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Characteristics associated with the discrepancy between subjective and objective executive functioning in depression

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ABSTRACT

Major depressive disorder (MDD) is associated with both self-reported (subjective) cognitive complaints and deficits in neurocognitive (objective) measures, but the correspondence between subjective and objective measures of cognition is low. This cross-sectional study aimed to (1) assess the association between subjective and objective measures of executive functions (EFs), and (2) explore factors associated with the discrepancy between subjective and objective EFs in MDD. Sixty-two participants with current or previous mild to moderate MDD and subjective EF complaints completed a clinical trial baseline assessment. An objective EF composite score was drawn from six neurocognitive measures, while the Behavior Rating Inventory of Executive Function-Adult version was applied as a measure of subjective EF. The association between the subjective and objective composites was evaluated using Spearman's rank order correlation. A discrepancy score was calculated to quantify the difference between subjective and objective EF. Factors associated with the discrepancy score were analyzed using regression analysis ($p < .05$). Participants reported extensive EF difficulties, but most performed in the normal range on objective EF measures. A weak correlation was detected between the subjective and objective measures ($r_s = .015$). More rumination ($\beta = -.364$) and higher IQ ($\beta = -.420$) were associated with reporting more subjective complaints than was evident from objective measures of EF (i.e., *underestimation*). Subjective and objective EF measures are weakly overlapping in MDD. Findings underscore recommendations to include both subjective and objective measures when assessing EFs in depression. In addition, findings suggest that targeting ruminative processes could help correct underestimation.

KEYWORDS

Cognition; depression; executive functions; objective; subjective

Deficits in cognitive functions (e.g., cognitive slowness, difficulty concentrating, and indecisiveness) are listed among the diagnostic criteria for major depressive disorder (MDD) and are commonly self-reported by MDD patients in both the active and remitted phase (Conradi et al., 2011; Potvin et al., 2016; Srisurapanont et al., 2015; World Health Organization, 2004). Consistent with this, meta-analyses have shown that MDD is associated with impaired performance on neurocognitive tests across several cognitive domains, including executive functions (EFs; Rock et al., 2014; Snyder, 2013). EFs are a set of higher-order cognitive processes, including shifting, inhibition, and updating of working memory (Miyake et al., 2000), necessary for goal-oriented and self-regulating behavior (Cohen, 2017). These processes are essential to daily life functioning in MDD (Cambridge et al., 2018) and are linked to cognitive biases and emotional regulation capacities, thus influencing depressive symptomatology (see Joormann & Stanton, 2016).

Interestingly, the correlations between *subjective* (self-reported) and *objective* (neurocognitive) measures of cognition have been found to be weak to moderate in MDD (Hoorelbeke et al., 2016; Keilp et al., 2018; Mohn & Rund, 2016; Potvin et al., 2016; Serra-Blasco et al., 2019). Patients tend to self-report more cognitive complaints than are evident from neurocognitive measures, and the prevalence is notably higher for subjective than for objective deficits (Douglas et al., 2018; Lahr et al., 2007; Pu et al., 2018; Srisurapanont et al., 2015). Multiple studies point to depressive symptom severity playing a central role in this discrepancy, being more closely related to subjective than objective measures of cognition, potentially through the influence of negative self-referential processes in evaluations of cognitive performance (Dhillon et al., 2020; Keilp et al., 2018; Lahr et al., 2007; Petersen et al., 2019; Serra-Blasco et al., 2019; Svendsen et al., 2012).

Similar challenges are associated with the assessment of EFs, and while the ecological validity of neurocognitive EF

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measures is moderate (Chaytor & Schmitter-Edgecombe, 2003), self-reported EFs is considered susceptible to contextual factors, the respondent's load of emotional distress, and metacognitive capacity (Hagen et al., 2019; Løvstad et al., 2016; Meltzer et al., 2017; Peters et al., 2014). Although not thoroughly evaluated in MDD, the correspondence between subjective and objective EF measures is found to be poor across samples (Dube et al., 2020; Hoorelbeke et al., 2016; Meltzer et al., 2017; Snyder et al., 2021). This has led to proposals that objective and subjective measures of EF assess different constructs, namely the efficiency of executive processes in a structured optimal-performance setting, and success in goal pursuit or typical everyday performance, respectively (Toplak et al., 2013).

