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Perceived Partner Burden in Neurological Disorders: Associations with Deficits in Emotion Recognition, Theory of Mind, Problems in Social Behavior, and Differences Between Disorders

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Abstract

Introduction: Behavioral changes may include deficits in emotion recognition, Theory of Mind (ToM), and problems in social behavior in neurological disorders. This might impact interpersonal functioning, possibly also contributing to partner burden. Understanding how perceived partner burden is related to deficits in emotion recognition, ToM, and problems in social behavior is crucial in neurological disorders, including multiple sclerosis (MS), stroke, and brain tumors. Furthermore, this study assessed how perceived partner burden differs between these neurological disorders. **Method:** The current study included 50 participants (MS: $n = 6$; stroke: $n = 32$; brain tumor: $n = 12$) and their romantic partners. Partners completed questionnaires regarding partner burden (Zarit Burden Interview; ZBI) and social behavior of the patient (Brock Adaptive Functioning Questionnaire; BAFQ). Patients completed measures regarding emotion recognition (Facial Expression of Emotion Stimuli and Tests; FEEST), ToM (Faux Pas Test; FP), and general cognition (Trail Making Test A + B; TMT' and the 15-Words Test Immediate Recall + Delayed Recall; 15-WT). **Results:** ZBI showed a positive significant association with BAFQ-Initiative, indicating partner-rated problems with initiative are associated with partner burden. Other factors showed non-significant associations with the ZBI. In the regression models, ZBI was only explained by BAFQ-Initiative and not by the FEEST, FP, or other BAFQ scales. However, both overall models were non-significant. The ZBI did not differ between MS, stroke, and brain tumor patients. **Conclusion:** This study provided a comprehensive understanding of deficits in emotion recognition, ToM, and problems in social behavior in association with partner burden. Problems in taking initiative should be assessed when aiming to alleviate burden. In rehabilitation settings, partner burden should be considered as a multifaceted construct.

Keywords: partner burden, social cognition, emotion recognition, theory of mind, social behavior, neurological disorders

Perceived Partner Burden in Neurological Disorders: Associations with Deficits in Emotion Recognition, Theory of Mind, Problems in Social Behavior, and Differences Between Disorders

Neurological disorders often pose major challenges for both patients and their partners. Besides cognitive and physical impairments, behavioral changes often play a central role in the burden experienced by partners who provide care to people with neurological disorders (Brooks et al., 1986; Silverman et al., 2021). Behavioral changes in such disorders often relate to impairments in social cognition and problems in social behavior (Henry et al., 2015; Nijsse et al., 2019). Social cognition, including emotion recognition and theory of mind (ToM), can be conceptualized as the mental processes involved in interpreting and/or recognizing social cues and understanding others' thoughts, intentions, and emotions (Adolphs, 2002). Deficits in social cognition, referring to the impaired processing of social cues and other's mental states, are assumed to be part of the underlying mechanism in behavioral change, which can result in social behavioral problems (Adolphs, 2002; Nijsse et al., 2019). Social behavior problems refer to observable interpersonal difficulties, including aggression and emotionality (Kennedy & Adolphs, 2012). As a result, social cognition deficits in emotion recognition, and ToM, and problems in social behavior can manifest as difficulties in interpersonal communication, which can contribute to relational difficulties linked to increased partner burden (Avci et al., 2016; Nijsse et al., 2019; Stiekema et al., 2019). Partner burden refers to the phenomenon where a patient's primary illness causes their spouse to suffer, encompassing emotional, physical, and economic hardships (Zarit et al., 1980). This burden may result in negative consequences, such as stress or social isolation (Avci et al., 2016). However, having a strong relationship is particularly valuable in the context of neurological disorders. Research has consistently shown that supportive relationships significantly enhance treatment adherence, emotional support, and overall health outcomes

(Reblin & Uchino, 2008). Since emotion recognition, ToM, and social behavior play a central role in interpersonal functioning, it is crucial to understand how these aspects relate to perceived partner burden in neurological disorders, including multiple sclerosis (MS), stroke, and brain tumors.

Two important aspects of social cognition include emotion recognition and ToM) (Westerhof-Evers et al., 2018). Emotion recognition is the ability to identify emotions in oneself and others and is considered a prerequisite for understanding people's thoughts (Baron-Cohen & Wheelwright, 2004; Bornhofen & Mcdonald, 2008). ToM can be defined as the competence to understand others' thoughts, beliefs, and behaviors and is similar to perspective-taking (Castelli, 2002). Although deficits in emotion recognition and ToM are assumed to be part of the underlying mechanism of problems in social behavior, the severity of these deficits is not always directly related to problems in social behaviors (Milders et al., 2008). This makes it essential to consider both deficits in emotion recognition and ToM (as measured by tests), and problems in social behavior (as rated by proxies) to gain a comprehensive understanding of the factors contributing to partner burden.

As reported in a recent qualitative study, deficits in social cognition may negatively affect their significant others (van den Broek et al., 2023). This study focused on impairments in emotion recognition and ToM after acquired brain damage, highlighting their impact on partners' experiences such as feelings of loneliness, sadness, and disappointment. Similarly, problems in social behavior, including lack of initiative and increased aggression as a result of traumatic brain injury (TBI), are linked with partner's feelings of hopelessness and frustration (Riley, 2016). Consequently, increased social cognition deficits and problems in social behavior could result in more misunderstandings and conflicts, accompanied by heightened emotional distress and negative emotions for partners. These interpersonal difficulties are associated with a higher perceived partner burden (Avci et al., 2016; Yeates, 2013). Following

this logic, more severe deficits in social cognition and more problems in social behavior might contribute to a higher perceived partner burden (Hypothesis 1a).

While deficits in emotion recognition, ToM, and problems in social behavior are interrelated, each aspect may contribute distinctively to partner burden, possibly varying in their degree of impact (Nijsse et al., 2019). To illustrate, in individuals with autism spectrum disorder (ASD), more deficits in ToM are associated with increased perceived partner burden (Baykal et al., 2018; Millar-Powell & Warburton, 2020). However, deficits in ToM are not limited to neurodevelopmental disorders; they are often present in neurological disorders, including MS, strokes, and brain tumors (Besnard et al., 2024; Happé et al., 1999; Lin et al., 2021). Given the finding that ToM impairments are identified across many different neurological disorders, it may be assumed that an association between ToM deficits and increased perceived partner burden exists in multiple neurological disorders (Hypothesis 1b). Additionally, patients with MS, stroke, and brain tumors often show deficits in emotion recognition and problems in social behavior, indicating that these aspects might uniquely contribute to partner burden (Cotter et al., 2016; Goebel et al., 2018; Nijsse et al., 2019).

Among individuals with different neurological disorders, the severity of social cognition deficits and social behavioral problems varies widely (Kennedy & Adolphs, 2012). However, on the group level, these deficits and problems are found to be comparably affected across various neurological disorders (Kennedy & Adolphs, 2012). Consequently, given that the severity of social cognition impairments and social behavioral problems are comparable across neurological disorders, it is reasonable to expect that partner burden may also be similarly affected between partners of patients with MS, stroke, or brain tumor (Hypothesis 2). However, this relationship has yet to be examined.

This study aims to examine partner burden in relation to deficits in emotion recognition, ToM, and problems in social behavior in neurological disorders. Therefore, the

first research question is (RQ1a): "*How is the severity of deficits in emotion recognition, ToM, and problems in social behavior, related to the level of burden experienced by partners of patients with neurological disorders?"* It is hypothesized that the severity of social cognition deficits in emotion recognition, ToM, and social behavior is associated with a higher perceived partner burden (H1a). This is followed by (RQ1b): *"Which aspects - emotion recognition, ToM, or social behavior – of individuals with neurological disorders could be most related to perceived partner burden?"* It is expected that ToM deficits are most related to perceived partner burden (H1b). However, impairments in general cognition might also result in challenges for patients and their partners, possibly contributing to partner burden (Brooks et al., 1986). To make sure the relationship between partner burden and deficits in remotion recognition, ToM, and problems in social behavior is not confounded, this study will consider general cognition as a control variable. Lastly, this study may reveal how perceived partner burden varies between different types of neurological disorders. The second research question (RQ2) is: "*Are there differences in perceived partner burden between partners of patients with MS, strokes, or brain tumors?"* It is hypothesized that no differences in partner burden between partners of patients with MS, strokes, or brain tumors can be identified (H2).

