The relation between mood and cognitive functioning in glioma patients

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Abstract

Glioma patients commonly suffer from mood disturbances and cognitive deficits. Previous research showed that mood is related to both self-reported and objective cognitive functioning. However, there has been relatively little extensive analysis of this relation regarding to glioma patients. In the current study, thirty-one patients with low-grade and anaplastic gliomas were recruited from three hospitals in the Netherlands. Mood states of the participants were measured by the Profile of Mood States questionnaire. Objective cognitive functioning was measured using a battery of neuropsychological tests and subjective cognitive functioning was measured using the Cognitive Failures Questionnaire. Pearson correlation and Spearman coefficients for correlation were calculated and subsequently partial correlation analyses were performed to assess confounding factors in the association between mood and cognitive functions. In line with the expectations, a number of associations appeared to be significant: scores on tension, depression, anger, vigor and fatigue were significantly related with several aspects of subjective and objective cognitive functioning. No clinical variable was found to affect relationships between mood and cognitive functioning. The small sample size might limit the validity of our results and generalizability might be limited due to the inclusion procedure. Longer-term follow-up is recommended to better understand the relation between mood states and cognitive functioning. Assessment of the examined relationship is clinically relevant, because it will provide additional information about the clinical situation of the patients.

Keywords: Glioma, mood, subjective cognitive functioning, objective cognitive functioning

Introduction

A brain tumor is an uncontrolled multiplication of cells in the brain growing independently of adjacent structures (Kolb & Whishaw, 2011). Brain tumors can be divided in primary and secondary brain tumors. Primary brain tumors arise in the brain or in the meninges. In contrast, secondary brain tumors emerge from metastases of tumors located in other areas of the body (Kuks & Snoek, 2007). Most prevalent primary brain tumors are gliomas (Maher et al., 2001). Gliomas originate from glial cells, which are responsible for supporting and protecting neurons (Bosma et al., 2006).

Glioma patients can have major psychological difficulties. One with high prevalence is cognitive impairment. A study of Fox, Mitchell, and Booth-Jones (2006) shows a surprisingly high degree of self-reported cognitive deficits. Between 50 to 80% of the patients reported deficits in at least one area. Additionally, a neuropsychological battery demonstrated several objective cognitive impairments in glioma patients (Miotto et al., 2011). Areas that are involved most frequently are executive functioning, memory, attention and processing information speed (Klein et al., 2001). Patients with a glioma tend to have different neuropsychological profiles than, for example, patients with strokes. Stroke patients show site-specific deficits, whereas glioma patients have more global cognitive impairments (Anderson, Damasio, & Tranel, 1990). The cause of cognitive deficits can vary considerably; treatments, anti-epileptic drugs and psychological stress can have adverse effects on different domains of cognitive functioning (Taphoorn & Klein, 2004). However, the tumor itself is the leading cause: associated edema, compression, destruction and displacement of intracranial structures in the brain, lead to cognitive impairments (Pahlson, Ek, Ahlström, & Smits, 2003; Klein et al., 2001). Due to problems in cognitive functioning, quality of life deteriorates. Patients can hardly adapt to the environment, which is making it less easy to be satisfied with life (Harder et al., 2004).

Another highly important psychological issue in glioma patients is mood disturbances. Arnold et al. (2008) found that 48% of primary brain tumor patients experienced anxiety, whereas 41% of the patients experienced depressive symptoms. In conclusion of the factor analysis of Bunevicius, Sarunas, Vytenis, Arimantas, and Robertas (2013), patients with a brain tumor are likely to experience high levels of anxiety and depression before and after surgery. In addition, patients with brain tumors have the highest risk of depression compared to patients with other types of cancers (Wellisch, Kaleita, Freeman, Cloughesy, & Goldman, 2002). Another study on depression is the one-year follow-up study of Mainio, Hakko, Koivukangas, and Räsänen (2005). Mainio and his colleagues used the Beck Depression

Inventory (BDI) to assess depression and found that twenty-eight percent of the sample was found to have a major depressive disorder. Lower functional status was significantly related with depression scores. However, next to lower functional status, mood disturbances can also be related to the location of the tumor (Barrash, Tranel, & Anderson, 2000; Hornak et al., 2003; Spiegel, Kim, Greene, Conner, & Zamfir, 2009), the negative consequences and uncertainty about the prognosis of the sickness (Pool, Heuvel, Ranchor, & Sanderman, 2004). As well as cognitive disturbance, mood disturbance is also a determining factor of quality of life in cancer patients (Dapueto, Servente, Francolino, & Hahn, 2005).