An important clinical implication of the weak association between assessment approaches is that self-reported cognitive complaints may not translate into objective deficits in MDD. Different treatment approaches could be appropriate for subjective and objective difficulties, and identifying factors associated with the discrepancy may prove useful for clinical decision-making and inclusion in clinical trials (Miskowiak et al., 2016; 2018; Petersen et al., 2019). Accordingly, a selection of studies have explicitly sought to identify factors associated with the discordance by using discrepancy scores (i.e., calculating the difference between levels of subjective and objective cognitive functioning) in depression samples (Petersen et al., 2019; Serra-Blasco et al., 2019; Srisurapanont et al., 2017). However, no consensus approach exists for the calculation of discrepancy scores. To the best of our knowledge, only one study has specifically investigated the factors associated with the EF discrepancy. In a depression sample consisting of remitted and partially remitted patients, Petersen et al. (2019) found prolonged illness duration and younger age to be associated with the underestimation of EFs—the tendency for respondents to rate their real-world functioning lower than objective indicators (e.g., neurocognitive measures). The authors suggested that a longer illness duration prompted underestimation through having experienced more failures, further increasing expectations of future cognitive difficulties and hampering functioning in daily life, while younger age could coincide with partaking in more demanding or distracting activities and having fewer compensatory strategies available. Petersen and colleagues also reported results from a secondary analysis of a more symptomatic depressed sample, where depressive symptom severity was related to underestimation. Notably, Petersen and colleagues did not replicate a previous finding in bipolar disorder, namely that having a higher verbal IQ is associated with less underestimation of EFs, proposedly through increased ability to compensate for difficulties in daily life (Miskowiak et al., 2016).

Still, much of the variance in the EF discrepancy remains to be accounted for, suggesting the influence of additional factors (Petersen et al., 2019). Deficits in EF processes are associated with increased *rumination*—a style of thought characterized by focusing repeatedly and passively on one's negative emotions (Joormann & Stanton, 2016; Nolen-Hoeksema, 2000). Theoretically, recurrent negative thought processes (i.e., rumination) may influence the discrepancy by placing a higher load on EF capacity in daily life than during the structured context of neurocognitive assessment (Petersen et al., 2019). Similarly, if subjective cognitive complaints stem from negative self-referential processes and internal misattribution biases, increased perceived competence presumably corresponds with fewer everyday cognitive difficulties. One's perceived competence may additionally influence the amount of effort invested in, and ability to persevere, challenging situations, subsequently influencing everyday functioning (Bandura et al., 1997). *Self-efficacy*, defined as an individuals' beliefs in their capacity to produce the actions required to manage prospective situations (Bandura et al., 1997), may thus influence the EF discrepancy. Indeed, previous research has found self-efficacy to influence the discrepancy between performance, as measured in a laboratory setting, and self-reported everyday functioning, in MDD (Milanovic et al., 2018). Still, this has not been investigated in the context of EFs.

The aims of the present cross-sectional study were twofold. First, it explored the relationship between subjective and objective measures of EF on the composite score level in an MDD sample with executive complaints. Second, the study investigated the factors associated with the discrepancy between self-reported EF and performance on neurocognitive measures for a global EF composite. The global EF composite sought to comprise neurocognitive measures tapping the subcomponents included in the model by Miyake et al. (2000): *shifting* (flexible switching between tasks and mental sets), *inhibition* (overriding irrelevant, automatic or dominant information), *updating* (manipulation of working memory content), and thus represent *common EF* (the ability to monitor for and integrate context information to maintain goal-directed behavior), encompassing all three subcomponents (Friedman & Miyake, 2017; Miyake & Friedman, 2012). In the following, global EF is used interchangeably with common EF. Previous studies on the discrepancy between subjective and objective cognition in depression have applied subjective EF scores based on the selection of single questionnaire items for which psychometric properties have not been evaluated (Petersen et al., 2019). The present study aimed to extend current knowledge through an in-depth focus on EFs and by applying a subjective measure with good psychometric properties. We expected higher levels of depressive symptoms, younger age, lower IQ, and more prolonged illness duration to be associated with underestimation of EFs (Miskowiak et al., 2016; Petersen et al., 2019; Serra-Blasco et al., 2019; Srisurapanont et al., 2017). Furthermore, the study aimed to investigate whether the strong conceptual candidates' rumination and self-efficacy, could account for the discrepancy beyond that of previously examined variables (depressive symptoms, age, IQ, and illness duration), and we expected underestimation to be associated with a stronger tendency to ruminate, and lower perceived self-efficacy.

Methods

Data were collected as part of a baseline neurocognitive assessment for a preregistered randomized controlled trial

Table 1. Neurocognitive measures included in the objective EF composite.