Methods

Participants

In the current study, data was collected as part of an ongoing study, T-ScEmo4ALL (Treatment of Social Cognition and Emotion Regulation), which is being conducted at the University Medical Centre Groningen (UMCG). T-ScEmo4ALL aims to evaluate the effectiveness of a comprehensive treatment for social cognitive impairments by evaluating a broad range of social cognition components (Heegers et al., 2025). This treatment has shown to be effective for patients with TBI, and its efficacy is now being evaluated in individuals

with various neurological disorders (Heegers et al., 2025). T-ScEmo4ALL includes participants with neurological disorders with identified impairments in social cognition. Eligible participants must be between 18 and 75 years old, and in a stable medical condition or more than six months post-acute injury.

For the current study, participants were required to have a diagnosis of either MS, stroke, or brain tumor. Additionally, participants needed to have a romantic partner who also participated in this study. No financial compensation was provided for participation in this research.

Procedure

The current study was approved by the Medical Ethical Committee of the UMCG (METc Groningen). Participants and their partners gave written informed consent before any neuropsychological tests or questionnaires. All assessments were completed prior to any intervention targeting emotion recognition, ToM, or social behavior, to ensure that results reflect the natural state of social functioning partner burden. Partners completed questionnaires assessing their perceived burden and the patient's social behavior. Patients completed social cognitive tests (emotion recognition, ToM) and additional cognitive tests. Tests of social and general cognition for patients were completed at the UMCG under the supervision of one of the researchers involved in T-ScEmo4ALL. Measurements used for partners were completed at home and sent to the UMCG after completion.

Measures

Demographic data included patients' medical diagnosis, age, gender, educational level, and partner's age and gender. To classify educational level, the Dutch classification system of Verhage was used, ranging from 1 (less than six years of primary school) to 7 (university degree), categorized as lower (1-3) and higher (4-7) education (Verhage, 1964). Furthermore, data were collected on relationship duration, whether the relationship started before diagnosis

and cohabitation status were collected. The following neuropsychological tests and questionnaires were administered for measurement.

Partner Burden

Questionnaire for Partners: Partner Burden. Partner burden was measured by using the Zarit Burden Interview (ZBI; Bédard et al., 2001). The ZBI assesses subjective caregiver burden and has demonstrated high internal consistency (Cronbach's alpha = .93) and strong test-retest reliability (ICC = .89) (Seng et al., 2010). For the current study, an abbreviated version of the ZBI, adapted by the UMCG, was used. This version consists of twelve items with response categories scored from 0 (never) to 4 (almost always). Partners rated how much each statement reflects their personal caregiving experience. The higher the score, the higher the perceived partner burden, with a maximum of 48. Scores above 20 indicate a high perceived partner burden (Bédard et al., 2001).

Social Behavior

Questionnaire for Partners: Social Behavior. To measure social behavior, the Brock Adaptive Functioning Questionnaire (BAFQ) was administered (Chaytor & Schmitter-Edgecombe, 2007). In this questionnaire, caregivers are asked to rate, on a Likert scale from 0 (hardly ever/never) to 4 (almost always), how often they observe each of sixty-eight social behavior problems in their partner. An abbreviated version, including five domains, was used. This version included the following subscales: Initiative, Emotionality, Aggression, Social Monitoring, and Empathy. A percentage score ranging from 0%-100% was generated for each subscale, with higher scores indicating more social behavioral problems in that aspect. Although the BAFQ also contains a change scale (percentage of behavioral changes), this study only included observed social behavioral problems as rated by proxies. This test has shown adequate internal consistency in other studies measuring social behavior (Cronbach's alpha=.92) (Jorna et al., 2021).

Social Cognition

Test for Patients: Emotion Recognition. Emotion recognition was measured using the subtest Ekman 60 Faces Test of the Facial Expressions of Emotion – Stimuli and Tests (FEEST) (Young et al., 2002). Sixty faces were shown with expressions of the primary emotions: anger, happiness, sadness, surprise, fear, and disgust (ten faces for each emotion). Stimuli were presented on a computer screen for five seconds, after which the patient chose which emotion label best described the emotion that was shown. The total score ranges from 0-60. Higher scores indicate better emotion recognition. The FEEST has been used in assessing facial emotion recognition in multiple neurological disorders (Young et al., 2002), with an acceptable test-retest reliability (Pearson's r = .71) (Kuhlmann & Margraf, 2023)

Test for Patients: Theory of Mind. To assess ToM, a shortened version of the Faux Pas Test (FP) was used (Stone et al., 1998). Patients are asked to identify a social faux pas within short vignettes in this test. The short version of the FP test consists of ten short stories, with half of them describing a situation that involves a faux pas (Spikman et al., 2011). Total scores range from 0-10, with higher scores indicating a better ToM. This test also includes a subscale measuring empathy, but because empathy is already included in the BAFQ, this subscale was not considered. The FP has previously been used to examine ToM in neurological populations (Stone et al., 2003), and has been shown to discriminate between patients with social cognition impairments and those without impairments (Gregory et al., 2002). The FP has demonstrated good test-retest reliability (Pearson's r = .89) (Yeh et al., 2018), and strong inter-rater reliability (ICC = .95 and .87) (Fernández-Modamio et al., 2018;).

General Cognition

Test for Patients: Verbal Learning and Memory. 15-Word Test (15-WT) is a verbal learning and memory test in which a list of 15 Dutch, non-associated nouns must be

remembered (van Zomeren, 1981). The list is presented five times. After each time, the patient is asked to recall as many words as possible, with higher scores indicating better verbal learning. For the immediate recall (IR), a maximum score of 75 can be obtained. After twenty minutes, participants are asked again to recall the list (delayed recall; DR), with a maximum score of 15. Higher scores reflect stronger memory performance. The reliability of the Dutch version is not available, but the English version of this task has shown adequate test-retest reliability for both the15-WT IR (Pearson's r =.77) and the 15-WT DR (Pearson's r = .70) (Geffen, 1994).

Test for Patients: Psychomotor Speed and Mental Flexibility. For psychomotor speed and mental flexibility, the Trail Making (TMT) was used. In part A, circles with numbers must be connected in ascending order as quickly as possible, measuring psychomotor speed (Reitan & Wolfson, 1985). In part B, participants must alternate between numbers and letters, again as quickly as possible. This part evaluates mental flexibility. Faster completion times indicate better psychomotor speed and mental flexibility. Both tests A and B have shown high construct validity (Cohen's d = .96 and d = .90) (Smith et al., 2008).

Statistical Analysis

Analysis of data was conducted using IBM SPSS statistical software (version 28). First, relevant demographic statistics were calculated, including age, gender, and clinical statistics. For all statistical analyses, when included, the following scores were used: raw scores of the ZBI and FP, percentage scores for all BAFQ-Social Behavior subscales, and percentile scores of the FEEST, TMT, and 15-WT. Missing data was not addressed in this study, analyses were conducted on complete cases only.

To assess the relationship between social cognition deficits and partner burden (RQ1a), Pearson's and Spearman's correlations were conducted between scores on the ZBI and the scores on the FEEST, FP, and BAFQ- Social Behavior subscales. Normality was

tested using the Shapiro-Wilk test, with a threshold of $p < .05$ indicating a violation of the normality assumption. Pearson's correlations were computed when both variables met the assumption of normality. For the remaining correlations, Spearman's correlations were used. To account for multiple testing, a Bonferroni-Holm correction was applied to the correlations between the ZBI and the FEEST, FP, and BAFQ-Social Behavior scales. No correction was applied to intercorrelations among the independent variables, as these analyses were examined in a more exploratory manner.

