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Electroconvulsive therapy and cognitive performance from the Global ECT MRI Research Collaboration

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ABSTRACT

The Global ECT MRI Research Collaboration (GEMRIC) has collected clinical and neuroimaging data of patients treated with electroconvulsive therapy (ECT) from around the world. Results to date have focused on neuroimaging correlates of antidepressant response. GEMRIC sites have also collected longitudinal cognitive data. Here, we summarize the existing GEMRIC cognitive data and provide recommendations for prospective data collection for future ECT-imaging investigations. We describe the criteria for selection of cognitive measures for mega-analyses: Trail Making Test Parts A (TMT-A) and B (TMT-B), verbal fluency category (VFC), verbal fluency letter (VFL), and percent retention from verbal learning and memory tests. We performed longitudinal data analysis focused on the pre-/post-ECT assessments with healthy comparison (HC) subjects at similar timepoints and assessed associations between demographic and ECT parameters with cognitive changes. The study found an interaction between electrode placement and treatment number for VFC ($F(1,107) = 4.14$, $p = 0.04$). Higher treatment was associated with decreased VFC performance with right unilateral electrode placement. Percent retention showed a main effect for group, with post-hoc analysis indicating decreased cognitive performance among the HC group. However, there were no significant effects of group or group interactions observed for TMT-A, TMT-B, or VFL. We assessed the current GEMRIC cognitive data and acknowledge the limitations associated with this data set including the limited number of neuropsychological domains assessed. Aside from the VFC and treatment number relationship, we did not observe ECT-mediated neurocognitive effects in this investigation. We provide prospective cognitive recommendations for future ECT-imaging investigations focused on strong psychometrics and minimal burden to subjects.

1. Introduction

Electroconvulsive therapy (ECT) has potent antidepressant effects with high response and remission rates (UK ECT Review Group, 2003). Sixty to eighty percent of individuals with treatment-resistant depression have rapid improvement or remission of depressive symptoms (Weiner and Reti, 2017). ECT is cost effective and reduces hospital readmission, suicide risk, and 1-year all-cause mortality (Kaster et al., 2021; Rhee et al., 2021; Ross et al., 2018; Slade et al., 2017). ECT is also medically safe and not associated with increased severe medical events (Kaster et al., 2021). Despite ECT's efficacy and safety, less than 1% of individuals diagnosed with major depressive disorder (MDD) receive ECT (Rhee et al., 2020; Wilkinson et al., 2018, 2021).

ECT is often utilized as a treatment of last resort because of stigma and risk of cognitive side effects (Slade et al., 2017). The cognitive adverse effects of ECT are transient but may mitigate clinical improvement (Alexopoulos et al., 2005; Chakrabarti et al., 2010; Kiosses and Alexopoulos, 2005; Kiosses et al., 2001; Porter et al., 2008; Rajagopal et al., 2013) and limit the use of ECT (Sackeim, 2017; Slade et al., 2017). While right unilateral (RUL) ultrabrief pulse ECT results in less cognitive impairment relative to bitemporal (BT) brief pulse (Lisanby, 2007; Sackeim, 2017; Semkovska et al., 2016), both still produce moderate to large (Cohen's $d = -0.53$ to -0.83) adverse cognitive effects (Tor et al., 2015). Key adverse cognitive effects include amnesia, executive dysfunction, and verbal dysfluency (Abbott et al., 2020; Lisanby et al., 2020; Loef et al., 2024; McClintock et al., 2011; Semkovska and McLoughlin, 2010; Vasavada et al., 2017a, 2017b). Current research demonstrates the return to pre-ECT baseline levels for most cognitive

domains in the weeks following an acute ECT series (Nuninga et al., 2018; Semkovska and McLoughlin, 2010; Vasavada et al., 2017a, 2017b). Autobiographical memory, which has numerous measurement challenges, may persist for up to six months (Martin et al., 2015; Semkovska and McLoughlin, 2013, 2014). The mechanisms and anatomic locations underlying cognitive adverse effects remain largely unknown (Bolwig, 2014; Singh and Kar, 2017).

The Global ECT MRI Research Collaboration (GEMRIC) was developed to combine longitudinal neuroimaging data from ECT studies across sites and institutions to investigate ECT's mechanism of action (Oltedal et al., 2017). GEMRIC utilizes a common analysis pipeline to combine ECT-imaging datasets from different study sites for mega-analyses. The increased power of the larger sample sizes associated with the GEMRIC database has examined structural and functional changes associated with ECT. Important findings to date from GEMRIC include ECT-mediated volumetric changes (Oltedal et al., 2018; Ousdal et al., 2020), relationships between electric field strength and volumetric changes (Argyelan et al., 2019), and volumetric changes associated with treatment response (Argyelan et al., 2023; Mulders et al., 2020).