Measure	Outcome	Subdomain
Perseverative errors (WCST)	Number of perseverative errors	Shift
Trail Making Test—condition four (D-KEFS)	Completion time (seconds)	Shift
Color-Word Interference Test—condition three (D-KEFS)	Completion time (seconds)	Inhibition
Commission errors (CPT-3)	Number of commission errors	Inhibition
Digit Span Backwards (WAIS-IV)	Number of correct responses	Working memory
Letter-Number Sequencing (WAIS-IV)	Number of correct responses	Working memory

Note. EF = executive function; WCST = Wisconsin Card Sorting Test; D-KEFS = Delis–Kaplan Executive Function System; CPT-3 = Conners' Continuous Performance Test-Third edition; WAIS-IV = Wechsler Adult Intelligence Scale-Fourth edition.

(NCT03338413) investigating the effectiveness of a cognitive remediation intervention (Hagen et al., 2020). This study was approved by the Regional Committee for MedicalResearch Ethics (2017/666), South-Eastern Norway, and conducted in accordance with the World Medical Association's Declaration of Helsinki. All participants provided written informed consent.

Participants

The data were collected at Lovisenberg Diaconal Hospital (Norway) between February 2018 and October 2018. The sample consisted of 62 participants (18–60 years of age) who had received a diagnosis of mild or moderate MDD according to the International Statistical Classification of Disease and Related Health Problems, 10th Revision (ICD-10) criteria (World Health Organization, 2004). Additionally, they had completed treatment consisting of short-term psychotherapy or psychoeducative courses at the Return-to-Work (RTW) outpatient clinic at Lovisenberg within the previous two years. To receive treatment at the RTW clinic, patients are required to hold a job and be on sick leave (or in the opinion of a general practitioner to be at risk of requiring it) owing to mental health problems of mild to moderate severity. Clinical psychologists conducted diagnostic evaluations during the screening process at the RTW clinic (predating study inclusion by two years at the most), and no additional evaluation of depression status was made upon inclusion in the study. Accordingly, the study participants were presumed to be a mixed MDD sample with a range of clinical states (active, partially remitted, and remitted). Participants were recruited through invitation letters ($n = 367$) that solicited response from those experiencing cognitive difficulties in daily life. To be included in the study, participants also had to self-report EF-related cognitive difficulties on a customized telephone interview, such as difficulties with concentration, organizing/planning, and working memory. All eligibility evaluations ($n = 91$) were made by the same rater (clinical psychologist). Exclusion criteria were ongoing alcohol or substance abuse, comorbid neurological conditions, and severe mental disorders (e.g., psychotic disorders) or cognitive problems interfering with the capacity to participate (see Hagen et al., 2020).

Measures

EF outcome measures

Subjective EFs were measured using the Global Executive Composite (GEC; 70 items) of the Behavior Rating Inventory of Executive Function-Adult Version (BRIEF-A; Roth et al., 2005). Here, participants report the extent to which specific cognitive complaints have occurred during the previous six months on a 3-point Likert scale (1 = never, 2 = sometimes, 3 = often). The BRIEF-A GEC comprises nine nonoverlapping subscales (Inhibit, Self-Monitor, Plan/Organize, Shift, Initiate, Task Monitor, Emotional Control, Working Memory, Organization of Materials), and two indexes (Behavioral Regulation Index, Metacognitive Index). The Cronbach's alpha for the BRIEF-A GEC is .92 in the normative sample (Roth et al., 2005).

To partially overcome the task-impurity problem, noted to be particularly important in investigations of the relationship between EFs and psychopathology, the objective composite score was drawn from six EF measures (Snyder et al., 2015). The measures were conceptualized to tap the subdomains of shifting, inhibition, and working memory, and to form a global EF composite (see Table 1). The number of perseverative errors from the computerized version of the Wisconsin Card Sorting Test (WCST; Heaton, 1993), and completion time on the Delis-Kaplan Executive Function System (D-KEFS) Trail Making Test condition 4 (Delis et al., 2001) were applied as measures of shifting. Measures of inhibition included the completion time measure on incongruent condition 3 of the Color-Word Interference Test from the D-KEFS and the number of commission errors (i.e., responses to non-targets) made on Conners' Continuous Performance Test-Third Edition (CPT-3; Conners, 2014). The number of correct responses on the Digit Span Backwards and Letter-Number Sequencing subtests from the Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV; Wechsler, 2014) were applied as measures of working memory.