Two multiple regression analyses were performed to determine the extent to which perceived partner burden was related to emotion recognition, ToM, and social behavior (RQ1b). Before conducting the regression analysis, assumptions of normality, homoscedasticity, linearity, and multicollinearity were checked. Normality was evaluated using visual inspection of Q-Q plots and a Shapiro-Wilk test. Homoscedasticity and linearity were evaluated using a scatterplot. Multicollinearity was assessed by using the Variance Inflation Factor (VIF), with values > 5 indicating multicollinearity (Kim, 2019).

Multiple regression analysis 1: The dependent variable consisted of ZBI, and the independent variables encompassed FEEST, FP, and subscales of the BAFQ. For the BAFQ, the two highest correlated subscales were used (RQ1a). To ensure social behavior is reflected in the regression model, the two BAFQ-Social Behavior scales with the highest uncorrected correlations with the ZBI were selected when no associations remained significant after the Bonferroni-Holm correction.

Multiple regression analysis 2: The dependent variable consisted of the ZBI, and the independent variables of the FEEST, FP, all BAFQ-Social Behavior scales, 15-WT IR + DR, and TMT A + B. This second regression model was conducted to examine whether the significant social cognitive and social behavioral variables of partner burden remained significant when controlling for general cognition.

Lastly, it was assessed if there are differences in partner burden between patients with MS, stroke, and brain tumors (RQ2). Normality was checked by a Shapiro-Wilk test to determine what test would be appropriate to use, based on the threshold of $p < .05$ indicating a violation of the normality assumption. A non-parametric Kruskal-Wallis test was conducted to examine if there were differences in perceived partner burden between partners of MS, stroke, and brain tumor patients. ZBI was used as the dependent variable, and neurological condition (MS, stroke, and brain tumor) as the independent variable.

Correlations were considered weak ($r < .20$), moderate ($r > .20 < .80$), or strong ($r > .80$) (Wuensch & Evans, 1996). Effect sizes for multiple regressions were classified as small ($f^2 = .02$), medium ($f^2 = .15$), or large ($f^2 = .35$) (Cohen, 1988). For Kruskal-Wallis tests, effect sizes are classified as small ($\eta^2 = .01$), medium ($\eta^2 = .06$), or large ($\eta^2 = .14$) (Cohen, 1988).

Results

The total sample for the current study consisted of 50 patients and their romantic partners. Patients with MS ($n = 6$) included relapsing-remitting and secondary progressive MS. In the biggest group, consisting of patients with strokes ($n = 32$), patients were diagnosed with cerebral infarctions, hemorrhages, transient ischemic attacks, and subarachnoid hemorrhages (SAH). Patients with a brain tumor ($n = 12$) included types of low-grade astrocytoma's, oligodendrogliomas, and meningiomas. Of the disorders with a clear localization, 10 cases were right-sided, and three were left-sided. For the remaining cases, localization was unclear, unspecified or involved multiple regions. Participant and partners' demographics are summarized in Table 1. As indicated below the table, not all data was available for all participants.

Table 1

Demographic Characteristics

Characteristics	Total (n = 50)	MS (n =6)	Stroke (n = 32)	Brain Tumor (n =12)
Patient:				
Sex, male *n* (%)	41 (82.0%)	4 (66.7%)	27 (84.4%)	10 (83.3%)
Age in years, *M (SD)*	55.8 (12.2)	45.5 (13.7)	62.4 (8.9)	52.3 (13.8)
Educational level *M (SD)*	5.5 (1.1)	4.7 (1.4)	5.6 (1.1)	5.8 (.75)
Partner:				
Sex, male *n* (%)	9 (18.0%)	2 (33.3%)	4 (12.5%)	3 (25.0%)
Age, *M (SD)*$^{+}$	56.5 (12.4)	44.8 (6.3)	61.1 (9.3)	50.8 (15.6)
Duration of relationship in years*, *M (SD)*	27.0 (16.8)	15.5 (11.8)	30.5 (16.0)	23.9 (18.7)
Relationship started before diagnosis^{++} *n* (%)	44 (91.7%)	6 (100%)	27 (90.0%)	11 (92.7%)
Patient and partners that live together** *n* (%)	46 (93.9%)	4 (66.7%)	31 (100%)	11 (91.7%)

Note. n = number of participants; M = mean; SD = standard deviation; $^{+}$ n = 37 (missing values: 2 in MS, 9 in Stoke, and 2 in Brain Tumor); *n = 38 (missing values: 2 in MS, in 9 Stroke, 1 in Brain Tumor); $^{++}$ = n = 48 (missing values: 2 in Stroke); **= n is 49 (missing values: 1 in Stroke)

Ratings by partners on the ZBI and BAFQ, and test performances by patients on the FEEST, FP, 15-WT IR + DR, and TMT A + B are summarized in Table 2. For ZBI, 21

partners scored above the cut-off of > 20, indicating high perceived partner burden (Bédard et al., 2001).

Table 2

Performances on Tests and Questionnaires

Characteristics	Total (n = 50)	MS (n = 6)	Stroke (n = 32)	Brain Tumor (n = 12)
ZBI[1**] *M (SD)*	17.4 (9.1)	22 .0 (2.6)	16.7 (10.3)	20.9 (6.3)
Social Cognition M (SD):				
FEEST[2+]	14.1 (16.8)	10.0 (9.2)	11.5 (11.5)	27.6 (25.2)
FP[1*]	8.5 (1.2)	9.0 (1.0)	8.5 (1.5)	8.4 (0.8)
Social Behavior M (SD) %:				
BAFQ-Initiative[3++]	54.2 (17.3)	68.3 (24.7)	49.3 (15.8)	60.5 (18.0)
BAFQ-Emotionality[3+]	42.8 (14.9)	34.3 (12.5)	46.7 (14.8)	38.2 (13.3)
BAFQ-Aggression[3+]	31.3 (8.6)	32.0 (12.0)	32.0 (9.7)	29.1 (6.7)
BAFQ- Social Monitoring[++]	54.8 (11.0)	65.6 (9.8)	53.9 (10.6)	53.5 (12.7)
BAFQ-Empathy[3+]	62.6 (17.3)	72 (24.3)	62.6 (17.0)	59.4 (18.8)
General Cognition M (SD):				
15-WT IR[2]	26.4 (27.6)	17.7 (24.6)	21.1 (25.0)	40.5 (32.3)
15-WT DR[2]	46.7 (30.4)	37.3 (29.0)	46.5 (30.6)	33.1 (20.2)
TMT-A[2]	38.2 (32.8)	35.7 (41.7)	45.1 (34.9)	36.5 (31.6)
TMT-B[2*]	40.3 (29.4)	24.7 (25.0)	47.2 (35.0)	36.1 (26.5)

Note. M = mean; *SD* = standard deviation, [1] = ZBI and FP are presented as raw scores; [2] = FEEST, 15-WT IR + DR, TMT-A +B are presented as percentile scores; [3] = all BAFQ-scales are presented as percentage scores of proxy-rated social behavior problems; * n = 49; ** n = 48; [+] n = 42; [++] n = 41

RQ1: Perceived Partner Burden in Relation to Emotion Recognition, ToM, and Social Behavior in Relation to Perceived Partner Burden

RQ1a: Associations of Emotion Recognition, ToM, and Social Behavior with Perceived Partner Burden

Assumption Checks

To assess the assumptions underlying correlation analysis, normality for all variables was assessed by both the Shapiro-Wilk test and Q-Q plots (see Appendix A). ZBI, BAFQ-Initiative, BAFQ-Social Monitoring, and BAFQ-Empathy did not show significant deviations from normality. Consequently, for all pairwise correlations among these variables, Pearson's correlation coefficients were computed. For all remaining correlations, in which one of the two variables did not meet the normality assumption, Spearman's rank-order correlations were used.