Here, we assess GEMRIC cognitive measures across all sites. We describe the demographic information of the GEMRIC patient and healthy comparison subjects (HC) who have longitudinal cognitive data. We assess the cognitive changes associated with each electrode placement (RUL, BT, bifrontal [BF], and left anterior right temporal [LART]) relative to the HC sample. We hypothesize that BT electrode placement would be associated with the most cognitive impairment. We then make prospective cognitive assessment recommendations for future GEMRIC sites to facilitate the study of neuroanatomic mechanisms underlying ECT cognitive impairment.

2. Methods

2.1. Participant selection

We included all subjects from the GEMRIC database with a diagnosis of MDD or bipolar disorder type I or II with most recent episode depressed, and with longitudinal (pre-/post-ECT) neurocognitive data. We also included HC with longitudinal neurocognitive data. Exclusion criteria for individuals diagnosed with MDD or bipolar disorder consisted of the following: 1) bipolar disorder diagnosis without specification of current episode; 2) less than four ECT treatments; 3) pre-ECT 17-item Hamilton Rating Scale for Depression (HAM-D) total score less than 19; or 4) unspecified electrode placement. As per GEMRIC regulations, informed consent was locally obtained from all sites in addition to the approval of the Regional Ethics Committee South-East in Norway (2018/769 The GEMRIC study).

2.2. Depression ratings

All sites used either the 17-item HAM-D or Montgomery-Asberg Depression Rating Scale (MADRS) to assess depression severity with each imaging assessment (Hamilton, 1960; Montgomery and Asberg, 1979). We converted MADRS to HAM-D with an established scale conversion (Heo et al., 2007). Response was defined as $\geq$ 50% improvement post-ECT in comparison to pre-ECT HAM-D (Husain et al., 2004).

2.3. Cognitive data

Thirteen sites contributed data with 34 neuropsychological measures at four time points: pre-, mid-, post-, and follow-up ECT (Supplemental Table 1: GEMRIC cognitive data from all sites*)*. Due to heterogeneity of represented cognitive domains and available data for multisite analysis, selection of cognitive measures was based on the following consensus criteria: 1) uniform data collection; 2) cognitive domain known to be impacted by ECT (e.g., memory, verbal fluency); and 3) large number of participants. As a result, five tests were selected for this analysis: Trail-Making Tests Part A (TMT-A) and B (TMT-B) (Reitan and Wolfson, 1985), letter (VFL) and category verbal fluency (VFC) (Lezak, 2012), and percent retention from verbal declarative memory tests (percent retention) (Table 1: Neurocognitive measures). Verbal learning and memory tasks included the Rey Auditory Verbal Learning Test (Lezak, 2012), California Verbal Learning Test-2nd Edition (Delis et al., 2000), and Hopkins Verbal Learning Test-Revised (Brandt and Benedict, 2001). The verbal memory tests were combined into one memory score by their percent retention score defined as *Delayed recall/Last learning trial*. The percent retention score reduces the possibility of over-estimating memory function from immediate and delayed free recall scores (Clark et al., 2010). Notably, only three sites measured autobiographical memory with two different tests: two sites used the Autobiographical Memory Interview – Short Form, and one site used the autobiographical fluency task (Dritschel et al., 1992; McElhiney et al., 2001). Therefore, this analysis did not include autobiographical memory (see Future Directions).

2.3.1. Electroconvulsive therapy

32% of participants underwent treatment using a MECTA versus 68% using a THYMATRON device. ECT procedures were site specific and included different devices: MECTA (MECTA Corporation, Tualatin, Oregon) or Thymatron (Somatics LLC, Venice, Florida, USA); electrode placements: BT, RUL, LART, or BF; pulse widths: 0.3–1.0 ms; and dosing methods: seizure titration or demographically informed. Treatment number was also site-specific with either fixed treatment or variable ECT endpoints. Sites had variable timing of the cognitive-imaging assessments: pre-, mid-, post-ECT, and follow-up (>1-month post-ECT) assessments. For this investigation, we focused on the pre-/post-ECT cognitive outcomes to maximize subject number. Post-ECT neuropsychological assessment was done within one week after the last ECT treatment across sites.

2.4. Analysis

GEMRIC data release 3.2 (DOI: 10.17605/OSF.IO/YP2G, link: https://osf.io/yp2g4/) was used for the analysis of pre-post change of the five neuropsychological outcomes (Table 1). Clinical response was defined as $\geq$ 50% change. To minimize group comparisons, RUL- and LART-ECT-Placements were grouped together (RUL). Many sites started with RUL and included a BT contingency in the context of RUL non-

Table 1
Neurocognitive assessment synthesis across Global ECT MRI Research Collaboration (GEMRIC) sites.