Predictor variables of the discrepancy scores

Six variables were included as potential predictors of the discrepancy scores. Specifically, the Beck Depression Inventory (BDI; Beck et al., 1961) was used to assess *depressive symptom severity*. The BDI consists of 21 items where respondents indicate on a four-point scale (total range: 0–63) the extent to which they have experienced depressive symptoms during the previous week. *Rumination* was assessed using the Ruminative Response Scale (RRS; Treynor et al., 2003) on which participants rated on a 4-point scale (22 items; total range: 22–88) how often they tend to respond to a depressive mood state with ruminative thinking. The General Self-Efficacy Scale (GSE; Schwarzer & Jerusalem, 1995) was used to assess perceived *self-efficacy* (10 items; total range: 10–40). Total scores were applied for the BDI,

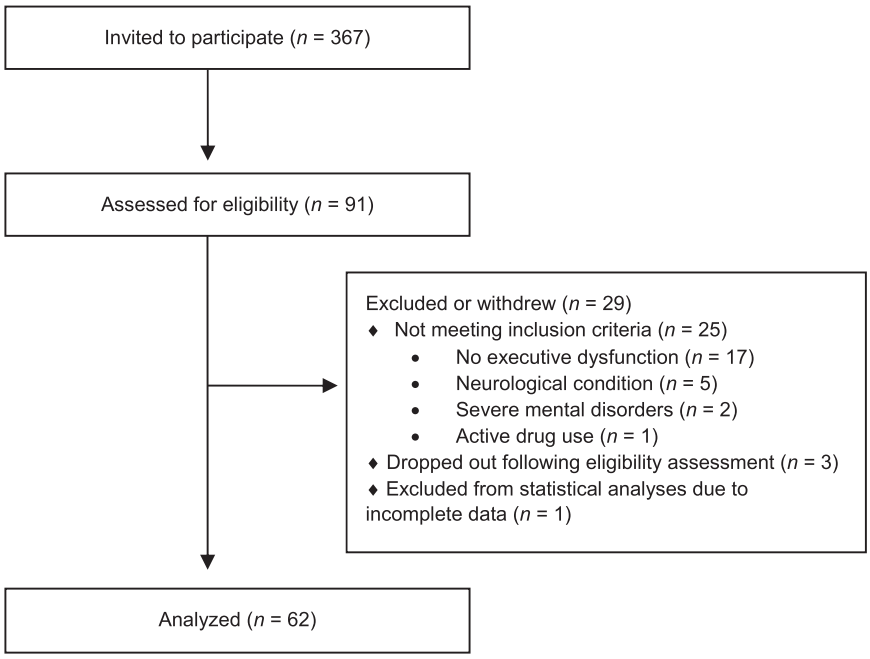

Figure 1. Flow chart of the study.

RRS, and the GSE, all with satisfactory internal consistency (Beck et al., 1988; Luszczynska et al., 2005; Treynor et al., 2003). To estimate *IQ*, the two-subscale (Vocabulary and Matrix Reasoning) version of the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) was applied. Information on demographic (*age*) and illness-related (*duration of illness*) factors were obtained from the customized telephone interview used for inclusion.

Statistical analysis

Data preparation and computation of the discrepancy score

To remove the effects of age, education, and sex, normative scores (T-scores, or scaled scores converted to T-scores) on the subjective and objective measures of EF were applied to calculate the composites. The objective composite score was calculated with equal weighting of each measure. To ensure that the direction was the same across all measures (higher scores indicate better performance or fewer difficulties), T-scores from the CPT-3 commission errors and BRIEF-A GEC were reversed. Subsequently, a *discrepancy score* was calculated by subtracting the objective composite T-score from the subjective composite T-score (BRIEF-A GEC). Participants who self-report more executive difficulties than are evident from their objective performance receive a negative discrepancy score (i.e., underestimation), while those who report fewer difficulties than their objective performance indicates receive a positive score (i.e., overestimation).

Data analysis

The correlations between the objective and subjective global EF composite, and their correlation with each of the predictors, were explored using Spearman's rank order correlations. Reversed BRIEF-A GEC scores were applied for the correlational analyses, with higher scores indicating better objective performance and fewer subjective difficulties. Multiple linear regression analyses were conducted to identify factors associated with the EF discrepancy score. To assess whether the distribution of scores for the independent and outcome variables were normally distributed, the Shapiro-Wilks test was applied. In the regression model, the EF discrepancy score was included as the dependent variable. Age, illness duration, IQ, depressive symptoms, rumination, and self-efficacy were included as independent variables. Given this study's exploratory nature, the results were not corrected for multiple comparisons (Perneger, 1998). All analyses were performed using SPSS version 24.0 for Windows.