The relationship between cognitive disturbance and mood states in glioma patients has already been explored. Taphoorn & Klein (2004) found that psychological distress, including depression and anxiety, could affect objective cognitive functioning. Furthermore, in the study of Brown et al. (2006), glioma patients had to complete the Mini Mental State Exam (MMSE) and had to report their moods on the Profiles of Mood States Short Form (POMS-SF). They found that increased depression correlated with lower scores on the MMSE in glioma patients. Similarly, a study of Fox, Lyon, and Farace (2007) on brain tumor patients concluded that depression and self-reported cognitive deficits were significantly correlated. In sum, it appears that both subjective and objective cognitive functioning are significantly associated with mood states.

Even if it is generally agreed that mood can affect cognitive functioning (Lezak, Howieson, Bigler, & Tranel, 2012), there has been relatively little extensive analysis of this relation with regard to glioma patients. Moreover, the correlative factors of other mood states than depression and anxiety have not been fully explored, regarding previous research. By providing an analysis of the relation between five different mood states, compiled by the POMS, and several objective and subjective cognitive domains in glioma patients, this study aims to meet these needs. The current study hypothesizes that mood states will be associated with objective and subjective cognitive functioning in glioma patients. More specifically, higher scores on tension, depression, anger or fatigue will be significantly related to lower scores on objective and subjective cognitive domains, whereas higher scores on vigor will be significantly related to higher scores on subjective and objective cognitive domains.

Method

Participants

In the current study, clinically stable patients (between 18 and 70 years of age) with a historically proven or a suspected low-grade glioma or anaplastic glioma participated. Patients were recruited via pathology databases or direct referral from three participating hospitals: the St. Elisabeth hospital in Tilburg, Medical Center Haaglanden in The Hague and the Erasmus University Medical Center in Rotterdam.

Screening

In order to be included in the study, patients had to have an insufficient level of physical activity leaving room for improvement. Furthermore, they had to be able and to be willing to participate in a physical exercise program.

Design

The current study served as a part of a larger study. The overall study was set up to assess whether an exercise program could improve cognitive functioning, fatigue, sleep, mood and quality of life in patients with low-grade glioma or anaplastic glioma.

The greater study was set up as a randomized single-blind controlled trial. Patients in the intervention group will have a six-month home-based exercise intervention whereas patients in the active control group were advised to walk 30 minutes a day for a minimum of five days a week (guidelines from the brochure www.30minutenbewegen.nl).

The larger study was conducted over a long term. Primary and secondary outcomes were assessed at baseline and after completion of the six-month exercise program or active walking program (intervention group and (semi-)active control group). The current analyses merely examined outcomes at baseline level. This study did not assess all primary outcomes (indicators of feasibility and performance on neuropsychological testing), nor all secondary outcomes (performance fitness and self-report questionnaires). Particularly, it merely examined the relation between self-reported mood states and cognitive functioning assessed by neuropsychological tests and a self-report questionnaire.

Procedure

Patients who were neuro-oncologically eligible received an invitation for participating and an information letter about the content of the study. A phone call was made two weeks after receiving the information letter to inform the patients about the content of the study and

to ask for their interest in participating. If the patients were willing to participate, they were asked to complete the International Physical Activity Questionnaire (IPAQ) as a self-report assessment for physical fitness; and the PACE questionnaire for an indication of interest in participating in the study.

If again patients indicated to be interested and if patients were showing an insufficient level of physical activity, they were asked also to complete the Physical Activity Readiness Questionnaire (PAR-Q), a screening for safety risks of exercising. If scores on this questionnaire were positive, patients could move to the next step of the inclusion procedure in which a neuropsychological screening was obtained to assess baseline scores of cognitive functioning.

At this point, neuropsychological testing could get started. The research-assistant visited all participants in their homes to administer the tests and questionnaires so they would not have to travel. Prior to the actual tests, the informed consent was obtained from the participants. Next, the neuropsychological assessment was administered. Patients underwent a standardized battery of neuropsychological tests consisting of tests of attention, memory and executive functioning. In this battery, several self-report questionnaires were handed out including questionnaires about sociodemographics, comorbid diseases, health behaviour, subjective cognitive function, mood, fatigue, sleep, health status, quality of life, and brain tumor symptoms. The patient could complete the questionnaires without the presence of the research-assistant, and return this by mail.