Neurocognitive Test	Domain	Metric	Direction of effect[a]	Number of sites
Trail-Making Test Part A	Processing speed/ attention	Seconds	Negative	8
Trail-Making Test Part B	Executive function	Seconds	Negative	7
Verbal Fluency Semantic	Language function	N words	Positive	7
Verbal Fluency Letter	Language function	N words	Positive	5
Rey Auditory Verbal Learning Test Hopkins Verbal Learning Test-Revised California Verbal Learning Test, Second Edition	Verbal learning and memory	% retention	Positive	3

[a] Positive signifies higher values represent enhanced neuropsychological performance, while lower values indicates diminished performance. Vice versa for negative direction of effect.

response or worsening clinical condition. These subjects were grouped as BT. Due to heteroskedasticity between the patient and HC groups, we applied square-root transformations to TMT and VF scores. Linear models assessed group differences (RUL, BT, and HC) between percent differences relative to baseline ("%diff") in neurocognitive outcomes ($100 \times (Post - PreECT)/PreECT$). All models were adjusted for demographic and clinical characteristics (age, sex, education, site, number of ECT treatments, pre-post HAM-D % change). To retain as many observations as possible, missing HAM-D and values for the HC group were imputed using each site's mean. In patients, we imputed missing HAM-D (RUL n = 1, BT n = 3) and education values using the mice package (Version: 3.14 van Buuren and Groothuis-Oudshoorn, 2011). For each neuropsychological measure, a full model was fit and then reduced with best-subset selection for the ECT covariates (electrode placement and treatment number) using Akaike Information Criterion (AIC) (Akaike, 1974), but main effects for treatment group, age, sex, education, site and number of treatments were retained for all models. Model fit assumptions on the residuals are equal variance and normality, which were both assessed visually; however, results are robust to violations of the model distributional assumption (Schielzeth et al., 2020). VFC, VFL, and percent-retention had two outliers and were removed. The restricted maximum-likelihood (REML) adjusted least-squares mean difference estimates are reported (Lenth, 2023). In the case of significant main effects or interactions between model covariates and outcomes, post-hoc comparisons were calculated to elucidate direction of effect. Reported results are averaged across all other covariates. Multiple testing was controlled for via the false-discovery rate using the method of Benjamini and Hochberg (1995). All analyses were performed in R (Version 4.1.3; R Core Team, 2023). Plots were made using raincloud plots (Allen et al., 2019) and gghalves (https://github.com/erocoar/gghalves). Tables 1 and 2 were made using gtsummary (Sjoberg et al., 2021). R code of the analysis is available upon request.

Table 2
Patient group demographics.

Group	RUL or LART	BT	HC	p-value[a]
Total *n*	115	42	39	
Age: years (± SD)	50 (15)	54 (9)	45 (15)	0.031
Sex: Male/Female	52/63	17/25	16/23	0.847
Diagnosis: Unipolar/bipolar	105/10	42/0	–	<0.05
Pre-ECT HAM-D-17 (± SD)	26 (5)	26 (5)	1 (1)	<0.001
Antidepressant response (%)[b]	59%	83%	–	0.004
Treatment number (± SD)	12 (5)	13 (5)	0 (0)	<0.001
No. of previous ECT[c,d]	0.6 (2.1)	1.8 (0.3)	–	0.0138
No. of depressive episodes[c,d]	6.3 (11.4)	3 (2.1)	–	0.040
Episode duration (month, (± SD)[d]	18.4 (42.9)	19.3 (25.7)	–	0.896
Age first treatment (± SD)[d]	34.6 (13.9)	40.4 (9.24)	–	0.077
Education				
Grade 6 or less	4 (3.5%)	1 (2.4%)	0 (0%)	
Grade 7–12 (without graduating high school)	12 (10%)	11 (26%)	0 (0%)	
Graduated high school	12 (10%)	2 (4.8%)	4 (10%)	
Part college or university	16 (14%)	4 (9.5%)	2 (5.1%)	
Graduated 2-year college (associate degree)	15 (13%)	10 (24%)	11 (28%)	
Graduated 4-year college (bachelor degree)	24 (21%)	8 (19%)	10 (26%)	
Part graduate or professional school	5 (4.3%)	3 (7.1%)	6 (15%)	
Completed graduate or professional school	27 (23%)	3 (7.1%)	6 (15%)	

[a] Kruskal-Wallis rank sum test; Welch two sample *t*-test, Pearson's Chi-squared test; Fisher's exact test.
[b] Clinical response was defined as ≥ 50% change.
[c] Median.
[d] Data not available for full sample (No. previous ECT = 51; No. dep. Episodes = 90; Dur. Episode = 99, Age first Treatment = 55).