Results

Sample characteristics

Sixty-two participants completed the baseline assessment and had complete data on all of the EF measures. In total, 60 participants were included in the multiple regression analyses, as two BDI scores were missing.

The participants were mostly women who were currently *not* taking antidepressant medication. The average age was 42.1 ($SD = 8.5$) years, with an average illness duration of 12.7 ($SD = 10.0$) years and 14.8 ($SD = 2.4$) years of education. Participants reported depressive symptoms on the BDI ($M = 16.4$, $SD = 7.3$) in the mild clinical range (Beck et al., 1988). The sample self-reported substantial global EF difficulties in daily life. Most performed in the average range on the neurocognitive EF measures (Figure 1 and Table 2).

Correlation between subjective and objective executive functioning measures, and between the predictors and the EF composites

The Spearman's rank order correlation between the subjective and objective EF composites was weak ($r_s = .015$) and

nonsignificant. Depressive symptoms ($r_s = -.494$), rumination ($r_s = -.499$), and self-efficacy ($r_s = .389$) correlated significantly with subjective EF, while IQ ($r_s = .437$) correlated significantly with objective EF (Table 3).

Global executive functioning discrepancy model

The model complied with the assumptions of linear regression. The Shapiro-Wilks test was nonsignificant for all independent and outcome variables, except for IQ and illness duration. The multiple regression model significantly predicted the global EF discrepancy score ($M = -16.2$, $SD = 9.8$, range $= -40.3$–5.7), $F(6, 53) = 9.7$, $p < .001$, with an $R^2 = .522$. Rumination and IQ were significantly associated with the discrepancy score. Higher IQ ($\beta = -.420$, $p < .001$) and more rumination ($\beta = -.364$, $p = .002$) were associated with relatively more reports of subjective complaints in global EF (Table 4).

Table 2. Demographic and clinical participant characteristics ($n = 62$).

Variable	Range	Count /*M* (*SD or* %)
Age (years)	28–59	42.1 (8.5)
Sex (female)		49 (79.0%)
First language (Norwegian)		51 (80.6%)
Education (years)	9–20	14.8 (2.4)
Antidepressant use (yes)		16 (26.7%)
Illness duration (years)	1–37	12.7 (10.0)
BDI ($n = 60$)	4–35.5	16.4 (7.3)
BDI dep. severity		
No dep.		13 (21.7%)
Mild dep.		25 (41.7%)
Moderate dep.		20 (33.3%)
Severe dep.		2 (3.3%)
Comorbidities (ICD-10 Code)		
Agoraphobia (F 40.0)		2
Social phobia (F 40.1)		1
Panic disorder (F 41.0)		4
Generalized anxiety disorder (F 41.1)		9
Anxiety disorder, unspecified (F 41.9)		1
Post-traumatic stress disorder (F 43.1)		1
Nonorganic insomnia (F 51.0)		2
Disorders due to substance use (F 10–F 19)		2
RRS ($n = 61$)	28–83	54.7 (11.6)
GSE ($n = 61$)	17–39	27.5 (5.2)
WASI IQ estimate	75–126	110.0 (11.0)
TMT 4, D-KEFS (scaled score)	1–13	10.1 (2.4)
Perseverative errors, WCST (T-score)	23–80	50.9 (9.5)
CWIT 3, D-KEFS (scaled score)	2–15	10.7 (2.7)
Commission errors, CPT-3 (T-score)	35–75	51.2 (9.7)
Digit Span Backwards, WAIS-IV (scaled score)	5–18	11.8 (2.3)
Letter-Number Seq., WAIS-IV (scaled score)	8–19	11.1 (2.2)
Objective EF composite	39–64	52.0 (4.8)
BRIEF-A GEC (T-score)	39–91	64.1 (8.5)

Note. BDI depression severity cutoff scores according to Beck et al. (1988). Participants with comorbidities, $n = 19$. Multiple comorbidities are possible for each participant. BDI = Beck Depression Inventory; dep. = depression; ICD-10 = International Classification of Diseases-10th Revision; RRS = Ruminative Response Scale; GSE = General Self-Efficacy Scale; WASI = Wechsler Abbreviated Scale of Intelligence; TMT 4 = Trial Making Test-Condition four; D-KEFS = Delis–Kaplan Executive Function System; CWIT 3 = Color-Word Interference Test-Condition three; WCST = Wisconsin Card Sorting Test; CPT-3 = Conners' Continuous Performance Test-Third edition; WAIS-IV = Wechsler Adult Intelligence Scale-Fourth edition; seq. = sequencing; EF = executive function; BRIEF-A GEC = Behavior Rating Inventory of Executive Function-Adult version Global Executive Composite.