The participants were invited to undergo the physical evaluation with a maximum Cardiopulmonary Exercise Test (CPET). This was another assessment for safety of exercise and baseline assessment to be able to evaluate exercise capacity. This test was performed in one of the one of the twenty-seven Sports Medical Centers (SMC's) in the Netherlands. A cycle ergometer with ECG registration and a gas exchange measurement were used. A positive result on this test was a last requirement for participating in the actual study.

Measurements

Sociodemographic and clinical variables

Sociodemographic variables were obtained via questionnaires. Included variables were gender, age, marital status, education and handedness. Clinical variables were obtained via pathology databases of the three cooperating hospitals. Including variables were diagnosis, tumor grade, previous recurrent tumor, lateralisation, lobe, operation, radiotherapy, chemotherapy and illness duration.

Measurement of mood

Participants were questioned to report their mood over the past week. This was obtained by the Dutch translation of the short version of the Profile of Mood States (POMS-SF; Wald & Mellenbergh, 1990), which consisted of 32 items that could be classified into five different scales: tension, depression, anger, fatigue and vigor. Responses were rated on a five-point scale (0 = *not at all*, 4 = *extremely*). Higher reports on these domains, except for the vigor domain, represent poorer mood. This questionnaire was a short and well-validated version of the POMS (McNair, Lorr, & Droppleman; 1971; 1981; 1992). A limit of the original POMS for measuring mood in cancer patients is its length. For physically ill patients, it takes three times as long as non-ill groups to complete the form. Since we have to deal with patient limitations, the POMS-SF is particularly useful in cancer patients. It is significantly shortened without losing information or internal consistency (Wald & Mellenbergh, 1990). Furthermore, the POMS-SF has good psychometric results, according to previous studies (Curran, Andrykowski, & Studts, 1995; Baker, Denniston, Zabora, Polland, & Williams, 2002).

Measurement of cognitive functioning

With regard to cognitive functioning, a distinction has to be made between objective cognitive functioning, that can be measured through neuropsychological testing, and subjective cognitive functioning, that can be assessed by self-report questionnaires (Pullens, de Vries, & Roukema, 2009). Both were taken into account in this study.

A battery of neuropsychological tests was used to measure objective cognitive functioning. It was derived from the 'Maastricht aging study' (Jolles, Houx, van Boxtel, & Ponds, 1995). This battery consisted of nine tests: the World Learning Test, the Concept Shifting Test, the Letter Digit Modalities Test, the Stroop Color-Word Test, Category Fluency, Letter fluency, Digit Span, the Test of Everyday Attention and the Verbal Paired Associates Test. Table 1 displays the tests and their parameter measures. This particular battery was chosen because of its great number of tests used for each domain of cognitive functioning.

Table 1

Battery of neuropsychological tests

Test name	Subtests	Parameter measured
Word Learning Test (WLT) (Brand & Jolles, 1995)	Word tasks (5)*, delayed recall*	Verbal memory, working memory and learning effect
Concept Shifting Test (CST) (Vink & Jolles, 1985)	CST-A, CST-B, CST-C*	Attention, executive functioning and psychomotor speed
Letter Digit Modalities Test (LDMT) (Smith, 1968)	Writing*, reading*	Attention, information processing speed and psychomotor speed
Stroop Color-Word Test (SCWT) (Stroop, 1935; Hammes, 1971)	Card I, card II, card III*	Attention, executive functioning, information processing speed and mental control
Category Fluency (CF) (Luteijn & van der Ploeg, 1983)	Animals*, professions*	Speed and flexibility of verbal thought process and application of strategies
Letter Fluency (LF) (Lezak, 1995)	Letter ‘n’*, letter ‘a’*	Speed and flexibility of verbal thought process
Digit Span (Wechsler, 1945)	Forwards*, backwards*	Attention, concentration and working memory
Test of Everyday Attention (TEA): Elevator counting (van Gorcum, Robertson, Ward, Ridgeway & Nimmo-Smith, 1994)	Elevator counting*, elevator counting with distraction*, elevator counting with reversal*	Auditory selective attention and working memory

Test of Everyday Attention (TEA): Telephone search (van Gorcum et al., 1994)	Telephone search*, telephone search while counting*, telephone search dual task decrement*	Divided attention
Verbal Paired Associates test (VPA) (Wechsler, 1945)	Word pairs rounds (4)*, delayed recall*	Verbal memory, working memory and learning effect

