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Sandra E. Rakers, Myrthe E. Scheenen, Herma J. Westerhof-Evers, Myrthe E. de Koning, Harm J. van der Horn, Joukje van der Naalt, and Jacoba M. Spikman
University of Groningen, University Medical Center Groningen

Objective: To examine associations between executive functioning (EF) and coping styles, separately for mild and moderate-severe traumatic brain injury (TBI) in the chronic phase postinjury. ***Method:*** Patients with mild ($n = 47$) and moderate-severe TBI ($n = 59$) were included, in addition to healthy controls (HCs; $n = 51$). Assessment consisted of EF tests (Trail Making Test, Zoo Map Test, Controlled Oral Word Association Test) and questionnaires examining EF (Dysexecutive Questionnaire) and coping styles (Utrecht Coping List). ***Results:*** Moderate-severe TBI patients showed significant more EF deficits, lower active coping and higher passive coping than mild TBI patients and HCs, whereas mild TBI patients did not differ from HCs. In the moderate-severe TBI group, a higher number of self-reported EF problems was related to lower levels of active coping, $r = -.43$, $p < .01$ and higher levels of passive coping, $r = .58$, $p < .001$, with proxy-reports relating to lower levels of active coping, $r = -.33$, $p < .05$. For mild TBI, a higher amount of self-reported EF problems was related to lower levels of active coping, $r = -.38$, $p < .05$ and higher levels of passive coping, $r = .55$, $p < .001$, with proxy-reports relating to higher levels of passive coping, $r = .39$, $p < .05$. Except for mental flexibility, EF performances were not associated with coping. ***Conclusions:*** This study shows strong associations between reported EF problems in daily life and coping styles. For moderate-severe TBI, proxy-reports may reflect EF impairments that complicate active problem-solving. However, reported EF problems by mild and moderate-severe TBI patients are also likely to reflect a psychological distress related to the way patients are inclined to deal with stressing situations that put a demand on their executive abilities.

General Scientific Summary
This study contributes to our understanding of cognitive functioning in relation to coping, and therefore of adaptation following traumatic brain injury. Overall, a higher amount of reported executive function problems in daily life by patients and proxies appeared related to lower levels of (adaptive) active coping, and higher levels of (maladaptive) passive coping. Our findings with regard to these relations give valuable information that can be used when offering rehabilitation.

Keywords: executive functioning, coping, traumatic brain injury, injury severity

Traumatic brain injury (TBI) is a major health and socioeconomic problem, with an estimate of more than 10 million cases each year worldwide (Hyder, Wunderlich, Puvanachandra, Gururaj, & Kobusingye, 2007). The majority of patients with TBI (85–90%) sustain a mild TBI, and although a subgroup (15–25%) show persistent complaints, the prognosis is generally favorable (Bazarian et al., 2005; Holm, Cassidy, Carroll, & Borg, & the Neurotrauma Task Force on Mild Traumatic Brain Injury of the WHO Collaborating Centre, 2005; Ponsford et al., 2012; Rohling et al., 2011). However, the majority of patients with moderate-severe TBI experience long-lasting cognitive, emotional and (social) behavioral deficits that interfere with functioning in daily life and the resumption of work (Anson & Ponsford, 2006; Benedictus, Spikman, & van der Naalt, 2010; de Koning, Spikman, Coers, Schönherr, & van der Naalt, 2015; Ponsford, Draper, & Schönberger, 2008; Spikman, Timmerman, Milders, Veenstra, & van der Naalt, 2012). The frontal areas of the brain are particularly vulnerable to damage in TBI, due to either focal cortical contusions or diffuse axonal injury (Fork et al., 2005; Gurdjian, 1976; Rabinowitz & Levin, 2014). Prefrontal damage is frequently demonstrated after moderate-severe TBI but is relatively rare following mild injury (Iverson, 2005; Rabinowitz & Levin, 2014; Spikman, Timmerman, Coers, & van der Naalt, 2016).

Sandra E. Rakers and Myrthe E. Scheenen, Department of Neuropsychology, University of Groningen, University Medical Center Groningen; Herma J. Westerhof-Evers, Center for Rehabilitation and Department of Neuropsychology, University of Groningen, University Medical Center Groningen; Myrthe E. de Koning, Harm J. van der Horn, and Joukje van der Naalt, Department of Neurology, University of Groningen, University Medical Center Groningen; Jacoba M. Spikman, Department of Neuropsychology, University of Groningen, University Medical Center Groningen.