Discussion

Poor correspondence between subjective and objective EF measures emerged from this depression sample. This mainly accords with previous findings on MDD for other cognitive domains, although a selection of studies have reported significant low to moderate associations (Keilp et al., 2018; Lahr et al., 2007; Mohn & Rund, 2016; Potvin et al., 2016; Serra-Blasco et al., 2019; Svendsen et al., 2012). Similarly, correlations in the low range is overall consistent with previous examinations of the relationship between subjective EFs as measured by the BRIEF-A and objective EF measures across samples (Dube et al., 2020; Hoorelbeke et al., 2016; Meltzer et al., 2017; Toplak et al., 2013), also when subjective measures have been aligned at the subdomain level with objective EF composites (Snyder et al., 2021).

Methodological and conceptual differences between subjective and objective measures of EF, including their administration and scoring, might contribute to the discrepancy (Toplak et al., 2013). Importantly, approaches are suggested to tap into different constructs, and while self-reports assess

Table 4. Results from the multiple linear regression analyses with the global EF discrepancy score as the outcome ($n = 60$).

		95% CI for *B*				
	B	*LL*	*UL*	*β*	*p*-value	R^2
Model					<.001*	.522
Constant	32.900	−8.200	−57.500			
Age	.001	−.237	.239	.001	.993	
Illness duration	−.015	−.215	.184	−.016	.877	
IQ	−.368	−.546	−.190	−.420	<.001*	
BDI	−.152	−.509	.206	−.113	.397	
RRS	−.311	−.500	−.123	−.364	.002*	
GSE	.396	−.074	.869	.210	.098	

Note. EF = executive function; LL = lower limit; UL = upper limit; BDI = Beck Depression Inventory; RRS = Ruminative Response Scale; GSE = General Self-Efficacy Scale. *$p < .05$.

Table 3. Spearman's rank order correlations between each of the predictor variables, and the subjective and objective EF composite scores ($n = 60$–62).

Variables	1	2	3	4	5	6	7
1. Age	–	–	–	–	–	–	–
2. Duration of illness	.128	–	–	–	–	–	–
3. Estimated IQ	.048	.144	–	–	–	–	–
4. BDI ($n = 60$)	.011	−.051	.200	–	–	–	–
5. RRS ($n = 61$)	−.087	.110	−.014	.385**	–	–	–
6. GSE ($n = 61$)	.214	−.157	.082	−.553**	−.321*	–	–
7. Obj. EF comp.	−.009	.176	.437**	.159	.081	.056	–
8. Sub. EF comp.	.085	−.075	−.119	−.494**	−.499**	.389**	.015

Note. BDI = Beck Depression Inventory; RRS = Ruminative Response Scale; GSE = General Self-Efficacy Scale; obj. = objective; EF = executive function; comp. = composite; sub. = subjective. For all measures, higher scores indicate better performance or less difficulties or symptoms, except for the BDI and RRS. *$p < .05$. **$p < .01$.

typical everyday performance, the ecological validity of objective measures is moderate (Chaytor & Schmitter-Edgecombe, 2003). In our study, most participants performed in the normal range on the objective measures, while self-reporting extensive executive difficulties. Errors related to EFs are more likely to occur over 6 months in the diverse contexts of daily life, as assessed by the BRIEF-A, than during the structured setting of neurocognitive assessment. Traditional neurocognitive measures may indeed lack sensitivity to detect variations within the normal range and subtle EF deficits (Snyder et al., 2015), and small individual differences in performance could translate into disproportionally large difficulties in real life (Stenfors et al., 2013). Similarly, the overall higher incidence of subjective cognitive complaints could be due to rating scales more specifically measuring the executive deficits present in MDD (Snyder et al., 2015). It is also likely that self-reports to a larger extent reflect changes in EFs relative to a pre-illness level, as respondents are more sensitive to deterioration than would be evident from the normative scores of a cross-sectional neurocognitive assessment (Serra-Blasco et al., 2019; Tran et al., 2021). Accordingly, a selection of patients with no deficits in neurocognitive measures would still experience everyday EF errors, hampering the association and promoting an overall pattern of underestimation in MDD patients.