Correlation Coefficients Among Measures

All Pearson's and Spearman's correlations are summarized in Table 4. A Bonferroni-Holm correction was applied to correlations involving the ZBI to control for multiple testing. Correlations between the other variables were exploratory and not corrected. A positive significant association between ZBI and BAFQ-Initiative was found, indicating that greater problems in with initiative as rated by partners are related to higher perceived partner burden. The strength of these associations was moderate. No significant correlations between ZBI and the FEEST, FP, and BAFQ-Social Behavior scales Emotionality, Aggression, Empathy, or Social Monitoring. The findings partially align with hypothesis 1a.

Table 3

Spearman's Correlations Coefficients Between Partner Burden and Social Cognition

Variable	1	2
1. ZBI		
2. FEEST	.23	
3. FP	-.16	-.08

Note. Bonferroni-Holm correction was applied to correlations involving ZBI.

Table 4

Pearson's and Spearman's Correlation Coefficients Between Partner Burden and Social Behavior

Variable	1	2	3	4	5
1. ZBI					
2. BAFQ-Emotionality	.27				
3. BAFQ-Initiative	.45[1†]	-.01			
4. BAFQ-Aggression	.13	.64**	.04		
5. BAFQ-Social Monitoring	.26[1]	.14	-.32[1]*	.16	
6. BAFQ-Empathy	.34[1]	.01	.43[1]*	-.05	.55**

Note. [1] = Pearson's correlations; all other correlations are Spearman's rank-order correlations. Bonferroni-Holm correction was applied to correlations involving ZBI. [†] $p = < .007$ (Bonferroni-corrected significance level). *$p = < .05$, ** $p = < .01$ (uncorrected significance levels)

RQ1b: Emotion Recognition, ToM, and Social - Behavior in Relation to Perceived Partner Burden

Assumption Checks

Assumptions of normality, homoscedasticity, linearity, and multicollinearity were assessed before performing a multiple regression analysis. Normality was checked by using a Shapiro-Wilk test and Q-Q plots (see Appendix A). Q-Q plots of normality for the 15-WT IR and TMT A + B were also assessed. Visual inspection of a scatterplot to assess homoscedasticity and linearity indicated that there was no evidence that these assumptions were violated, as no systematic pattern could be detected. VIFs were all below 5, indicating no multicollinearity (Kim, 2019). The results do not indicate violations of the assumptions required for a multiple regression analysis (see Appendix A).

Multiple Regression Model of for Partner Burden

The first multiple regression analysis was conducted to examine variables related to the ZBI including the FEEST, FP, BAFQ-Initiative, and BAFQ-Empathy. Only BAFQ-Initiative remained significant after Bonferroni correction (see Table 4). Therefore, the second BAFQ-Social Behavior scale (BAFQ-Empathy) was added based on its significance prior to Bonferroni-Holm correction to retain representation of social behavior in the regression model (see Appendix B). The regression model was not statistically significant, F (4, 35) = 2.634, p = .051, R^2_{adj} = .144. Collectively, the variables have a moderate effect size (f^2=.300), although the model's explanatory power (R^2) was low. Among the independent variables, BAFQ-Initiative was the only variable that demonstrated a significant association with the ZBI when controlling for the FEEST, FP, and BAFQ-Empathy (p = .033). However, this finding should be interpreted with caution, given the nonsignificant overall model fit. The current findings contradict hypothesis 1b.

Table 5

Multiple Regression Model of Partner Burden, Including Emotion Recognition, ToM, and Social Behavior

ZBI	*B*	95% CI for *B*		*SE B*	*t*	*p*	*β*	R^2	R^2_{adj}
		LL	*UL*						
Model								.23	.14
Constant	0.05	-25.30	25.4	12.44	0.00	.997			
FEEST	0.21	-0.10	0.21	0.08	0.19	.850	.10		
FP	0.05	- 2.00	2.4	1.09	0.69	.498	.03		
BAFQ-Initiative	0.19	0.02	0.36	0.08	2.22	.033*	.36		
BAFQ-Empathy	0.09	-0.08	0.27	0.09	1.07	.292	.18		

Note. $*p < .05$. *B* = unstandardized coefficients; CI = confidence interval; LL = lower limit, UL; upper limit; *SE B* = standard error of unstandardized coefficient; *t* = t-statistic; β = standardized coefficient; R^2 = determination coefficient; R^2_{adj} = adjusted R^2

The second regression model, with ZBI as the dependent variable, included the FEEST, FP, BAFQ-Social Behavior scales, 15 WT IR + DR, and TMT A + B (see Table 6). 15-WT IR and TMT A + B were included in this regression model to account for the possible influence of general cognition on partner burden. This model also did not demonstrate a significant association with the ZBI, F (11, 26) = 1.790, p = .11, R^2_{adj} = .190, with a large effect size (f^2 = .758) (Cohen, 1988). In this regression model, BAFQ-Initiative was again the

only significant contributor to ZBI (p = .032), controlling for the FEEST, FP, all other BAFQ-Social Behavior scales, 15 WT IR + DR, and TMT A +B.

Table 6

Multiple Regression Model of Partner Burden Including General Cognition

ZBI	*B*	95% CI for *B*		*SE B*	*t*	*p*	*β*	R^2	R^2_{adj}
		LL	*UL*						
Model								.43	.19
Constant	-5.77	-35.47	23.93	14.45	-0.40	.693			
FEEST	0.09	-0.08	0.26	0.08	1.14	.264	.18		
FP	0.77	-1.91	3.44	1.30	0.59	.561	.11		
BAFQ-Initiative	0.12	0.02	0.37	0.09	2.27	.032*	.39		
BAFQ-Empathy	0.10	-0.13	0.33	0.11	0.89	.383	.19		
BAFQ-Emotionality	0.05	-0.22	0.32	0.13	0.38	.709	.08		
BAFQ-Aggression	0.18	-0.26	0.61	0.21	0.84	.412	.17		
BAFQ-Social Monitoring	-0.11	-0.47	0.26	0.18	-0.60	.555	-.13		
15-WT IR	-0.11	-0.23	0.01	0.06	-1.87	.072	-.34		
15-WT DR	-0.01	-0.12	0.10	0.05	-.111	.912	-.02		
TMT-A	0.06	-0.08	0.21	0.07	0.89	.380	.24		
TMT-B	-0.05	-0.20	0.11	0.08	-0.66	.517	-.18		

Note. $*p < .05$. *B* = unstandardized coefficients; CI = confidence interval; LL = lower limit, UL; upper limit; *SE B* = standard error of unstandardized coefficient; *t* = t-statistic; β =standardized coefficient; R^2 = determination coefficient; R^2_{adj} = adjusted R^2

RQ2: Comparison of Perceived Partner Burden Between MS, Stroke, and Brain Tumor Patients

Assumption Checks

Assumptions for parametric testing were assessed before analysis. The distribution of ZBI scores significantly deviated from normality across the different neurological disorders as indicated by the Shapiro-Wilk test. For perceived partner burden, a significant deviation from normality was found, W (48) = .948, p = .033. Therefore, a non-parametric alternative to a one-way ANOVA was performed (Kruskal-Wallis test).

Comparison of Partner Burden Between Neurological Disorders

A Kruskal-Wallis test was performed on the ZBI scores of the three neurological disorders (MS, stroke, and brain tumor) (see Table 7). The differences in ZBI between multiple neurological disorders were not statistically significant, with a negligible effect size (η^2 = .00) (Cohen,1998), aligning with hypothesis 2.

Table 7

Partner Burden Between Different Neurological Disorders

Neurological Disorder (n = 48)	ZBI score *M (SD)*	Mean Rank	*H*	df	*p*
			1.741	2	.419
MS (n = 6)	22.0 (2.65)	21.3			
Stroke (n = 30)	16.71 (10.31)	23.4			
Brain Tumor (n = 12)	20.91 (6.33)	29.0			

Note. M = mean; SD = standard deviation; H = Kruskal-Wallis; df = degrees of freedom

Discussion

The current study aimed to provide an understanding of perceived partner burden in relation to deficits in emotion recognition ToM, and problems in social behavior in neurological disorders, specifically for MS, strokes, and brain tumors. Three research questions were addressed: whether the severity of deficits in emotion recognition, ToM, and problems in social behavior were associated with perceived partner burden (RQ1a), which particular aspects were most strongly related to this burden (RQ1b), and whether the level of perceived partner burden differs between MS, stroke, and brain tumor patients (RQ2). The findings revealed that social cognition was not associated with perceived partner burden. For social behavior, higher reported problems in initiative, as rated by partners, were associated with partner burden (RQ1a). At the model level, no significant results were found when examining which aspects could be most strongly related to this perceived partner burden (RQ1b) However, within both models, initiative was significantly associated with partner burden. Furthermore, partner burden did not differ between MS, stroke, and brain tumor (RQ2).

