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A study on treatment sensitivity of ecological momentary assessment in obsessive–compulsive disorder

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Abstract

As part of a larger clinical trial, this ecological momentary assessment (EMA) study pursued the main goal of demonstrating that the EMA method is sensitive to treatment effects of detached mindfulness and cognitive restructuring for obsessive–compulsive disorder (OCD). A second goal was to provide a descriptive analysis of OCD symptoms and influencing factors in participants' everyday lives. Thirty-nine participants were included in the final analyses. EMA sampling involved a smartphone and comprised 4 days with 10 random prompts per day both before (Pre-Treatment EMA) and after the completion of a 2-week clinical intervention of either detached mindfulness or cognitive restructuring (Post-Treatment EMA) that participants had been randomly allocated to. The EMA questionnaire included items on the frequency of obsessions, subjective burden due to obsessions, perceived current stress, emotions, and on the frequency of compulsions and other dysfunctional behaviors. Descriptive Pre-Treatment EMA results highlight the importance of compulsions and emotional states of tension/discomfort in OCD. Pre–Post comparisons showed a significant reduction of avoidance behavior, obsessions, and burden due to obsessions, with a nonsignificant trend also indicating a reduction of compulsions. There was no pre to post effect concerning emotions. This study adds to the existing research on OCD symptoms and offers further evidence in confirmation of established theoretical models of OCD. Also, our results can be taken as evidence for treatment sensitivity of the EMA method in OCD. Further research is needed to replicate, broaden, and generalize our results.

KEYWORDS

cognitive restructuring, detached mindfulness, ecological momentary assessment, Obsessive-compulsive disorder, OCD, treatment sensitivity

1 | INTRODUCTION

Diagnostic and Statistical Manual of Mental Disorders (DSM-5) defines obsessive–compulsive disorder (OCD) by intrusive and unwanted thoughts, images, or urges (i.e., obsessions) followed by repetitive overt behaviours or mental acts (i.e., compulsions) that patients employ to reduce fear and tension caused by the above-named obsessions (American Psychiatric Association, 2013). The link between obsessions that

are followed by compulsions to reduce distress forms the core of contemporary models of OCD proposed by Rachman (1997, 1998), Salkovskis (1985, 1999), and Wells (2011).

Clinical assessment of OCD in adults typically entails clinician-administered rating scales, with the Yale-Brown Obsessive–Compulsive Scale (Y-BOCS; Goodman et al., 1989) constituting the gold standard in terms of measuring changes through treatment (i.e., treatment sensitivity) in clinical research, and a number of self-report scales such as the Obsessive–Compulsive Inventory—Revised (Foa et al., 2002), the Vancouver Obsessional Compulsive Inventory (Thordarson et al., 2004), and the Padua Inventory-Palatine Revision (Gönner, Ecker, & Leonhart, 2010). As Overduin and Furnham (2012) point out, most self-report scales show good psychometric properties while exhibiting differences concerning the facets of OCD being measured. In terms of treatment sensitivity, however, there is comparably little evidence concerning self-report scales, comprising the Obsessive–Compulsive Inventory—Revised (Abramowitz, Tolin, & Diefenbach, 2005) and the preceding version of the Padua Inventory, that is, the Padua Inventory-Revised (Van Oppen, Emmelkamp, van Balkom, & van Dyck, 1995).

When it comes to direct in vivo measures of OCD symptoms that rule out retrospective biases naturally attached to the above-named rating scales, a traditional yet less contemporary approach is the so-called Behavioral Avoidance Test (BAT), which measures a person's avoidance behaviour and his or her subjective units of distress (SUDs) when being confronted with a feared object or situation. Although BATs exhibit good treatment sensitivity, as shown by Steketee, Chambless, Tran, Worden, and Gillis (1996), for example, they are usually not set in the person's personal environment and are also difficult to design given a wide range of feared situations within and across individuals with OCD (Taylor, 1995).