3. Results

3.1. Demographics and clinical characteristics

A total of 197 patients (11 study sites) and 39 HC subjects (3 study sites) had longitudinal clinical and neurocognitive data. We excluded patients with fewer than 4 four treatments (n = 1), a baseline HAM-D total score of less than 19 (n = 27), unknown electrode placement (n = 2), or unspecified bipolar disorder episode (n = 10). The remaining patients received ECT as a treatment for MDD (n = 147) or bipolar disorder I or II disorder most recent episode depressed (n = 10). The final sample included 157 patients (88 female, mean age = 51.2 years ± 13.8 SD) and 39 HC subjects (23 female, mean age = 44.6 years ± 15.2).

115 subjects received RUL (includes 2 subjects with LART), and 42 subjects received BT subjects (includes 25 subjects who transitioned from RUL). RUL received 12.3 ± 5.3 treatments and BT received 13.4 ± 5.4. In both groups, the pre-ECT HAMD total score was 26 ± 5 with a significantly higher response rate in the BT group (83%) than in the RUL group (59%, $p = 0.0045$). RUL and BT did not differ in mean age, sex, pre-ECT HAM-D-17, treatment number, education, or diagnosis (all $p > 0.1$). Both patient groups were significantly older compared to the HC group ($p = 0.031$), but HC and patient groups did not differ in sex-ratio ($p > 0.1$) (Table 2: Patient and HC demographics). The raw neurocognitive data and subject number for each test are presented in Table 3.

3.2. Analysis of change in neuropsychological performance

AIC reduced the main effect and interaction variables to the following: site, age, sex, education, antidepressant response (% change in HAM-D), treatment number, ECT placement (RUL, BT, and HC) or "group", treatment number-group interaction, sex-group interaction, and age-group interaction.

3.3. Verbal fluency category

VFC had a group-treatment number interaction (F(1,107) = 4.14, p = 0.04). Post-hoc analysis revealed that increased treatment number resulted in improved VFC performance in the BT group (β = 0.85, 95% CI [−0.12, 1.82]). In contrast, increased treatment number resulted in decreased VFC performance in the RUL group (β = −0.37, 95% CI [−1.11, 0.36]). The difference in slope between BT and RUL was significant ($\beta_{diff} = -1.23$, p = 0.04).

3.4. Percent retention

The main effect for group (RUL and HC) was significant for percent retention (F(1,81) = 4.35, p = 0.04). Post-hoc analysis revealed that

Table 3
Summary of neuropsychological results (pre-/post-ECT or longitudinal change).

Measure		RUL	BT	HC
Trail-Making Test Part A	N	76	36	23
	Δ seconds (± SD)	−2 ± 18	−3 (22)	−3 (16)
Trail-Making Test Part B	N	75	30	23
	Δ seconds (± SD)	−4 (21)	3 (34)	−2 (17)
Verbal Fluency Semantic	N	61	38	23
	Δ word number (± SD)	−2 (15)	6 (17)	−1 (7)
Verbal Fluency Letter	N	26	32	23
	Δ word number (± SD)	−3 (16)	1 (27)	6 (17)
Percent Retention	N	60	0	31
	Δ percent recall (± SD)	2 (26)	NA	0 (20)

mean performance in HC decreased by −20.4% (95% CI [−38, −2.74]) relative to an increase in mean performance in RUL by 11.95% (95% CI [1.54, 21.5]). BT subjects did not have percent retention data.

3.5. Trail-making tests, verbal fluency letter, and other main effects

All other neuropsychological measures (TMT-A, TMT-B, VFL) showed no main effects for group or group interactions (all $p > 0.05$). VFC had sex differences ($F(1,107) = 4.24$, $p = 0.04$) with males performing 5.9 %diff better after treatment than females ($t(1, 107) = 2.1$, p