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Correspondence concerning this article should be addressed to Sandra E. Rakers, Department of Neuropsychology, University Medical Center Groningen, University of Groningen, Hanzeplein 1, 9700RB Groningen, the Netherlands. E-mail: s.e.rakers@umcg.nl

Frontal system damage after a TBI often leads to deficits in executive functioning (EF; Stuss, 2011). Executive functions are crucial for goal setting, planning, and carrying out activities in an effective way (Lezak, 1995), and therefore enable adaptation to novel and complex situations. Deficits in EF may therefore compromise adaptive behavior to a changed situation following TBI. Because damage to the prefrontal circuits is common after moderate-severe TBI, executive functions are frequently found to be impaired in this group, affecting the ability of patients to adapt behavior to changing circumstances. EF deficits do also occur in patients with mild TBI but are mostly resolved within 1 to 3 months (Ponsford et al., 2012; Schretlen & Shapiro, 2003).

TBI is also a major life event that as such can have a significant and disruptive impact on daily functioning (Sherer & Sander, 2014, p. 257). To adjust to the consequences of a TBI, including the corresponding emotions that are encountered, patients have to rely on their coping skills. Coping is the way a person is responding to distressing situations. It is a psychological trait that is defined by Lazarus and Folkman (1984, p. 141) as a person's "constantly changing cognitive and behavioral efforts to manage specific external and/or internal demands that are appraised as taxing or exceeding the resources of the person." Coping is most frequently divided into active problem-focused and passive emotion-focused coping. Active coping is generally seen as adaptive in patients with mild as well as with moderate-severe TBI, with strategies that involve an active approach to search for opportunities to solve problems and to confront stressful situations (Anson & Ponsford, 2006; Maestas et al., 2014). On the other hand, passive coping involves focusing on the emotions that result from a stressful situation, rather than dealing with the stressor itself. Passive coping is generally considered maladaptive in patients with mild to severe TBI and has often been associated with feelings of depression and anxiety (Anson & Ponsford, 2006; Spitz et al., 2013; Tomberg, Toomela, Ennok, & Tikk, 2007). Thus, the way patients cope with stressors following brain injury appears critical for adequate behavioral and emotional adjustment and is therefore important for outcome. Several studies reported changes in coping following mild to severe TBI, most often with a decreased use of active coping and an increased reliance on passive coping (Dawson, Cantanzaro, Firestone, Schwartz, & Stuss, 2006; Spitz et al., 2013; Tomberg et al., 2007).

Hence, both EF and coping are central constructs for effective adaptation to the consequences of a TBI. Patients have to rely on their coping skills to respond to distressing situations, but on a cognitive level, they also need executive functions to set goals, to solve problems and to effectively adjust their behavior to the changed circumstances. Therefore, it has been suggested that the use of coping styles is related to EF, and consequently, when EF deficits are present, adaptive coping behavior may become compromised (Wilder-Willis, Shear, Steffen, & Borkin, 2002). Kpran, Levine, Stuss, and Dawson (2007) suggested that TBI-related EF deficits may interfere with the capacity of patients to effectively select and employ active coping strategies (Krpan et al., 2007). As a result, passive coping may be used by default and consequently result into persistent mental distress and posttraumatic complaints.

Thus far, the relationship between EF and coping following TBI remains unclear as existent literature yielded mixed findings (Anson & Ponsford, 2006; Spitz et al., 2013; Krpan et al., 2007; Wood & Rutterford, 2006). Some studies found relations between executive performances and coping styles (Krpan et al., 2007; Spitz et al., 2013), for which Krpan and colleagues (2007) demonstrated that higher scores on executive tests were related to a higher level of active coping and a lower level of passive coping in TBI patients with injury severities ranging from mild to severe. However, such relation between executive performance and coping styles in patients with mild to severe injury has not been consistently found (Anson & Ponsford, 2006; Spitz, Schönberger, & Ponsford, 2013; Wood & Rutterford, 2006). It might be possible that the severity of the TBI plays a crucial role with regard to these inconsistent findings. So far, patients with varying severities are often studied together. There may be a qualitative difference in the relation between EF and coping for patients with mild TBI opposed to patients with a moderate-severe TBI, considering that EF deficits mostly resolve within weeks to months after mild injury, but may be more persistent following a moderate-severe TBI. Therefore, the aim of the present study was to assess the relationship between EF and coping styles separately for patients with mild versus patients with moderate-severe TBI. In addition, comparisons were made with a group of healthy controls (HCs). We hypothesized that a higher amount of EF impairments would be related to a lower level of active problem-focused coping and a higher level of passive emotion-focused coping.