By contrast, direct observation of OCD rituals can be considered as more ecologically valid than BATs because measures are taken in the person's personal surroundings. As such, direct observation has been shown to be sensitive to treatment effects (e.g., Turner, Hersen, Bellack, Andrasik, & Capparell, 1980), yet this method is hardly applicable to outpatients, which restricts its practical meaning for clinical trials. On the contrary, as pointed out by Taylor (1995), diary methods, which involve having patients keep track of their symptoms in everyday life (e.g., by means of a self-observation form), have been used since the 1980s for assessing frequency and other features of obsessions in a way that is ecologically valid and minimizes retrospective bias. Also, this approach has been used for assessing outcome to behavioral treatment in OCD patients and shows good treatment sensitivity (e.g., Boersma, Den Hengst, Dekker, & Emmelkamp, 1976; Foa, Steketee, & Milby, 1980).

Yet, this approach remained the exception in outcome research, which is why Mavissakalian and Barlow noted back in 1981 that frequency measures of OCD behaviours are underrepresented in outcome research, leading Taylor (1995) to conclude that diary methods are urgently needed to shed light on how OCD-specific treatments lead to changes in the patients' personal environment. The fact that as far as we know little has changed regarding this circumstance is what gave rise to our idea of using a modern form of diary method, that is, ecological momentary assessment (EMA), to measure treatment effects in a sample of OCD patients.

Key Practitioner Message

- This ecological momentary assessment (EMA) study examined symptoms of obsessive–compulsive disorder (OCD) and the extent to which the EMA method is sensitive to treatment effects.
- EMA sampling took place both before and after an intervention of either detached mindfulness (DM) or cognitive restructuring (CR).
- Pre-treatment results highlight the importance of compulsions and emotional states of tension/discomfort in OCD.
- Pre–Post comparisons show a reduction of avoidance behaviour, obsessions, and burden due to obsessions, with a nonsignificant trend also indicating a reduction of compulsions.
- Results can be taken as evidence in confirmation of contemporary models of OCD and as proof of treatment sensitivity of the EMA method in OCD.

EMA, a term originally coined by Stone and Shiffman (1994), has gained heightened attention within the past 10 years (e.g., Trull & Ebner-Priemer, 2009, 2013). Offering many possibilities of collecting data in people's everyday lives, for example, via a smartphone sending random prompts throughout the day asking the patient to rate his or her mood, major advantages of EMA as compared with retrospective symptom scales are the reduction of retrospective bias and the enhancement of ecological validity (Ebner-Priemer & Trull, 2009; Shiffman, Stone, & Hufford, 2008).

However, to date, there is hardly any EMA research in OCD and not a single study that used EMA as a measure of outcome with regard to an intervention. Gloster et al. (2008) used an EMA approach (one prompt in 4 hours across 7 days) to study recall accuracy for OCD symptoms, whereas Purdon, Rowa, and Antony (2007) asked OCD sufferers to keep diary of their attempts to suppress their thoughts over 3 days, revealing that thought suppression is a frequently used but ineffective strategy among OCD sufferers.

There are a few studies that used EMA to evaluate clinical trials dealing with psychological disorders other than OCD. The study that most inspired our design was provided by Munsch et al. (2009), who used two EMA sampling periods of one week each before and after treatment to demonstrate the efficacy of a CBT intervention on binge eating. EMA sampling in this study was smartphone-based and featured five fixed prompts per day.

The EMA study that this publication deals with was part of a larger clinical trial (Rupp, Jürgens, Doebler, Andor, & Buhlmann, 2019), which compared two different approaches to dealing with obsessions, that is, detached mindfulness (DM) and cognitive restructuring (CR). The

latter draws on the theoretical models by Salkovskis (1985, 1999) and Rachman (1997, 1998) and teaches patients to question their distorted appraisals of intrusive thoughts and to develop alternative attitudes towards them, for example, by re-evaluating risk and the amount of personal responsibility. DM, by contrast, was based on Wells's (2011) metacognitive model of OCD and, instead of teaching patients to *actively* deal with their cognitions, educates them to *passively* observe their obsessions from a distance instead of experiencing them as important events that require immediate action. Both interventions comprised four double sessions of 100 min each within 2 weeks. As expected, both interventions were similarly effective at reducing OCD symptoms as measured with the German version of the Y-BOCS (Hand & Büttner-Westphal, 1991). Theoretical background, treatment procedure, and results of the clinical trial have been described elsewhere (Rupp et al., 2019).