Perceived Partner Burden in Relation to Emotion Recognition, ToM, and Social Behavior (RQ1)

The expectation that more deficits in social cognition and problems in social behavior are associated with perceived partner burden, is only partially supported by the results (RQ1a) (Avci et al., 2016; den Broek et al., 2023). Social cognition aspects emotion recognition and ToM were not related to partner burden. For social behavior, the current results revealed a moderate positive association between perceived partner burden and initiative. No significant associations with partner burden were found for the other social behavior aspects, including emotionality, empathy, aggression, and social monitoring.

The findings suggest that reported problems with initiative as rated by partners may be impactful in caregiving contexts. Initiative is defined as a person's capacity for self-initiated actions and proactive engagement with their surroundings (Fay & Frese, 2001). A potential explanation for the relationship between problems with initiative and partner burden is that lack of initiative is a core feature of apathy, which is a well-established contributor to caregiver burden in neurodegenerative disorders (Delfino et al., 2021; Zhao et al., 2025). Apathy encompasses symptoms such as reduced interest, motivation, and initiative compared to the patient's previous level of functioning (Delfino et al., 2021). These may result in reduced emotional responsiveness and poor treatment adherence, increasing both emotional and physical strain on caregivers (Witgert et al., 2009). Additionally, caregivers often misinterpret apathy as a voluntary choice of the patient, which causes distress for partners (Yeager & Hyyer, 2008). This makes problems with initiative, as part of apathy, one of the most challenging behavioral symptoms for partners.

The lack of relationship between partner burden and emotion recognition, ToM, and other social behavior aspects might be explained by the fact that participants were required to be in a stable phase of their condition. Several patients lived with their neurological disorder for over two years. Over time, social cognition deficits and problems in social behavior may have become less disruptive within their relationships. Research in neurodegenerative disorders found that caregiver burden might be more related to the initial emergence of behavioral changes, rather than the severity of symptoms (Gaugler et al., 2005; Perren et al., 2006). Consequently, in the current sample, partners may have adapted to the behavioral changes, which reduced perceived partner burden despite ongoing social cognition deficits and problems in social behavior.

Regarding the second part of the research question (RQ1b), it was expected that ToM would be most strongly related to perceived partner burden (Baykal et al., 2018; Millar-

Powell & Warburton, 2020). Although the overall models were not statistically significant, both models showed a marginally significant relationship between initiative and partner burden, contradicting the hypothesis. The association between initiative problems and partner burden is consistent with previous evidence of a link between this apathy symptom and caregiver burden (Delfino et al., 2021; Zhao et al., 2025). General cognition, which was included as a potential covariate, was also not significantly associated with partner burden.

The current findings suggest that partner burden is not associated with social cognition deficits and with only one aspect of social behavior problems. Although overall partner burden was mild in the current sample, still nearly half of the partners reported high experienced levels of burden. This raises the question of whether perceived burden might be more related to factors other than deficits in social cognition and problems in social behavior. It is important to consider that partner burden is a multidimensional construct, including strain in emotional, physical, psychological, and financial domains (Avci et al., 2016; Liu et al., 2020). Therefore, it is plausible that emotion recognition, ToM, and social behavior only play a limited role in this complex, multifaceted experience.

Among behavioral components related to partner burden, other factors such as the partner's coping could outweigh the influence of the severity of social cognition deficits and social behavior problems (Van Den Kiekeboom et al., 2020; Ziello et al., 2014). Partner burden might be less influenced by the patient's behavior, and more by the partner's behavior to appropriately adapt to the patient's alterations accompanied by neurological disorders (Reis et al., 1994). Behavioral flexibility, described as adjusting roles and communication patterns as a response to neurological disorders, may help reduce partner burden (Maggio et al., 2018; Rolland et al., 2011). Multiple studies highlight that partner flexibility within caregiving situations is crucial to coping with the behavioral changes in neurological disorders, including

social cognition deficits and social behavioral problems (Maggio et al., 2018; Rolland et al., 2011; Tan et al., 2023).

Differences in Perceived Partner Burden Between MS, Strokes, and Brain Tumors (RQ2)

The result that perceived partner burden did not differ between partners of patients with MS, strokes, and brain tumors, aligns with the expectation. This lack of differences in perceived partner burden suggests strain might not be driven by a specific diagnosis. Instead, it likely reflects the aforementioned multifaceted nature of caregiving, which is shaped by a broad range of influences (Liu et al., 2020). The various factors contributing to partner burden make it likely that the neurological diagnosis itself does not determine the burden experienced.

Strengths and Limitations

A notable strength of the current study is its focus on a topic that has received limited attention in the existing literature. This study is unique in its focus on distinct domains of social cognition and social behavior in neurological disorders and its associations with partner burden, allowing for a comprehensive analysis of this relationship.

However, there are several important limitations that have to be acknowledged when interpreting the results. First, the study's cross-sectional nature requires careful interpretation of the results, as the direction of the relationship between partner burden and initiative cannot be established. Therefore, it remains unclear if problems with initiative result in strain, or if high partner burden gradually weakens a patient's initiative. Furthermore, the focus on a patient group with longstanding social functional impairments likely reduced variability across measures, including partner burden, social cognition, and social behavior. To illustrate, in the current study, partner burden and social behavior aspects were generally mildly impaired, and ToM showed minimal impairment. The mild performances on tests and

reported problems, along with moderate variability in these measurements, may have limited the ability to detect significant associations. Lastly, the small sample size of the subgroups represents another important limitation. This was particularly true for the MS group, which consisted of six participants. However, because the current study is part of ongoing research (T-ScEmo4ALL), the sample size is expected to increase in the future.

Implications and Future Directions

Building upon prior research showing that having a strong relationship is particularly valuable throughout neurological illnesses (Reblin & Uchino, 2008), the current findings provide valuable insights into how partner burden is related to deficits in emotion recognition, ToM, and problems in social behavior in neurological disorders. This study revealed the importance of assessing patients' initiative in efforts to alleviate partner strain. Furthermore, given that nearly half of the partners in this sample reported a heightened burden, factors beyond the patient's social cognition and social behavior may contribute to partner burden. Therefore, partner burden should be considered as a multidimensional construct, making it also crucial to assess and, if necessary, intervene in partner-related characteristics such as flexibility (Maggio et al., 2018). Fostering partner flexibility might provide a buffer against the burden independently of the patient's impairments. However, this requires additional research. Future research should also focus on partner burden in relation to the rate of behavioral change in neurological patients, rather than the severity of social cognition deficits and social behavior problems. Furthermore, investigating the multidimensional nature of partner burden, irrespective of a diagnosis, is essential to guide future research aiming at improving rehabilitation approaches.

Conclusions

In conclusion, this study provides a more nuanced understanding of partner burden in relation to deficits in emotion recognition, ToM, and problems in social behavior in

neurological disorders. Patient's problems with initiative, as rated by partners, were linked to partner burden. Given the limited associations between other aspects of social cognition and social behavior with partner burden, along with the lack of consistent patterns across diagnoses, rehabilitation strategies should address initiative-related challenges and focus on the individual needs of both patients and their partners.

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Appendix A

RQ1: Social Cognition Deficits in Relation to Perceived Partner Burden

RQ1a: Assumption Tests of Normality

Shapiro-Wilk test is preferred for smaller sample sizes and therefore used in the current project. Q-Q plots were also examined for visual inspection of normality.