Method

Design and Setting

This study contains data from patients included in two larger prospective follow-up studies investigating mild TBI (UPFRONT-study) and moderate-severe TBI (T-ScEmo study). The majority of patients of both studies have been admitted to the University Medical Center Groningen (UMCG), a level one trauma center and rehabilitation center. In addition, mild TBI patients from the St. Elisabeth Hospital Tilburg and Medical Center Twente were included, and moderate-severe TBI patients from Reade Amsterdam and Rehabilitation Friesland were included. Data were acquired in compliance with the ethical regulations of the UMCG and all patients and HCs signed an informed consent. On emergency department admission, neurological examination was performed to determine the Glasgow Coma Scale (GCS) score and duration of posttraumatic amnesia (PTA). Neuropsychological assessment consisted of EF tests and questionnaires for everyday EF and coping styles. For mild TBI patients, EF tests and questionnaires were conducted at approximately 3 months postinjury and the coping questionnaire was completed at 6 months postinjury. For patients with moderate-severe TBI, neuropsychological assessment including the neuropsychological tests and questionnaires took place between 7 months and 34[1/2] years postinjury.

Participants

Between July 2011 and January 2015, TBI patients were approached by the participating centers to take part in the studies. Mild TBI was defined by a GCS score of 13–15, PTA duration of $\leq$24 hr and/or a loss of consciousness of $<$30 min (Vos et al., 2012). Patients of 18 years and older were included and patients who had (frontal) CT abnormalities were excluded from participation in the study. Moderate-severe TBI was defined by a GCS

score of <13, loss of consciousness of ≥30 min and/or PTA duration of ≥24 hr (Malec et al., 2007), with patients of 18 years and older with a time since injury of at least 3 months being included. In addition, HCs were recruited and tested at the UMCG as a comparison group for the EF and coping measures. General exclusion criteria for patients and HCs consisted of addiction to alcohol or drugs, major psychiatric or neurological disorders, insufficient comprehension of the Dutch language, or scores below cut-off on a test for symptom validity (Amsterdam Short-Term Memory Test).

Measures

Neuropsychological tests for executive functions. The Trail Making Test (TMT) is a test for EF. Time on Condition B was used as a measure for cognitive flexibility (Arbuthnott & Frank, 2000). In this condition, numbered as well as lettered circles have to be connected in ascending sequence while alternating between the two (Reitan, 1958).

The Zoo Map Test is part of the Behavioral Assessment of the Dysexecutive Syndrome (Wilson, Alderman, Burgess, Emslie, & Evans, 1996), intended to measure EF, specifically planning. Complex planning strategies have to be formed and carried out, as participants are instructed to plan a visit to specific locations on a map, while a number of restricting rules needs to be kept in mind. Total scores range from below 0 to 16.

Controlled Oral Word Association Test (COWAT) is a verbal task intended to measure executive control (Schmand, Groenink, & van den Dungen, 2008). Participants have to come up with as many words as possible that start with a specific letter within 1 min, whereas in the meantime they have to comply to three rules that are given on beforehand. Total scores from three different starting letters (D-A-T, K-O-M or P-G-R) were calculated.

EF questionnaire. The Dysexecutive Questionnaire (DEX) is also part of the Behavioral Assessment of the Dysexecutive Syndrome and is used to examine difficulties in everyday situations that involve EF (Wilson et al., 1996). The questionnaire consists of 20 items that are answered on a 5-point Likert scale ranging from 0 (*never*) to 4 (*very often*). The DEX consists of two versions, a self-rating questionnaire (DEX-Self) and, to account for possible self-awareness deficits, a questionnaire for a significant other (DEX-Proxy). We calculated total scores of both questionnaires, ranging from 0 to 80.

Coping questionnaire. The Utrecht Coping List (UCL) is a self-report questionnaire that examines how participants cope with problems or stressful situations (Schreurs, Tellegen, & Willige, 1984; Schreurs, van de Willige, Brosschot, Tellegen, & Graus, 1993). The UCL consists of 47 items on a 4-point Likert scale ranging from 1 (*seldom or never*) to 4 (*very often*). The items are divided over seven subscales, from which we used the active problem-focused coping subscale (UCL-A) and the passive emotion-focused coping subscale (UCL-P), both containing seven items.