It was surprising that depressive symptoms were not related to the global EF discrepancy score in the present study. Most previous studies have linked cognitive underestimation with higher depressive symptom severity in MDD (Petersen et al., 2019; Serra-Blasco et al., 2019; Srisurapanont et al., 2017), and the association between emotional distress and self-reported EF, also observed in the present study, is well-established (Hagen et al., 2019; Løvstad et al., 2016; Meltzer et al., 2017; Peters et al., 2014). Interestingly, in the study by Petersen et al. (2019), depressive symptom severity was not related to the EF discrepancy in a remitted sample. Such an association only emerged in the more symptomatic secondary sample. This may explain the pattern of findings observed in the current study, given the mixed nature of our sample, presumably including actively depressed, partially remitted, and remitted participants, with overall depressive symptom severity in the mild range likely limiting the influence on the discrepancy score. In line with this, Miskowiak et al. (2016) also found no significant association between depressive symptoms and the EF discrepancy in a sample with bipolar disorder, currently in remission. The overall evidence that depressive symptom severity contributes to the EF discrepancy in affective disorders is thus more limited than for other cognitive domains. At the same time, the observation of a discrepancy between objective and subjective indicators of EF outside the context of MDD (e.g., in healthy individuals and in those suffering from other forms of psychopathology) indicates that factors other than severity of the depressive symptoms may underlie the underestimation (Toplak et al., 2013; Van der Elst et al., 2008).

One of the key findings of this study is the role of rumination in the underestimation of EFs. Rumination is proposed to hold bidirectional links with executive processes, as deficits in EFs facilitate the proliferation of repetitive negative thought processes in working memory while limiting EF capacity (Joormann & Stanton, 2016; Philippot & Brutoux, 2008). On the one hand, the association between rumination and underestimation supports the notion that recurrent negative thought processes restrict EF performance more heavily in daily life than during neuropsychological assessment. In accordance with the present study, a recent meta-analysis indeed found weak associations between recurrent negative thought processes (i.e., rumination and worry) and neurocognitive measures of the EF subcomponents included in our composite (Zetsche et al., 2018). Concurrently, the association with underestimation may stem from the influence of a ruminative thinking style on evaluations of one's own cognitive performance, potentially increasing the focus on cognitive failures and promoting negative self-judgments (Malivoire et al., 2018; Rimes & Watkins, 2005). In the present study, rumination significantly influenced the global EF discrepancy score, while overall depressive symptom severity included in the same model did not. Considering the observed association between depressive symptoms and rumination, and their correlation with subjective EF, this may indicate that the effect of depressive symptoms on underestimation is secondary to such underlying aspects. Indeed, previous research in multiple sclerosis has also identified rumination to be central to the association between depressive symptoms and perceived cognitive difficulties (Malivoire et al., 2018). Nonetheless, the general tendency of self-report measures to correlate more strongly with subjective than objective measures could explain why rumination was associated with underestimation (Dube et al., 2020).

Contrary to our hypothesis, underestimation of global EF was associated with higher IQ in the present study, diverging from previous investigations in the context of affective disorders (Miskowiak et al., 2016; Petersen et al., 2019; Serra-Blasco et al., 2019). This association is likely to be influenced by the moderate overlap between EF and IQ, at least for the working memory subdomain (Friedman et al., 2006). Thus, performing above average on the IQ measure coincided with increased performance on objective EF measures. At the same time, a weak negative association (non-significant) was found between IQ and subjective EF difficulties, in accordance with previous findings (Løvstad et al., 2016). As such, although speculative, another interpretation is that having a higher IQ improve the ability to recognize subtle changes in EF performance, causing distress and an increased sense of impairment, not captured in neurocognitive measures.

In previous research, Milanovic et al. (2018) found self-efficacy to bridge the gap between performance-based measures of functioning and everyday functioning in an MDD sample, also when depressive symptoms had been accounted for. It has been suggested that greater (cognitive) self-efficacy could lead to more extensive use of compensatory cognitive strategies in daily life (Bandura, 1989; Burmester et al., 2016). However, in the present study, greater self-efficacy did not significantly influence the EF

discrepancy score beyond the additional variables included, although being associated with experiencing less EF difficulties. Even so, our findings warrant further research into the potential contribution of self-efficacy to the EF discrepancy.