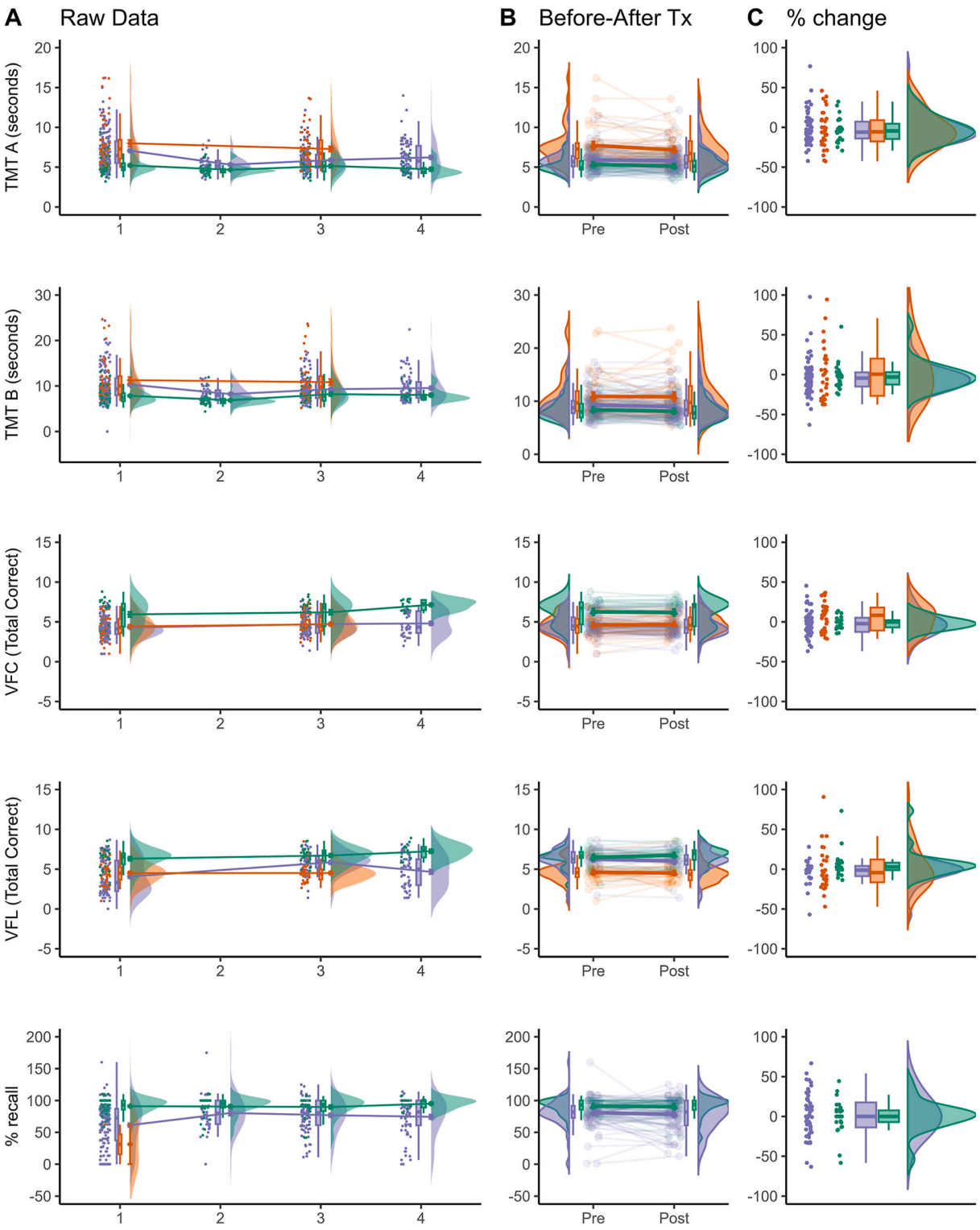

Fig. 1. A. Available raw data for the following time points for RUL (includes LART), BT, and HC data: 1) pre-ECT; 2) mid-ECT; 3) post-ECT (within one-week of finishing series); and 4) follow-up ECT (>1-month post-ECT). The focus of this investigation is pre- and post-ECT cognitive measures. B. Pre-/post-ECT trajectories of square-root transformed values. C. Percent change (pre-/post-ECT) change of square-root transformed data. Shown are half-violin data distributions, mean (SD), and histograms.

= 0.04). TMT-A also had sex differences ($F(1,120) = 4.34$, $p = 0.03$) with males performing 7.3 %diff worse than females ($t(1, 120) = 2.1$, $p = 0.03$). TMT-A (F(7,120) = 2.12, p = 0.04) and percent retention (F (2,81) = 3.12, p = 0.04) demonstrated site differences. ECT treatment number was not significant any of the models.

Statistical results are summarized in Figs. 1 and 2 and Table 3. When controlling for multiple testing via false discovery rate, none of the effects remained significant ($p_{adj} > 0.1$; Fig. 2B).

4. Discussion

We assessed five neurocognitive outcomes (TMT-A, TMT-B, VFL, VFC, and percent recall) from the GEMRIC database. We focused on pre-/post-ECT neurocognitive measures that had the most consistent administration across the study sites to maximize the sample sizes for each measure. Our sample size was robust from 91 subjects (60 patients and 31 HC) with percent retention to 135 subjects (112 patients and 23 HC) with TMT-A. Each cognitive measure included HC subjects with longitudinal testing for comparative normative data. The larger sample allowed us to investigate and correct for seven covariates (group, age, sex, education, site, number of ECT treatments, pre-post HAM-D % change) and interactions for each neurocognitive measure. Our results demonstrated a group (RUL, BT, and HC) and treatment number interaction for VFC (impaired VFC performance with increased RUL treatment number) and a group main effect for percent retention. Post-hoc analysis with percent retention revealed that the group main effect was related to a decreased HC performance and therefore deemed spurious (see Supplemental Fig. 1). Overall, we found no significant effect of group or group interactions for TMT-A, TMT-B, or VFL.