Analysis

For analyzing data, SPSS version 23.0 was used. Missing values comprised less than 5% of the data and were excluded from analyses (Dong & Peng, 2013). Assumptions were checked. To examine differences between HCs, patients with mild and patients with moderate-severe TBI, χ^2 tests for categorical data, Kruskal-Wallis H tests and Mann–Whitney *U* tests for ordinal data, and one-way analysis of variance for parametric data were conducted. In addition, post hoc comparisons were computed using univariate tests under the Bonferroni criterion. Associations between measures were tested with Pearson correlations for parametric data and Spearman's rank correlations for nonparametric data. The overall alpha level was set at .05, two-sided.

Results

Participants

A total of 106 TBI patients were included, with 47 mild TBI and 59 moderate-severe TBI patients. In addition, 51 HCs were included. Groups were well matched with regard to age and gender. However, moderate-severe TBI patients had a significantly lower educational level compared to mild TBI patients ($p < .001$) and HCs ($p < .001$). Furthermore, moderate-severe TBI patients had significantly lower GCS scores compared to mild TBI patients (see Table 1).

EF and Coping Measures

Table 2 shows significant differences between the group of HCs, mild and moderate-severe TBI patients for the EF and coping measures. Post hoc analyses revealed significant differences between the moderate-severe TBI patients compared to HCs and mild TBI patients, whereas mild TBI patients did not significantly differ from HCs.

Table 1
Participant Characteristics, M (±SD)

Variable	1. HC (n = 51)	2. Mild TBI (n = 47)	3. Mod-Sev TBI (n = 59)	Difference 1–2-3 F/χ^2/H/U	p
Age	41.9 (14.2)	37.5 (14.5)	42.9 (13.1)	F = 2.1	.121
Gender, male (%)	35 (68.6%)	31 (66.0%)	48 (81.4%)	χ^2 = 3.7	.156
Education	5.9 (.8)	5.8 (.8)	5.0 (1.0)	H = 28.9	<.001
GCS score		14.4 (.7)	9.2 (4.1)	U = 171	<.001
PTA days			31 (32)		

Note. TBI = traumatic brain injury; HC = healthy controls; Mod-Sev = moderate to severe; Education = 7-point scale ranging from 1 (*primary school education only*) to 7 (*university education*); PTA = posttraumatic amnesia; GCS = Glasgow Coma Scale.

Table 2
Comparisons of Executive Functioning and Coping Measures, M (±SD)

Variable	1. HC (n = 51)	2. Mild TBI (n = 47)	3. Mod-Sev TBI (n = 59)	Difference 1–2-3 F/H	p
Neuropsychological tests for executive functions					
TMT B	55.4 (16.8)	59.7 (23.7)	76.3 (28.3)	H = 20.5	<.001
Zoo Map	13.5 (4.2)	12.4 (4.5)	11.3 (4.4)	H = 9.2	<.05
COWAT	42.7 (11.9)	37.7 (11.8)	32.3 (10.4)	F = 11.7	<.001
Executive functioning questionnaire					
DEX-Self	12.3 (6.6)	16.3 (9.7)	29.1 (12.7)	F = 39.9	<.001
DEX-Proxy	11.4 (7.3)	12.8 (10.6)	33.8 (10.6)	F = 90.6	<.001
Coping questionnaire					
UCL-A	19.7 (3.6)	19.0 (3.0)	16.4 (4.3)	F = 12.2	<.001
UCL-P	10.4 (2.7)	10.7 (3.4)	12.3 (3.4)	H = 11.3	<.01

Note. TBI = traumatic brain injury; HC = healthy controls; Mod-Sev = moderate to severe; TMT B = Trail Making Test B; COWAT = Controlled Oral Word Association Test; DEX = Dysexecutive Questionnaire; UCL-A = Active problem-focused coping subscale of the Utrecht Coping List (UCL); UCL-P = Passive emotion-focused coping subscale of the UCL.

With regard to scores on EF tests, post hoc analyses showed that moderate-severe TBI patients performed significantly worse than HCs for mental flexibility ($p < .001$), planning ($p < .05$) and executive control ($p < .001$) and compared to mild TBI patients for mental flexibility ($p < .01$) and executive control ($p < .05$).

