advances understanding of adjustment to neurological disorders. Future research needs to determine how high average premorbid IQ buffers the effects of cognitive decline on emotional well-being with a particular focus on personal and social resources.

Acknowledgements

The authors would like to thank the Cancer Council Queensland for funding this study and also acknowledge the support of staff and services for recruitment of participants. We are particularly grateful to Ea Stewart, Kathryn Horrigan, Megan Broughton, Vivien Biggs and Val Goodwin for their expertise and support.

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Table 1.

Results of ANCOVA Investigating the Interactive Effects of Estimated Premorbid IQ (EPIQ) and Global Neuropsychological Function (GNF) on Emotional Well-being and Quality of Life ($n = 73$)

Independent variables (IVs)		Depression		FACT-General		FACT-Emotional Well-Being		FACT-Functional well-being	
		M (SD)		M (SD)		M (SD)		M (SD)	
Low average – average EPIQ	Low GNF ^a ($n = 28$)	17.00 (11.5)		64.77 (21.8)		14.56 (6.3)		14.00 (5.0)	
	High GNF ($n = 21$)	6.00 (6.7)		80.08 (13.6)		18.93 (4.2)		19.55 (5.0)	
	Low GNF ($n = 9$)	9.78 (10.1)		74.48 (16.1)		19.39 (6.3)		14.11 (5.8)	
	High GNF ($n = 15$)	8.92 (6.2)		73.67 (15.6)		17.55 (5.0)		17.78 (4.9)	
Covariate	Education	F	η^2	F	η^2	F	η^2	F	η^2
		1.82	.03	3.46	.05	–	–	3.62	.05
	IV (low average to average/high average)	0.43	.00	0.28	.00	1.51	.02	2.12	.03
IV (low/high)	GNF	4.99*	.07	1.44	.02	0.82	.01	9.91**	.13
	EPIQ x GNF	5.03*	.07	3.47	.05	4.92*	.07	0.63	.01

^a Low GNF $\leq$ -.68 (z-score); High GNF $>$ -.68 (z-score)

* $p < .05$, ** $p < .01$

Figures

Figure 1.

Significant interactions between estimated premorbid IQ (EPIQ) and global neuropsychological function (GNF) for depression, emotional well-being and quality of life