Our main result agrees with previous knowledge that VFC is adversely impacted by ECT and may be sensitive to electrode placement. A meta-analysis focused on RUL cognitive performance with ultrabrief pulse width demonstrated large effect sizes with VFC (Cohen's d = −0.98) (Semkovska et al., 2011). Although our results were not significant for VFL likely due to a smaller RUL sample, a multi-site RUL investigation has demonstrated moderate effect size (Cohen's d = −0.39) for longitudinal pre-/post-ECT changes in VFL (Lisanby et al., 2020). Another longitudinal RUL ECT neurocognitive investigation compared differences in amplitude-mediated changes in cognitive performance (Abbott et al., 2021). In this study, the primary cognitive outcome was focused on percent retention, which was stable throughout the ECT series. A secondary analysis revealed impairment in both VFL and VFC. Another large study (n = 634) demonstrated large effect sizes for post-ECT impairment in VFL and VFC (Loef et al., 2024). Further research is needed, but the RUL electric field geometry may transiently impact frontal-temporal circuitry associated with verbal fluency (Baldo et al., 2006). Focal Electrically Administered Seizure Therapy (FEAST), nonconvulsive electrotherapy (NET), hybrid ECT, and magnetic seizure therapy represent novel treatment modalities that may reduce the impact on frontal-temporal circuitry and preserve verbal fluency performance (Deng et al., 2024; Nahas et al., 2013; Regenold et al., 2015; Zhang et al., 2022).

Contrary to our hypotheses, we did not observe impairment with BT for any cognitive domain. This result is in stark contrast to prior research showing larger cognitive impairment with BT electrode placement (Kolshus et al., 2018; Martin et al., 2020). A meta-analysis demonstrated the largest effect sizes for word list delayed recall (Semkovska and McLoughlin, 2010). Our sample size was relatively modest for the BT group. A range of 30–38 BT subjects had TMT and VF data, but no BT subjects had percent retention data (Table 3). Dosing patterns (seizure titration vs. demographically based), charge, and treatment frequency (twice vs. thrice weekly) are additional variables that may have influenced these results and will be a focus of future investigations. Given the limitations of the available dataset discussed below, we hesitate to draw definitive conclusions regarding the absence of ECT-mediated neurocognitive effects for the BT subjects. However, BT did demonstrate improved efficacy relative to RUL, which is consistent with past research demonstrating faster and improved response rates with BT relative to RUL and BF (Kellner et al., 2010).

We acknowledge several limitations necessary for result interpretation. First, we had significant site differences in neurocognitive performance in TMT-A and percent retention. ECT administration and study protocols were site specific and therefore have variable patterns of subject selection (e.g., we excluded 27 subjects with a pre-ECT HAM-D-17 < 19), ECT devices, parameters, and standard operating procedures. Despite our relatively large sample size, we were unable to assess

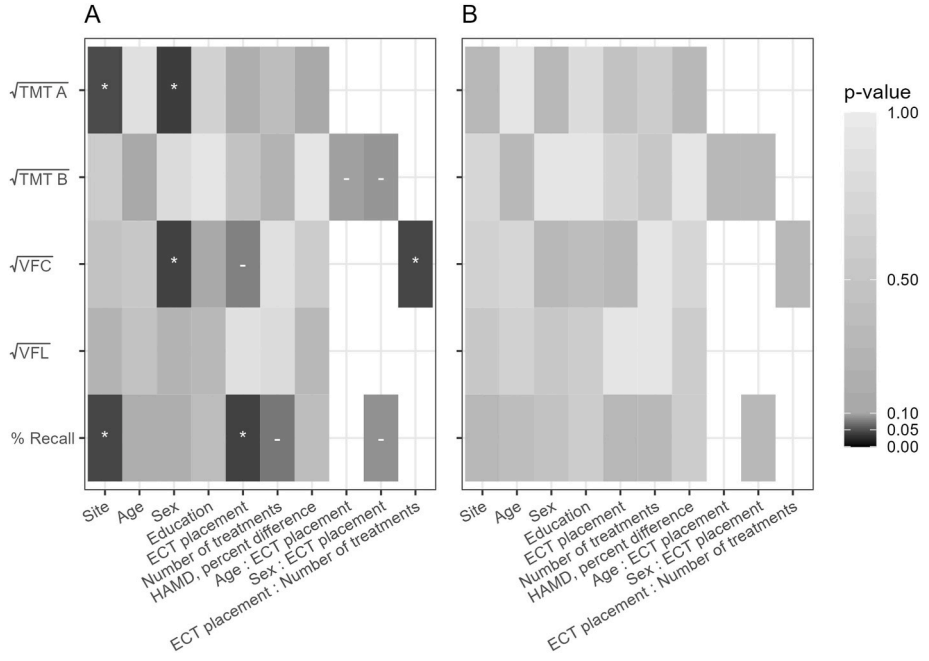

Fig. 2. Summary of p-values for all possible effects for the five neurocognitive measures. p-value stars indicate: p > 0.10 = blank; p < 0.10 = "-"; p < 0.05 = "*". Panel A is uncorrected p-values, and Panel B includes corrected p-values.