For reported EF deficits in daily life, both patient and proxy scores were significantly higher in the moderate-severe TBI group than in the mild TBI group ($p < .001$) and in the HC group ($p < .001$). Comparisons between self-reported and proxy-reported EF deficits in the moderate-severe TBI group revealed significantly higher levels of reported EF problems by proxies than by patients ($p < .05$). Mild TBI patients reported more EF complaints than their proxies, although this did not reach significance ($p = .109$).

Concerning coping styles, the moderate-severe TBI patients reported a significantly lower level of active coping and a significantly higher level of passive coping than mild TBI patients ($p < .01$) and HCs ($p < .01$).

Correlations Between EF and Coping Styles

Table 3 presents the correlation coefficients between EF measures, comprising tests and questionnaires, and coping styles. In the moderate-severe TBI group, only better performance on the mental flexibility test (TMT B) was moderately correlated with a higher level of active coping. EF test scores did not significantly correlate with coping in the mild TBI group and the HC group.

Self-reported EF deficits were highly positively correlated with passive coping in both TBI groups and the HC group. In the mild and the moderate-severe TBI groups, self-reported EF deficits and active coping were negatively correlated. Correlations between proxy-reported EF deficits and coping differed across the TBI groups. In the mild group, only a moderate positive relation with passive coping was found, which was a pattern similar to that in the HC group. In the moderate-severe TBI group, however, a significant negative moderate correlation was only found with active coping.

Discussion

The main objective of the present study was to investigate the relationship between EF and coping styles in patients with TBI, and in particular whether this relationship is different for mild versus moderate-severe TBI. Our results showed for both TBI severity groups that subjectively reported EF problems in daily life

Table 3
Correlations Between Executive Functioning Measures and Coping

Variable	1. HC (n = 51)		2. Mild TBI (n = 47)		3. Mod-Sev TBI (n = 59)	
	UCL-A	UCL-P	UCL-A	UCL-P	UCL-A	UCL-P
Neuropsychological tests for executive functions						
TMT B	.01	−.06	.07	−.09	−.29*	.01
Zoo Map	.07	.05	.15	−.09	−.11	.13
COWAT	.08	.09	−.04	.22	.04	.22
Executive functioning questionnaire						
DEX-Self	−.23	.55***	−.38*	.55***	−.43**	.58***
DEX-Proxy	−.03	.39**	−.21	.39*	−.33*	.10

Note. TBI = traumatic brain injury; HC = healthy controls; Mod-Sev = moderate to severe; TMT B = Trail Making Test B; COWAT = Controlled Oral Word Association Test; DEX = Dysexecutive Questionnaire; UCL-A = Active problem-focused coping subscale of the Utrecht Coping List (UCL); UCL-P = Passive emotion-focused coping subscale of the UCL.
* $p < .05$. ** $p < .01$. *** $p < .001$.

by patients and proxies were strongly associated with coping styles, although with differential relations between mild and moderate-severe TBI. Performance on EF tests was not associated with coping styles, with the exception of one mental flexibility test.

In this study, neuropsychological tests for EF revealed that moderate-severe TBI patients were clearly impaired on all tests administered when compared to HCs. This is in line with previous findings (Finnanger et al., 2013; Spikman et al., 2012) and can be interpreted as a consequence of damage to prefrontal circuits underlying EF. As expected, mild TBI patients performed on a HC level on performance-based tests and thus had no objective EF impairments in the early chronic stage postinjury (Ponsford et al., 2012; Schretlen & Shapiro, 2003).

Neuropsychological EF tests are important to measure impairments objectively. Nevertheless, a drawback of such tests is that they may not always capture the full range of EF problems in daily life (Burgess et al., 2006; Burgess, Alderman, Evans, Emslie, & Wilson, 1998; Chaytor, Schmitter-Edgecombe, & Burr, 2006). Therefore, questionnaires investigating subjectively experienced EF problems by patients and observed problems by significant others may have additional value in the assessment of EF.

In our study, the amount of self-reported and proxy-reported EF problems in daily life was significantly higher in the moderate-severe TBI group than in the mild TBI and HC groups. Furthermore, proxies of moderate-severe TBI patients reported a significantly higher level of EF problems than patients themselves, which is indicative of impaired self-awareness in this moderate-severe TBI patient group (Burgess et al., 1998; Prigatano, 2005). Consistent with the absence of objective EF impairments, mild TBI patients did not significantly differ from HCs in the amount of self-reported and proxy-reported EF problems.