Note. * tests used in analysis

Self-reported frequency of cognitive failures was measured by the Dutch translation of the original Cognitive Failures Questionnaire (CFQ; Broadbent, Cooper, FitzGerald, & Parkes, 1982). Participants were to indicate whether several cognitive failures had happened to them in the past six months. The questionnaire consisted of 25 items that have been differently classified throughout history. We opted to use the classification that emerged from a principal components analysis of Wallace, Kass, & Stanny (2002), because it was the only classification that was retested and confirmed with a confirmatory factor analysis (Wallace, 2004; Zimprich, van Boxtel, & Jolles, 2009). The items could be classified into four different scales: memory (e.g., "Do you find you forget your appointments?"), distractibility (e.g., "Do you read something and find you haven't been thinking about it and must read it again?", blunders (e.g., "Do you say something and realize afterwards that it might be takes as insulting?" and names (e.g. "Do you find you forget people's names?"). Responses could range from 0 to 4 (0 = *never*, 4 = *very often*). Higher scores indicate more cognitive failures. The CFQ has high internal consistency, high test-retest correlation and is a well validated questionnaire (Vom Hofe, Mainemarre, & Vannier, 1999; Wagle, Berrios & Ho, 1999).

Statistical analysis

Statistical analysis was done with the Statistical Package for the Social Sciences, version 20 (IBM SPSS Statistics 20). The total scores for each scale of the POMS and the CFQ were calculated. Demographic and clinical data were analyzed to describe the sample. Given that all variables were continuous, a series of analyses were performed using the Pearson and Spearman correlation coefficients. Preliminary analyses were performed to check for violation of the assumptions for the correlation analyses. Pearson correlation coefficients were used as a parametric measure of the relationship between mood states and subjective and objective cognitive functioning. Spearman correlation coefficients were used as a non-parametric alternative. One-tailed tests were administered to look for higher scores on neuropsychological tests that was associated with higher scores on tension, depression, anger and fatigue (and conversely, higher neuropsychological scores that were associated with higher scores on tension). Since simple correlation analyses cannot rule out the possibility of a third variable that causes the relation between the two measured variables, partial correlation analyses were performed to assess confounding factors that were associated with both mood and cognitive functioning.

Both raw scores and z-scores, corrected for age, gender and education, were used. However, not all raw scores could be transformed into z-scores due to a limited availability of normative scores. To easily transform raw scores into standardized z-scores, we made use of normative data. Adult normative data of the POMS and of several neuropsychological tests that were used in the battery were available for the Dutch population. Normative scores for the mood states were recruited from the instruction manual of the Dutch Shortened Profile of Mood States (van der Ark, Marburger, Mellenbergh, Vorst, & Wald, 2003). Neuropsychological normative scores were recruited from the Maastrict Aging Study (MAAS) (van der Elst, 2006). Normative scores for the CFQ were not available.

Results

Sociodemographic and clinical characteristics

A total participation of 31 participants was obtained (21 female and 10 male). Subjects ranged in age from 25 to 63 years (mean age, 46,8 years). The most common pathologic diagnosis was oligodendroglioma, followed by astrocytoma and oligoastrocytoma. Characteristics of the patients are reported in table 2.

Table 2

Patient characteristics

Variable	Total (%) N = 31
Sex	
Male	10 (32.2)
Female	21 (67.8)
Age in years	
Mean	46.8
Standard deviation	9.2
Marital status	
Married	21 (67.8)
Unmarried	1 (3.2)
Cohabiting	4 (12.9)
Single	4 (12.9)
Otherwise	1 (3.2)
Education (Verhage, 1964)	
Finished primary school and further education for less than two years	1 (3.2)
Lower than MULO/MAVO-level, for instance LTS, LEAO, LNHO	1 (3.2)
MULO/MAVO/MEAO degree	14 (45.2)
HAVO/VWO/HEAO/HBS/HBO degree	11 (35.5)
VWO/university degree	4 (12.9)