neurocognitive differences with all the site-specific variables in ECT administration. These factors contributed to significant data variability and decreased statistical power to detect longitudinal changes in cognitive performance. Second, neurocognitive assessment protocols were study- and site-specific. Some sites had a limited emphasis on collection of cognitive data and excluded important neurocognitive domains such as verbal learning and memory or autobiographical memory. The inclusion of only five cognitive measures included across multiple sites represents a significant limitation of this investigation. Third, we used education as a proxy for intelligence quotient. Longitudinal cognitive performance should include measures of premorbid intelligence, which was unavailable in the current GEMRIC database (Camprodon-Boadas et al., 2024). Fourth, percent recall may bias the pre-ECT results as poor performing subjects on list learning trials may recall a larger percentage of words. Furthermore, the pre-post change of the five neuropsychological outcomes may have been more susceptible to regression towards the mean as opposed to a different statistical analysis (repeated measures analysis of variance with baseline cognitive measure included as a covariate). Given the significant limitations of this dataset, we hesitate to draw definitive conclusions regarding the absence of ECT-mediated neurocognitive effects with four of the five tests used in this investigation and highlight the need for harmonized neurocognitive assessment protocols and procedures.

4.1. ECT neurocognitive battery for GEMRIC

The GEMRIC Clinical and Cognitive Work Group, comprised of an interdisciplinary team of experts in neuropsychiatry and clinical neuropsychology across the globe, has provided recommendations for prospective data collection for ECT-imaging investigations. The goal is to increase uniform neurocognitive data collection procedures across sites to improve measurement of the cognitive changes that occur with ECT. The selected tests met the following objectives: cognitive domains 1) sensitive to cognitive effects of ECT; 2) ease of administration; 3) minimal cost; 4) available in multiple languages; and 5) established reliability and validity; 6) availability of normative data; and 7) minimization of subject burden.

The recommended neurocognitive domains and tests are listed in Table 4. TMT-A, TMT-B, VFL, VFC, and RAVLT were included in our retrospective analysis. The RAVLT is available in several different languages with standardized administration and normative data. The Symbol Digit Modality Test (SDMT) is an easy-to-administer test to assess psychomotor processing speed, attention, and incidental learning (Strauss et al., 2006). This test is highly sensitive to cognitive impairment and includes multiple forms with normative data to minimize practice effects. Digit span backward (DSB) assesses working memory (Weschler, 1997). The Test of Premorbid Function (TOPF) estimates premorbid intellectual ability (Wechsler, 2009). The Montreal Cognitive Assessment (MoCA), a measure of global cognitive function that is sensitive to gross neurocognitive abnormalities, screens for preexisting cognitive impairment (Nasreddine et al., 2005; Rossetti et al., 2011) and can be used to examine global cognitive functioning changes after ECT. The GEMRIC Clinical and Cognitive Work Group also recommends pre-/post-ECT assessments at a minimum with emphasis on additional time points: mid-ECT (before electrode placement switch) and follow-up assessments (1-, 3- and 6-month post-ECT).

The GEMRIC Clinical and Cognitive Work Group evaluated several different autobiographical memory tests. The Autobiographical Memory Interview (AMI) strengths include published administration and scoring manual, validation in an amnestic and ECT samples, and controls for retention time interval and encoding age (Kho et al., 2006; Kopelman, 1989; Kopelman et al., 1989, 1990; O'Connor et al., 2010; Sienaert et al., 2010; Stoppe et al., 2006). This test is licensed and copyrighted and must be purchased. The AMI has a long administration time (~90 min) testing recollections over multiple time epochs. The use of a specific or multiple AMI time epochs as a standalone instrument has not been validated for longitudinal assessments. The Autobiographical Memory Test (AMT) is efficient (approximately 15 min for entire test), available in the public domain, and validated in depression and ECT samples (Deng et al., 2024; Raes et al., 2008; Williams and Broadbent, 1986; Williams and Scott, 1988). However, the AMT does not control for retention time interval or encoding age and does not measure consistency of autobiographical memory over time. The Columbia University Autobiographical Memory Interview – Short Form (CAMI-SF) is relatively easy to administer, has an administration and scoring manual, and was designed to assess changes in autobiographical memory consistency related to ECT (McElhiney et al., 1997). However, the CAMI-SF is sensitive to test-retest interval, does not control for encoding age, can have lengthy administration time (up to 30–45 min for baseline assessment), and there have been concerns regarding its validity, including ecological validity, as the CAMI-SF tests the accuracy of baseline memory recall (Semkovska and McLoughlin, 2013). Given the limitations of the available autobiographical memory tests, the GEMRIC Work Group recommended that each site include their autobiographical memory test of choice.