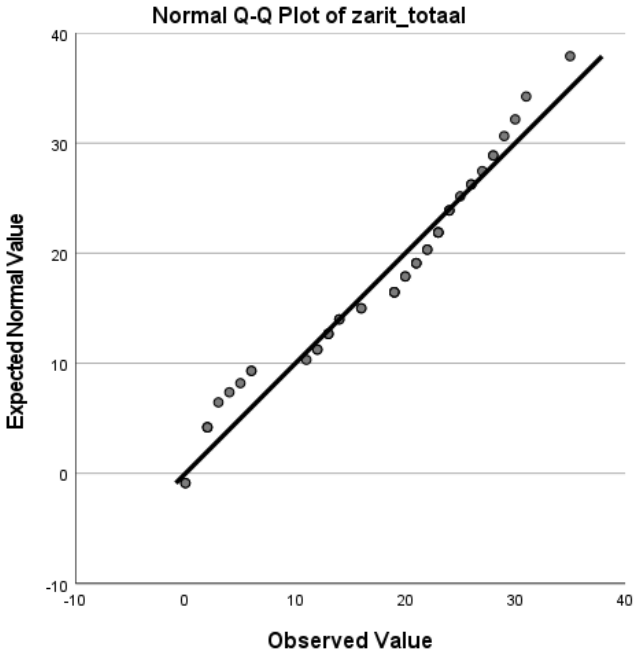
Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
zarit_totaal	,161	38	,015	,947	38	,070
15 WT IR Percentiel Score	,173	38	,006	,844	38	<,001
15 WT DR Percentiel Score	,108	38	,200*	,955	38	,130
TMTB/A ruwe score	,173	38	,006	,893	38	,002
TMTB percentiel score	,135	38	,078	,919	38	,009
FEEST percentile score	,269	38	<,001	,758	38	<,001
BAFQ Initiative percentage	,096	38	,200*	,965	38	,275
BAFQ Emotionality percentage	,152	38	,027	,946	38	,066
BAFQ Agression percentage	,217	38	<,001	,873	38	<,001
BAFQ Social Monitoring percentae	,127	38	,128	,967	38	,315
BAFQ Empathy percentage	,132	38	,091	,958	38	,159
FauxPas raw score	,225	38	<,001	,859	38	<,001

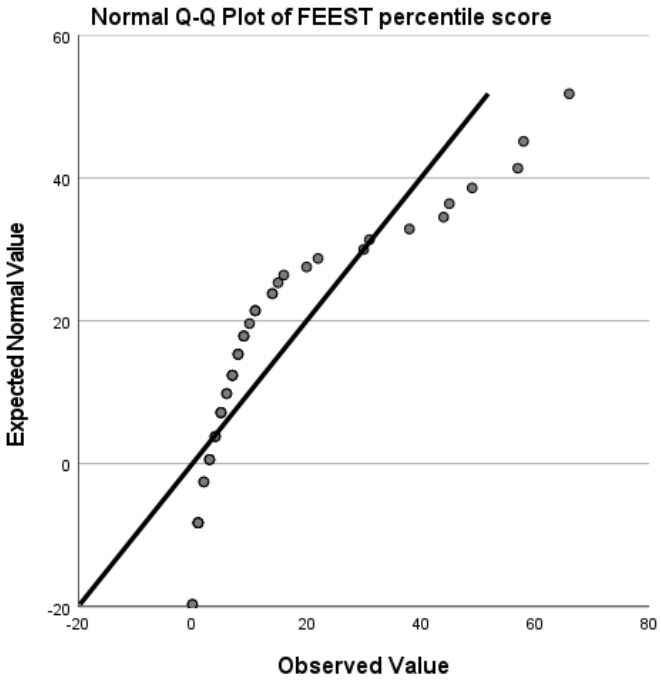
*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

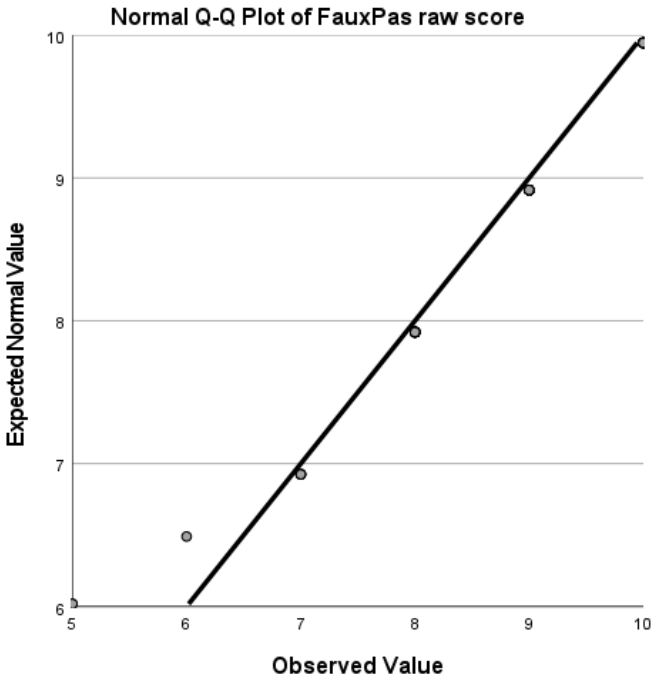
ZBI:


Normal Q-Q Plot of zarit_totaal
Expected Normal Value
Observed Value
40
30
20
10
0
-10
-10
0
10
20
30
40

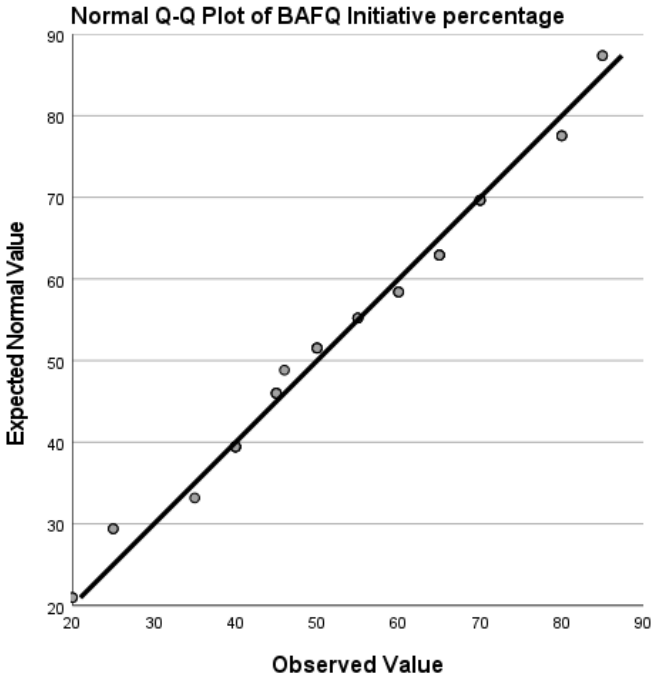
FEEST:


Normal Q-Q Plot of FEEST percentile score
Expected Normal Value
Observed Value
60
40
20
0
-20
-20
0
20
40
60
80

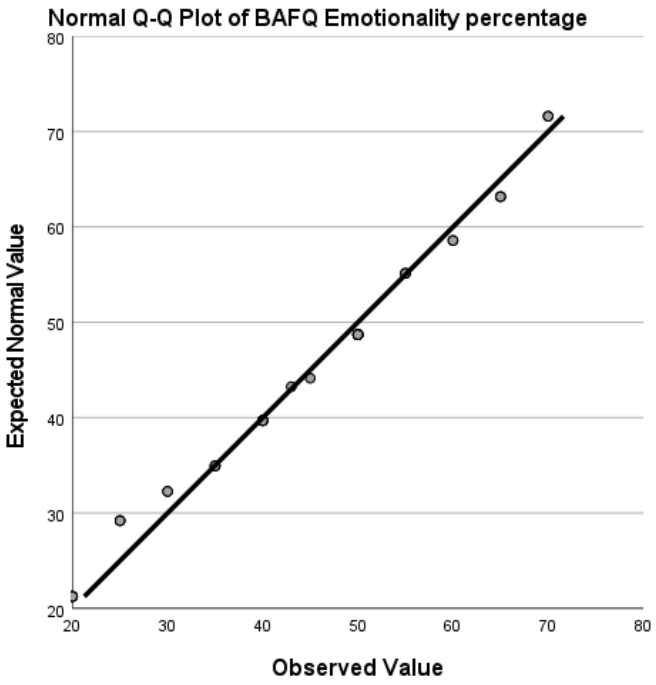
FP:



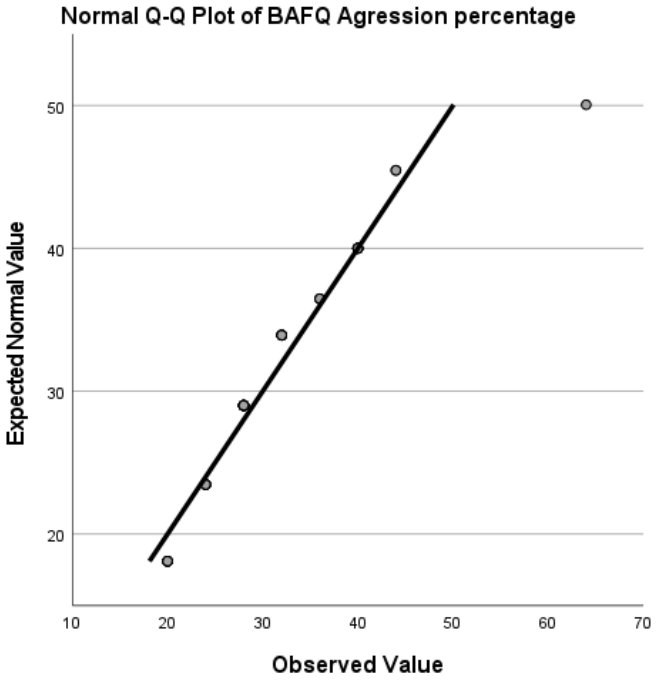
BAFQ Initiative:



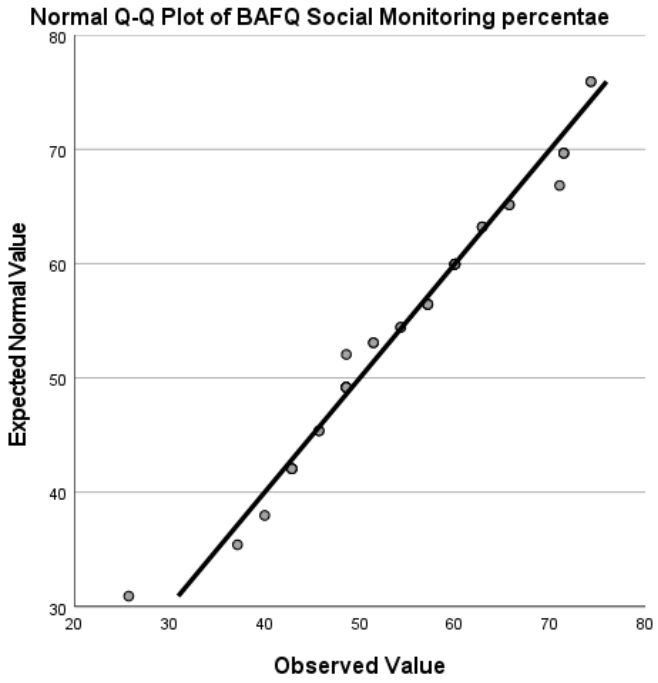
BAFQ Emotionality:



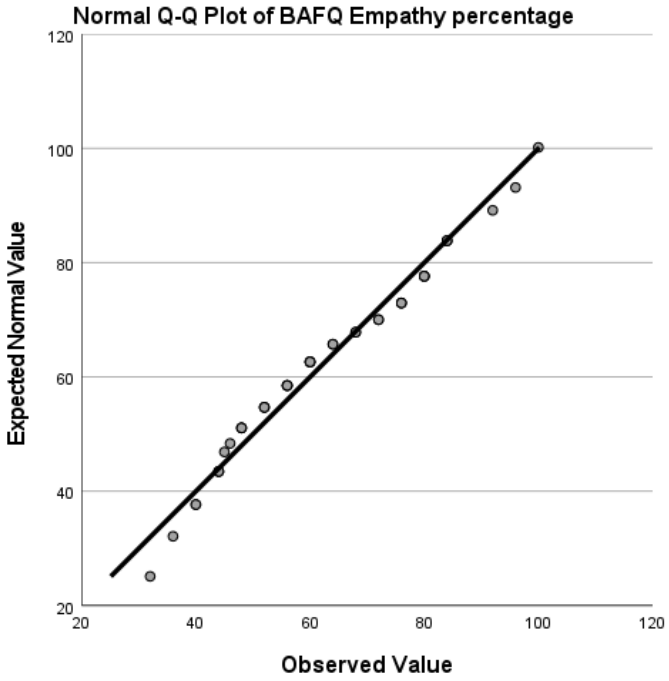
BAFQ Aggression:



BAFQ Social Monitoring:



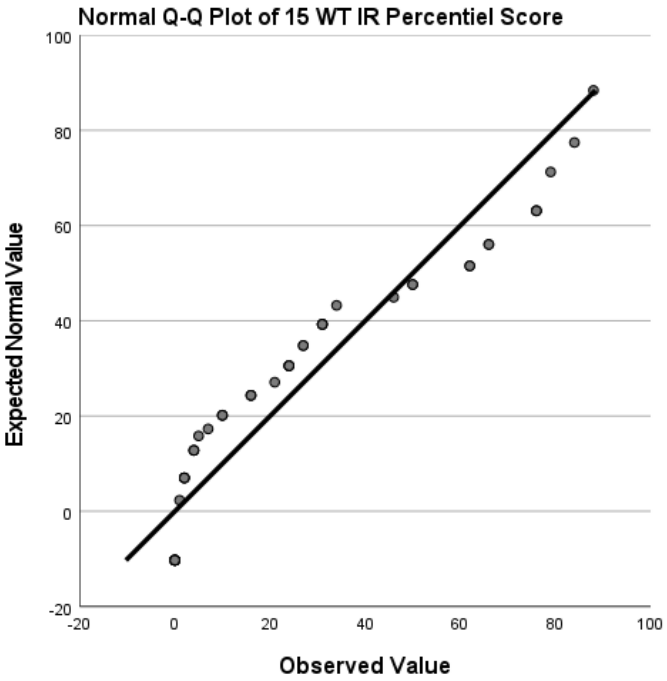
BAFQ Empathy:



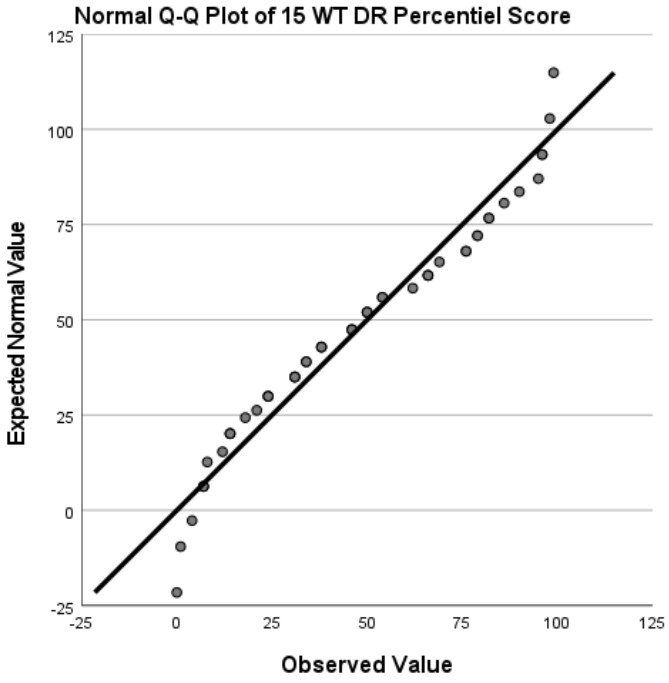
RQ1b: Assumptions of Normality, Linearity, Homoscedasticity, Multicollinearity

Q-Q plots from RQ1a were also used for RQ1b to assess normality. Additional Q-Q plots cognitive tests are shown below.