Diagnosis	
Astrocytoma	12 (38.7)
Oligodendroglioma	13 (41.9)
Oligoastrocytoom	4 (12.9)
Not available	2 (6.5)
Tumor grade	
Grade 2	19 (61.3)
Grade 3	12 (38.7)
Previous recurrent tumor	
Yes	9 (29.0)
No	19 (61.3)
Not available	3 (9.7)
Lateralisation	
Right hemisphere	14 (45.2)
Left hemisphere	16 (51.6)
Not available	1 (3.2)
Lobe	
Frontal	24 (77.4)
Temporal	2 (6.5)
Parietal	2 (6.5)
Tempo-parietal	1 (3.2)
Not available	2 (6.5)
First operation	
Yes	30 (96.8)
No	1 (3.2)
Operation type (of the patients with a first operation)	
Stereotactic biopsy	6 (20.0)
Resection	12 (40.0)
Complete resection	6 (20.0)
Incomplete resection	5 (16.7)
Not available	1 (3.3)

Second operation	5 (16.1)
Yes	8 (25.8)
No	18 (58.1)
Not available	
Operation type (of the patients with a second operation)	1 (20.0)
Resection	1 (20.0)
Complete resection	3 (60.0)
Incomplete resection	
History of cranial irradiation	
Yes	17 (54.8)
No	13 (41.9)
Not available	1 (3.2)
History of chemotherapy	
Yes	9 (29.0)
No	21 (67.7)
Not available	1 (3.2)
Illness duration	
Mean	6.5
Standard deviation	5.3

Preliminary analyses

Preliminary analyses were performed to check for violation of the assumptions for the correlation analyses considering normality, linearity and homoscedasticity. For each variable, histograms were inspected to assess normality. Furthermore, scatterplots have been generated to check for violation of the assumptions of linearity and homoscedasticity. Scores on the POMS-SF, the CFQ and the neuropsychological battery appeared to be normally distributed and the distribution of scores can be considered linear with evenly spread scores in a oval shaped pattern.

Correlation analyses

Correlation analyses were divided into five sections, based on the five mood states that we are examining. Results of the correlation analyses with raw scores between mood states and objective cognitive test scores are presented in table 3. Table 4 provides the results of the correlation analyses with z-scores. In table 5, correlations between mood states and self-reported cognitive failures are shown.

The first analysis examined how scores on tension were associated with measures of cognitive functioning. A higher score on tension was found to be significantly related to a lower score the subtest counting with distraction of the TEA (poorer performance); r(28)=-0.462 p=0.007, and the subtest 'reading' of the LDMT (poorer performance); r(28)=-0.352, p=0.033. Concerning the former effect, no standardized scores for the TEA were available. The latter effect remained significant using z-scores (i.e., controlling for gender, age and education); r(28)=-0.393, p=0.019. According to Cohen, these effect sizes are moderate (Cohen, 1988). The analyses did not provide further support for the influence of tension on cognitive functioning; no significant effects were found for other test scores. With regard to self-reported cognitive functioning, no relationship appeared to be significant.

The second analysis examined whether scores on depression were associated with objective and subjective measures of cognitive functioning. Three significant associations were found. First of all, higher scores on depression were related to lower scores on the subtest 'reading' of the LDMT (poorer performance); r(25)=-0.402, p=0.023 and this was also the case using z-scores (i.e., controlling for gender, age and education); r(25)=-0.422, p=0.016. Furthermore, a higher score on depression was related to a lower score on the TEA subtest counting with distraction (poorer performance); r(25)=-0.359, p=0.039. No standardized scores were available for this TEA subtest. Higher scores on depression were also related to higher scores on the SCWT card III (poorer performance); r(25)=0.360, p=0.039. This association remained the same using z-scores (i.e., controlling for gender, age and education); r(25)=0.357, p=0.037. Other neuropsychological test scores did not significantly correlate with depression. Regarding self-perceived cognitive functioning: patients with higher scores on depression showed lower scores (more complaints) on memory; r(25)=0.419, p=0.078 and blunders; r(25)=0.443, p=0.013. All effect sizes are moderate (Cohen, 1988).

The third analysis examined whether scores on anger were negatively associated with measures of cognitive functioning. Higher scores on anger were significantly related to lower scores on elevator counting with distraction (TEA) (poorer performance); r(29)=-0.355,

p=0.044 and higher on the subtest time per target/counting of the TEA (poorer performance); r(29)=0.411, p=0.021. Also, for the dual task decrement concerning this task (the decrement in a patient's scores from the raw scores to the counting with distraction), higher scores were associated with higher scores on anger (poorer performance); r(29)=0.429, p=0.016. Higher scores on anger were also associated with lower scores on Digit Span forwards (poorer performance); r(31)=-0.323, p=0.044). No z-scores were available for the TEA and Digit Span forwards test. The correlation coefficients represent a moderate association (Cohen, 1988). However, no significant results were found for the remaining neuropsychological test scores. With regard to self-reported cognitive functioning, patients with higher scores on anger showed lower scores (more complaints) on memory; r(27)=0.327, p=0.048 and blunders; r(27)=0.567, p=0.001. The former indicates a moderate association whereas the latter indicates a strong correlation (Cohen, 1988).