Adoption of the standardized cognitive testing battery recommended in this text by participating GEMRIC studies can help provide a harmonized and comprehensive dataset that can be used to answer many questions still outstanding in ECT treatment, including the nature and course of cognitive changes experienced during acute ECT treatment, the neurobiological correlates and underlying mechanism of these changes, and the impact of ECT parameters such as pulse width, amplitude, electrode placement, treatment number contribute to these changes, and how to integrate cognitive assessment in clinical practice. This will allow for refinement of ECT treatment parameters to make mechanism-based adjustments to minimize adverse cognitive effects while preserving the unparalleled efficacy of ECT.

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Table 4
Prospective GEMRIC neurocognitive battery.

Domain	Neurocognitive measures	Duration
Processing speed	Symbol Digit Modality Test (SMDT)	~3 min
Attention	Trail Making Test Part A (TMT-A)	~3 min
Language function	Verbal Letter Fluency (VFL), Category Fluency (VFC)	~8 min
Memory - verbal	Rey Auditory Verbal Learning Test (RAVLT)	~40 min (inclusive of a 20–30 min delay period during which other tests can be administered)
Memory - autobiographical	Autobiographical Memory Test (AMT)	~15 min
	Autobiographical Memory Interview (AMI)	~90 min
	Columbia University Autobiographical Memory Interview – Short Form (CAMI-SF)	~40 min
Executive function	Trail Making Test Part B (TMT-B)	~6 min
Working memory	Digit Span Backwards (DSB)	~10 min
Premorbid IQ	Test of Premorbid Functioning (TOPF)	~5 min
Global cognitive function	Montreal Cognitive Assessment (MoCA, version 8.1)	~10 min

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Maximilian Kiebs: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Danielle C. Farrar:** Writing – review & editing, Writing – original draft. **Antoine Yrondi:** Writing – review & editing. **Narcis Cardoner:** Writing – review & editing. **Noora Tuovinen:** Writing – review & editing. **Ronny Redlich:** Writing – review & editing. **Udo Dannlowski:** Writing – review & editing. **Carles Soriano-Mas:** Writing – review & editing. **Annemiek Dols:** Writing – review & editing. **Akihiro Takamiya:** Writing – review & editing. **Indira Tendolkar:** Writing – review & editing. **Katherine L. Narr:** Writing – review & editing. **Randall Espinoza:** Writing – review & editing. **Maarten Laroy:** Writing – review & editing. **Philip van Eijndhoven:** Writing – review & editing. **Esmée Verwijk:** Writing – review & editing. **Jeroen van Waarde:** Writing – review & editing. **Joey Verdijk:** Writing – review & editing. **Hannah B. Maier:** Writing – review & editing. **Pia Nordanskog:** Writing – review & editing. **Guido van Wingen:** Writing – review & editing. **Linda van Diermen:** Writing – review & editing. **Louise Emsell:** Writing – review & editing. **Filip Bouckaert:** Writing – review & editing. **Jonathan Repple:** Writing – review & editing. **Joan A. Camprodon:** Writing – review & editing. **K. Tristan Donaldson:** Writing – review & editing. **Leif Oltedal:** Writing – review & editing, Software, Resources. **Ute Kessler:** Writing – review & editing. **Åsa Hammar:** Writing – review & editing. **Pascal Sienaert:** Writing – review & editing. **Kaat Hebbrecht:** Writing – review & editing. **Mikel Urretavizcaya:** Writing – review & editing. **Jean-Baptiste Belge:** Writing – review & editing. **Miklos Argyelan:** Writing – review & editing. **Mate Baradits:** Writing – review & editing. **Jasmien Obbels:** Writing – review & editing. **Bogdan Draganski:** Writing – review & editing. **Alexandra Philipsen:** Writing – review & editing. **Alexander Sartorius:** Writing – review & editing. **Didericke Rhebergen:** Writing – review & editing. **Olga Therese Ousdal:** Writing – review & editing. **René Hurlemann:** Writing – review & editing. **Shawn McClintock:** Writing – review & editing, Writing – original draft. **Erik B. Erhardt:** Writing – review & editing, Writing – original draft, Visualization, Software, Formal analysis. **Christopher C. Abbott:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

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Appendix A. Supplementary data

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