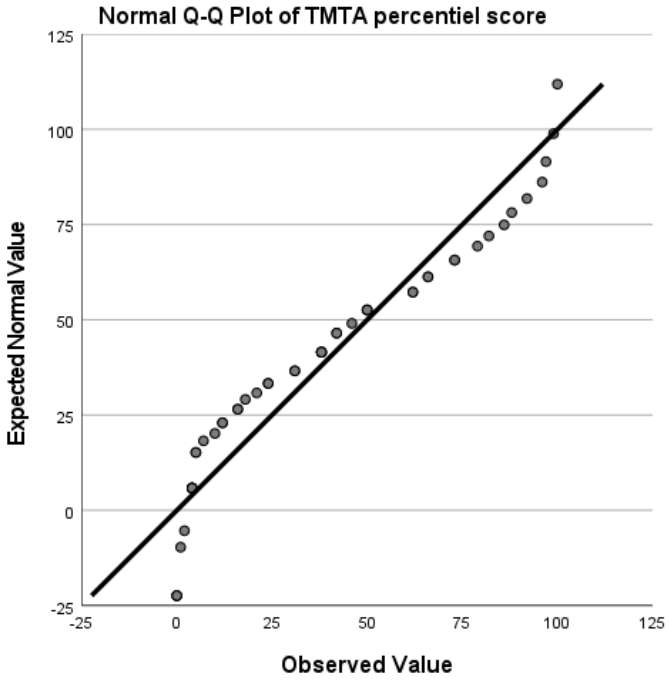
15-WT IR:



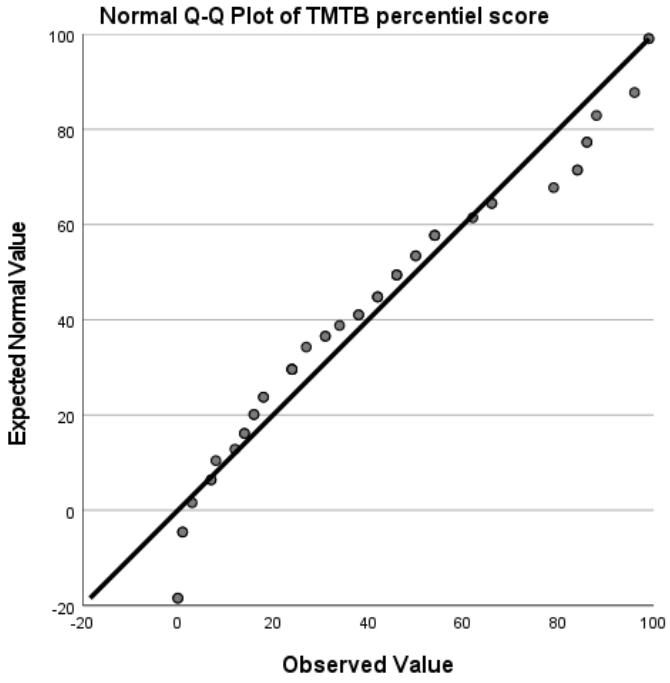
15-WT DR:


Normal Q-Q Plot of 15 WT DR Percentiel Score
Expected Normal Value
Observed Value
125
100
75
50
25
0
-25
-25
0
25
50
75
100
125

TMT-A:


Normal Q-Q Plot of TMTA percentiel score
Expected Normal Value
Observed Value
125
100
75
50
25
0
-25
-25
0
25
50
75
100
125

TMT-B:



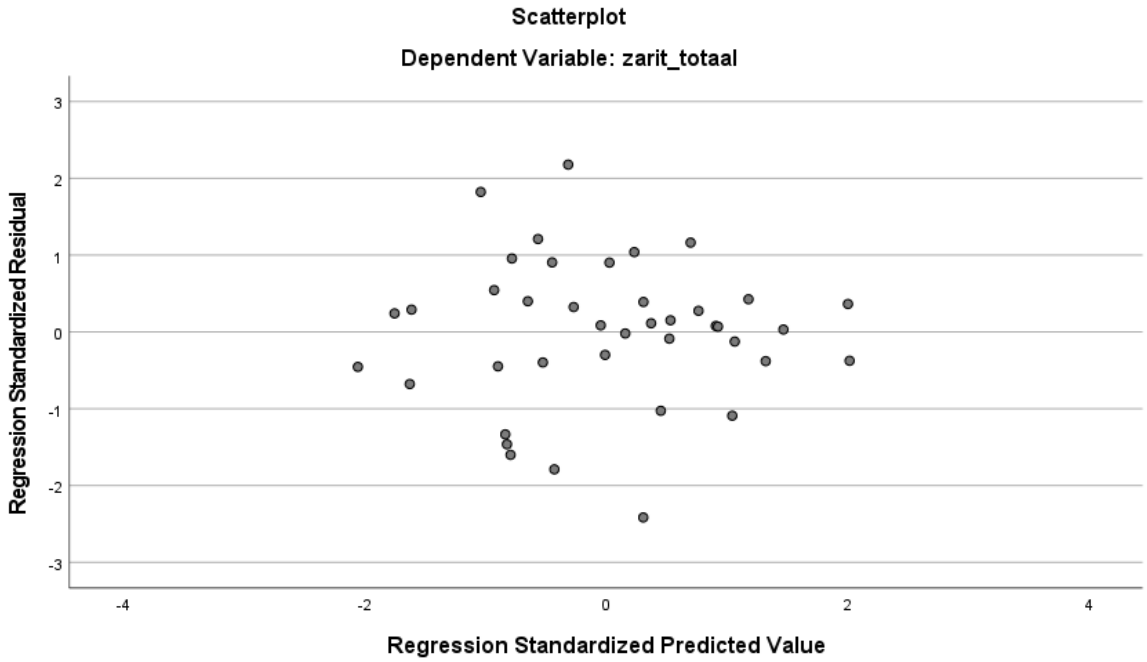
Multicollinearity for both multiple regression analyses:

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95,0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	-5,898	14,400		-,410	,685	-35,497	23,701		
	FEEST percentile score	,089	,083	,174	1,078	,291	-,081	,259	,835	1,198
	FauxPas raw score	,694	1,297	,099	,535	,597	-1,971	3,359	,642	1,558
	BAFQ Initiative percentage	,193	,087	,379	2,224	,035	,015	,371	,753	1,328
	BAFQ Empathy percentage	,099	,110	,194	,897	,378	-,128	,325	,465	2,153
	BAFQ Social Monitoring percentae	-,107	,173	-,134	-,618	,542	-,463	,249	,463	2,161
	BAFQ Emotionality percentage	,048	,131	,077	,363	,720	-,222	,317	,489	2,043
	BAFQ Agression percentage	,180	,207	,178	,872	,391	-,245	,606	,525	1,905
	TMTA percentiel score	,065	,072	,241	,902	,375	-,083	,212	,307	3,262
	TMTB percentiel score	-,049	,074	-,175	-,661	,514	-,202	,104	,313	3,197
	15 WT IR Percentiel Score	-,125	,084	-,388	-1,494	,147	-,298	,047	,324	3,082
	15 WT DR ruwe score	,160	,665	,059	,241	,811	-1,206	1,527	,361	2,767

a. Dependent Variable: zarit_totaal

Homoscedasticity and linearity:



Appendix B

Uncorrected Correlations with Partner Burden

	Correlations with ZBI
Social Behavior	.23
FEEST	
FP	-.16
Social Cognition	
BAFQ- Emotionality	.27[1]
BAFQ- Initiative	.45[1]**
BAFQ- Aggression	.13
BAFQ- Social Monitoring	.28[1]
BAFQ- Empathy	.34[1]*

Note. [1] = Pearson's correlations; all other correlations are Spearman's rank-order correlations. *p = < .05. **p = < .01