The fourth analysis examined whether scores on fatigue were negatively associated with measures of cognitive functioning. No significant associations were found for the raw scores, but when adjusted for age, gender and education, one association appeared to be significant. Higher z-scores on fatigue were significantly associated with lower z-scores on the subtest 'reading' on the LDMT (poor performance); r(28)=-0.319, p=0.049. This indicates a moderate correlation (Cohen, 1988). Regarding self-reported cognitive functioning: patient with higher scores on fatigue showed higher scores on memory (more complaints); r(27)=0.486, p=0.005, distractibility; r(27)=0.347, p=0.028, blunders; r(27)=0.372, p=0.028 and names; r(27)=0.381, 9=0.023. The correlation with self-reported failures in memory is strong, whereas the correlations with the four other self-reported cognitive failures were moderate (Cohen, 1988).

The fifth analysis examined whether scores on vigor were associated with measures of cognitive functioning. A higher score on vigor was significantly related to a lower score on the TEA-telephone search (better performance); r(27)=-0.381, p=0.025. Z-scores were not available for this relationship. The correlations were considered moderate (Cohen, 1988). The analysis did not provide further support for a relationship between vigor and cognitive functioning; differences in vigor did not significantly correlate with any neuropsychological test score or self-reported cognitive failure.

Partial correlation analyses

Subsequently, partial correlation analyses were performed to assess the role of potentially confounding factors in the association between mood and cognitive functions since the results may show a false correlation between mood and cognitive functioning (van Stralen, Dekker, Zoccali, & Jager, 2010). Factors considered potential confounders were illness duration, history of radiation and history of chemotherapy. We have a clinical presumption that these can serve as a third variable affecting the dependent and independent variable factors. Neuropsychological studies have shown that due to a history of chemotherapy, cognitive functions can be affected in brain tumor patients (Wefel & Schagen, 2012). Mood disturbances can also appear as a side-effect of chemotherapy (Chernecky, 1998). According to Aoyama et al. (2007), radiotherapy can lead to deterioration of neurocognitive functioning. Patients with a brain tumor who had received radiotherapy also reported more depressive and anxious symptoms than patients who did not receive radiotherapy. (Page, Hammersley, Burke, & Wass, 1997). Illness duration is a factor influencing both mood and cognitive functioning too. Significant associations were found in Parkinson patients (Foster et al., 2013). However, none of the mentioned clinical variables was found to affect the relation between mood and cognitive functioning.

Table 3

Pearson and Spearman coefficients for correlations between mood states and neuropsychological tests

	Tension	Depression	Anger	Fatigue	Vigor
WLT total good	-0.197	-0.140	0.098	-0.017	-0.095
WLT delayed recall	-0.103	-0.068	-0.101	0.148	0.026
CST-C time	0.243	0.165	0.019	0.116	-0.178
LDMT-writing total good	-0.206	-0.188	-0.125	-0.118	-0.510
LDMT-reading total good	-0.352*	-0.402*	-0.208	-0.294	0.056
CF total	0.026	0.014	0.102	0.178	-0.430
LF total	0.222	0.074	-0.350	0.223	-0.39
Digit Span forwards	-0.225	-0.306	-0.323*	-0.308	0.211
Digit Span backwards	-0.256	-0.239	-0.186	-0.053	0.006
TEA-elevator counting	0.187	0.050	-0.081	0.122	-0.108
TEA-elevator counting with distraction	-0.462**	-0.359*	-0.322*	-0.009	-0.145
TEA-elevator counting with reversal	0.042	0.036	-0.104	0.112	-0.088
TEA-telephone search time	0.085	0.175	0.104	0.266	-0.160
TEA-telephone search score	0.043	0.071	-0.117	0.037	-0.381*
TEA-telephone search while counting time	0.045	0.124	0.097	0.084	-0.228
TEA-telephone search time per target	0.263	0.129	0.108	-0.092	-0.134
TEA-telephone search time per target/counting	0.339	0.344	0.411*	-0.124	0.128
TEA-telephone search while counting dual task decrement	0.287	0.316	0.429*	-0.168	0.183
VPA total score	-0.164	-0.211	-0.235	-0.262	-0.024
VPA delayed recall	-0.155	-0.207	-0.235	-0.266	-0.022
SCWT card III	0.170	0.360*	0.185	-0.058	-0.113
SCWT strint	-0.205	-0.030	-0.156	-0.265	-0.132

Note. All correlations are significant at one-tailed level.