In contrast to previous findings on EFs and other cognitive domains in MDD (Petersen et al., 2019; Srisurapanont et al., 2017), younger age was not associated with underestimation in our study. It has been suggested that underestimation may stem from cognitive deficits being particularly disabling in young people, potentially through behaviors that make them more susceptible to everyday cognitive errors (e.g., smartphone use) while they have developed fewer compensatory strategies (Petersen et al., 2019). However, the restricted age range in our study, with most participants being between 30 and 50 years of age, may have limited the possibility of detecting a significant contribution of age to the discrepancy scores.

Moreover, the results from the present study indicate that the cumulative load of a prolonged illness period (duration of illness) does not relate to increased underestimation of EF. This contrasts with the findings from a remitted MDD sample but aligns with those from the more symptomatic sample reported by Petersen et al. (2019). However, information on the duration of illness was retrieved from self-reports, making it susceptible to bias.

Executive functions are involved in metacognitive and self-referential processes, relevant to the evaluation of own cognitive performance, and thus potentially moderate the relationship between subjective and objective cognition (Burmester et al., 2016; Serra-Blasco et al., 2019). Indeed, Serra-Blasco et al. (2019) found better performance on neurocognitive EF measures to be related to underestimation of attention and memory in an MDD sample of participants across clinical states. Accordingly, the potential role of EF as a confounding factor in evaluation of the discrepancy between subjective and objective measures should be noted.

Clinical implications and future directions

To date, there is no established approach to assess cognition in MDD, including EFs. A growing body of research has found that self-reported cognition is essential to several aspects of functioning, quality of life, and risk of relapse (Kim et al., 2016; Lorimer et al., 2020; Wang et al., 2019), and that subjective and objective measures contribute uniquely to disability (Naismith et al., 2007). However, our findings accord with previous research suggesting that subjective EF is a poor indicator of the neurocognitive status in MDD (Keilp et al., 2018). It seems that both measures may capture different aspects of EFs, and the findings from the present study underscore recommendations to include both approaches to the assessment of cognition in depression (Miskowiak et al., 2018; Potvin et al., 2016; Serra-Blasco et al., 2019).

In a similar vein, self-evaluation of cognitive processes is suggested to influence depressive symptomatology and functioning, and underestimation is associated with reduced quality of life and more perceived stress (Dhillon et al., 2020; Miskowiak et al., 2016; Petersen et al., 2019). Therefore, correcting underestimation could be a valuable treatment aim, and the findings from the present study indicate that this could be achieved by targeting ruminative processes. Moreover, psychoeducation regarding the relationship between neurocognitive deficits and depression could help treat negative self-referential processes (Morey-Nase et al., 2019), and the finding that subjective EF correlates weakly with objective EF performance could be taken into account in such treatments to reduce underestimation.

Future research should investigate the association between objective and subjective EF measures in depression, including on the subcomponent-level, using empirically derived composites of neurocognitive tests (e.g., using factor analyses), and compare them with a subjective EF measure with adequate psychometric properties at the subdomain level.

Limitations

Sample characteristics and the methodological approach have implications for the interpretation of results. Participants were included based on self-reported executive complaints and accordingly reported substantial EF difficulties. At the same time, the study would fail to include those with actual EF deficits, not reporting such complaints. Self-reported everyday difficulties were not validated through additional evaluations of the participants' actual functioning. Even if underestimation is typical of depression (Lahr et al., 2007; Petersen et al., 2019), generalizability to samples with fewer cognitive complaints could consequently be reduced. Given the restricted between-clinician agreement for MDD diagnosis (Regier et al., 2013), and that the diagnostic assessments predated study inclusion, an additional diagnostic assessment would have improved the certainty and description of the included participants. Similarly, the sample size and the lack of diagnostic reassessment did not allow for subgroup analyses regarding clinical state, previously suggested to influence the discrepancy (Serra-Blasco et al., 2019). The study included a substantial number of participants that were non-depressed at the time of assessment, reducing generalizability to MDD patients with more severe symptomatology. The small sample size and the exploratory approach necessitate caution in interpreting results. The cross-sectional design does not allow any conclusions to be drawn about the directionality of associations.

Conclusion

To summarize, the weak correlation between self-reported and neurocognitive EF measures in this MDD sample is in accordance with the view that the approaches assess different aspects and suggest that both approaches should be included in the assessments of EFs. Findings indicate that patients' characteristics influences the observed discordance between assessment approaches and that rumination may represent treatment targets for those seeking to correct underestimation.

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