The relation between reported EF problems and coping styles in the moderate-severe TBI group, implies that a higher amount of self-reported EF problems by patients was associated with lower levels of active coping and higher levels of passive coping. In addition, a higher amount of proxy-reported EF problems was related to lower levels of active coping, although no relation with passive coping was found. Because of indications for a lower level of self-awareness in this moderate-severe group (Burgess et al., 1998), particularly the finding that a higher amount of proxy-reported EF deficits was associated with lower levels of active coping by patients, is in line with the hypothesis that the presence of EF problems is related to a decreased ability to actively cope with emotionally stressing situations (Krpan et al., 2007).

With regard to passive coping within the moderate-severe TBI group, patients who report EF problems also experience a higher tendency to deal with emotional stress in a passive, maladaptive way. Apparently, this is not recognized by their significant others, since proxy ratings of EF problems were not correlated to higher levels of passive coping. Interestingly, although the neuropsychological test results clearly indicated EF impairments in the moderate-severe patient group, none of these tests showed a significant relationship with coping, with the exception of a positive relation between mental flexibility and active coping. This discrepancy with regard to strong associations between subjective EF problems in daily life and coping, opposed to limited evidence for relations between EF performance based tests and coping, is consistent with recent findings by Wolters et al. (2015). These rather contradictory results could be explained by differences in the constructs measured by the objective EF tasks and the subjective EF questionnaires. It seems reasonable to assume that performances on EF tasks reflect patients' problems solving skills, whereas it may be the case that self-reported EF problems in daily life reflect not only problems in executive activities but the experienced burden and psychological distress as well (Simblett & Bateman, 2011).

For the relation between reported EF and coping in the mild TBI group, we found again that a higher number of self-reported EF problems was related to lower levels of active and higher levels of passive coping. A higher amount of EF problems reported by proxies of mild TBI patients was only related to a higher level of passive coping, a pattern similar to that in the HC group. The latter finding is in contrast with the moderate-severe TBI group, where a significant negative correlation between proxy-reports for EF problems and active coping had been found.

Because mild TBI patients performed on a HC level on the EF tests, the relations in the mild TBI group between the subjectively experienced EF problems in everyday functioning and the experienced difficulties to effectively tackle complex daily life situations, could less likely be explained by objective EF impairments. It is generally thought that with reported persistent complaints in mild TBI, psychological mechanisms that influence perceived control and ability to change emotionally stressing situations play an important role (Hou et al., 2012; Scheenen et al., 2016). This is also exemplified in the work undertaken by Brands, Köhler, Stapert, Wade, and van Heugten (2014), as they addressed the stress-buffering effect of self-efficacy and demonstrated that higher self-efficacy was related to lower levels of passive coping and increased active coping in acquired brain injury patients (Brands et al., 2014). It is possible that self-efficacy also reflects feelings of capability to tackle complex task situations, and therefore subjectively experienced EF functioning. This is in line with the idea that a higher level of self-reported EF problems on the DEX by patients with TBI may in part reflect psychological distress that is related to the way patients are inclined to deal with stressing situations that put a demand on their executive abilities.

There are some limitations to this study. Educational level was higher in mild TBI patients compared to moderate-severe TBI patients. Although not consistently found, a higher educational attainment has been linked to a greater use of active coping (Wolters, Stapert, Brands, & van Heugten, 2011), and may therefore have skewed our findings. Even though our data set revealed no significant correlations between educational level nor estimated premorbid IQ scores and coping styles in both groups, this should be kept in mind when interpreting this data. Furthermore, a note of caution is due here since the dataset did not meet the assumptions to perform analysis of covariance. In addition to educational level, time since injury may also have influenced the relationship between EF and coping. Further studies, which take these variables into account, will need to be undertaken.

In conclusion, we found strong associations between self and other reported EF problems and coping styles in two TBI severity groups. These associations were partly different for patients with mild and patients with moderate-severe TBI. For moderate-severe TBI, in particular proxy-reported difficulties in EF may reflect the consequences of EF impairments related to a decreased use of active coping with complex problems. However, our results

showed little evidence for relations between scores on objective EF tasks and coping styles, indicating that EF and coping may only be limitedly related. We suggest that in moderate-severe TBI as well as in mild TBI patients, self-reported EF problems are in part a manifestation of general psychological distress, involving a perceived lack of control and belief in the ability to tackle difficult situations.

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