*p < .05. **p < .01.

Table 4

Pearson and Spearman coefficients for correlations between z-scores of mood states and available z-scores of neuropsychological tests

	Tension	Depression	Anger	Fatigue	Vigor
WLT delayed recall	-0.125	-0.053	0.073	0.163	0.003
CST-C time	0.280	0.299	0.620	0.123	-0.194
LDMT-writing total good	-0.225	-0.193	-0.178	-0.122	-0.064
LDMT-reading total good	-0.393*	-0.422*	-0.269	-0.319*	0.040
SCWT card III*	0.226	0.357*	0.193	-0.112	-0.181
SCWT strint*	-0.224	-0.110	-0.148	-0.295	-0.150

Note. All correlations are significant at one-tailed level.

*p < .05. **p < .01.

Table 5

Pearson coefficients for correlations between mood states and self-reported cognitive failures

	Tension	Depression	Anger	Fatigue	Vigor
Memory	0.281	0.419*	0.327*	0.486**	-0.153
Distractibility	0.142	0.319	0.295	0.347*	-0.081
Blunders	0.298	0.443*	0.567**	0.372*	-0.043
Names	0.137	0.080	0.119	0.381*	0.255

Note. All correlations are significant at one-tailed level.

*p < .05. **p < .01.

Discussion

Findings of this study

The present study aimed to investigate the relation between various mood states and aspects of self-reported and objective cognitive functioning. Several of the expected influences were supported by the data we found. All of the significant effects were found in the right direction and the magnitude of the observed effects was moderate to strong.

Higher scores on tension were related to a poorer performance on the subtest reading of the LDMT, indicating a poor performance on a measure of attention, information processing speed and psychomotor speed, and on the TEA elevator counting with distraction, indicating a poor performance on a measure of auditory selective attention and a measure of working memory.

Higher scores on depression were significantly correlated with a poorer performance on the subtest reading of the LDMT, indicating a poorer performance on a measure of attention, information processing speed and psychomotor speed, and on the TEA elevator counting with distraction, indicating a poor performance on a measure of auditory selective attention and a measure of working memory. Higher scores on depression were also significantly related to a poorer performance on the Stroop Task Card III, indicating a poorer performance on a measure of attention, executive functioning, information processing speed and mental control. Concerning self-reported cognitive failures, a higher score on depression was associated with more memory problems and blunders.

Higher levels of anger were related to a significantly poorer performance on the three measures of the TEA: elevator counting with distraction, telephone search score and dual task decrement. These results reveal that patients who had a higher score on anger performed poorer on a measure of auditory selective attention, working memory and of divided attention. Higher scores on anger also were related to more problems with memory and blunders.

Higher scores on fatigue were related with a poor performance on the subtest reading of the LDMT, which is a measure of attention, information processing speed and psychomotor speed. Higher scores on fatigue were also related to higher scores on self-reported frequency of memory problems, distractibility, blunders and problems with names.

Higher scores on vigor were related to better performances on the TEA telephone search, indicating a better performance on a measure of divided attention.

By correcting for gender, age and education, all significant effects remained significant and one effect which appeared as non-significant in the analyses of raw scores

appeared to be significant when using z-scores. These findings contribute to the raw score findings, leaving out the probability of gender, age and/or education affecting the results.

Relation to previous research

The findings of this study confirm and extend the results of previous research on the relation between mood states and scores on objective and subjective cognitive scores. Taphoorn & Klein (2004) found that anxiety and depression could affect different domains objective cognitive functioning. Furthermore, Brown et al. (2006) found that an increased depression correlated with lower scores on the MMSE. The current study also found significant correlations between mood states and objective cognitive functioning. Moreover, this study found evidence for the association between depression, anxiety, anger and vigor and objective cognitive functioning. The current study also used a higher range of neuropsychological tests compared to these studies. For each domain of cognitive functioning, several tests were used. Results of Fox et al. (2007) suggested that depression was significantly associated with self-reported cognitive deficits, which was measured with a 6-item questionnaire. The study examined the depression scale of the POMS-SF and, whereas our study examined all scales of the POMS-SF and found significant correlations between tension, depression, anger and fatigue and self-reported cognitive functioning. Instead of a shortcut of six items to measure self-reported cognitive functioning, this study had a 25-item questionnaire. It allowed us to draw conclusions about more than just self-reported functioning in general, namely about several aspects of self-reported cognitive functioning (memory, distractibility, blunders and problems with names).

Limitations of this study

In the inclusion procedure, the first thing to be asked was interest in participating the study. Patients with severe mood problems will not have the interest or motivation to participate in the study and as a consequence that specific group is excluded. Similarly, there is a high probability that extremely tired or highly anxious participants have not joined the study. This is likely to have affected the results.

Concerning the sample size, the current study used only 31 participants and this might have limited the validity of our conclusions. The larger the sample is, the larger the margin of accuracy will be and the better the sample will reflect the population that we are studying. This implies that correlations could have reached statistical significance, if only more participants were recruited.

The testing environment (in patients homes), where the neurocognitive battery was obtained, could be distracting for the patients. This environment could influence cognitive functioning. Instead, this battery should be completed at a standard laboratory setting. However, we chose to visit the patients at home, because travelling to the hospital or university will take too much effort for the patients.

There is a problem of overgeneralizing concerning the POMS-SF. The questionnaire was used to assess mood states that occurred in the previous week. This indication of mood states may be different from the mood states which occurred at another point of time. The POMS-SF is better useable for estimating mood changes in time instead of estimating interindividual differences in mood, which this study attempts to do (van der Ark, Marburger, Mellenbergh, Vorst, & Wald, 1995). Another limitation of the POMS is that vigor is used as a positive mood state. However, one could wonder if vigor really is a mood state. The same applies to fatigue. It is discussible if we can speak here about the relationship between mood and cognitive functioning.

With regard to the inclusion procedure, results of the current study can only be generalized to glioma patients who 1) have an insufficient level of physical activity and 2) are able to exercise and 3) have the motivation to follow the intervention program.

Statistics used for this study have limitations too. Concerning correlation analyses, people often draw conclusions based on a cause-and-effect relationship. However, correlation does not imply causation. We cannot say whether a negative mood state results in a negative score on a neurocognitive test, we can only say whether the two are associated. We need to be cautious when interpreting the results.

Evaluation of the patients was only done once. Longitudinal evaluations would be more informative about the relation between mood and cognitive functioning in glioma patients. These data are available for the greater study now, but were not available for the current study at the moment of analyzing the data. It is recommended for further investigation.

Positive aspects of this study

Concerning the neuropsychological battery: for each domain of neurocognitive functioning (i.e., attention, memory and executive functioning), a large number of tests were used. It is of major importance to compile a battery that covers several cognitive domains. However, it is important not to compile a battery which is too large. Consequently, there is a higher risk for deterioration by impairment. This is especially important with cancer patients (Ritchie et al., 2014).

The current study looked not at objective cognitive functioning or self-reported cognitive functioning, but it took both measures into account. However, the relationship between objective-and subjective cognitive functioning has not been explored in this study. Future studies are warranted to shed light on this matter.

Recommendations for the future

Concluding, future studies will benefit from evaluating the relationship between objective and subjective cognitive functioning and doing a longitudinal research. Furthermore, it is necessary to replicate these findings, taking into consideration limitations of the current study. It would be advisable to use a larger sample size whereas this study's sample size is very limited. Finally, a random sampling method should be done whereas this study cannot be generalized to a larger population due to the inclusion procedure.

Clinical relevance

Our findings add to the growing evidence of the association between mood and cognitive functioning. Negative mood states were negatively associated with one or more aspects of objective and subjective cognitive functioning and the positive mood state was positively associated with one aspect of objective functioning. The assessment of the association between mood and cognitive functioning is clinically relevant, because it will provide additional information about the clinical situation of the patients and therefore it would be easier to choose treatments for these patients. It would be interesting to explore whether improvements of cognitive functioning might have a positive effect on mood and, conversely, a positive mood might enhance cognitive functioning. Cognitive disturbances and mood disturbances have an impact on quality of life (Harder et al., 2004; Dapueto, Servente, Francolino, & Hahn, 2005) and are acknowledged to be predictive factors in the survival of glioma patients (Taphoorn & Klein, 2004; Mainio et al., 2006). Improving mood or improving cognitive functioning might improve quality of life.

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