The main reason for which we complemented our clinical trial by a Pre- and Post-EMA assessment was to address the above-described lack of ecologically valid outcome data and to hence demonstrate that the EMA method is sensitive to treatment effects in OCD.[1] Second, an inferior aim in applying EMA to our OCD sample was to provide a brief descriptive analysis of OCD symptoms as well as related emotions, behaviors, and influencing variables.

In EMA research, it is crucial to ensure that participants are not overwhelmed by too many items in the questionnaire. Thus, the design of an EMA questionnaire always means a tradeoff between informative content and practicability. Our decisions regarding the items that were finally included in the questionnaire (see Table 2) were based on the current state of the scientific literature on OCD and common knowledge within this field so that we deliberately restrict the upcoming literature review to a few rather unusual variables.

Our decision to study compulsive action monitoring aiming at keeping track of one's potential mistakes as another dysfunctional coping behavior was based on evidence pointing towards both a lack of memory confidence (Hermans, Martens, De Cort, Pieters, & Eelen, 2003; McNally & Kohlbeck, 1993) and a lack of attention confidence (Hermans et al., 2008) in OCD patients. Given the large body of evidence showing that intolerance of uncertainty is a common feature not only of generalized anxiety disorder, but also of OCD (e.g., Gentes & Ruscio, 2011), we also added the experience of uncertainty to our EMA questionnaire. Moreover, Salkovskis's model (1985) assumes that what leads to negative emotions in OCD is a certain form of misinterpretation of obsessions—which is what actually lends obsessions their burdensome character. Therefore, apart from a reduced frequency of compulsions and obsessions, an effect of treatment could also consist in a decrease of perceived *burden* regardless of the frequency of obsessions. Because both of our interventions aimed at teaching patients a novel way of dealing with obsessions, we deliberately included this variable in the EMA questionnaire.

In terms of variables influencing the occurrence and severity of OCD symptoms, our first choice was stress because it is the most studied construct, with evidence demonstrating the link between stress and OCD symptoms (especially obsessions) dating back to the 1970s (summarized by Horowitz, 1975). Further evidence showing that stress has an impact on OCD symptom severity, drawing both on cross-sectional and longitudinal designs, has, for example, been provided by Findley et al. (2003) and Lin et al. (2007). The crucial influencing role that stress appears to play regarding OCD symptoms led us to include this variable as covariate in all regression models described below.

Regarding the descriptive analysis, we did not formulate hypotheses because we did not apply any inferential statistics that would allow to actually confirm hypotheses. Instead, this analysis was exploratory in its nature, though of course guided by the predictions of the above-named theoretical models and the overall research question to what extent the EMA method would reflect OCD symptoms and related phenomena in participants' everyday lives. Given our main goal to demonstrate treatment sensitivity and the different ways in which an effect of treatment may be reflected in OCD, we hypothesized that:

1. All dysfunctional behaviours, that is, compulsions, avoidance, thought suppression, and action monitoring, should decrease from Pre-Treatment EMA to Post-Treatment EMA in both treatment conditions.
2. All negative emotions associated with OCD should decrease from Pre-Treatment EMA to Post-Treatment EMA in both treatment conditions.
3. Both treatments should lead to a decrease of obsessions from Pre-Treatment EMA to Post-Treatment EMA.
4. Across treatments, during Pre-Treatment EMA, the burden resulting from obsessions should correlate higher with the frequency of obsessions than during Post-Treatment EMA because patients learn to deal with obsessions in a different way.

2 | METHODS

The study was conducted between January 2017 and July 2018. The study protocol was approved of by the ethics committee of the Department of Psychology and Sport Science at the University of Münster, Germany. Also, it was registered at ClinicalTrials.gov under the ID NCT03002753. All participants provided written informed consent after the study procedure had been fully explained.

2.1 | Participants

Our 40 participants were the same OCD patients (completer sample) as those in the clinical trial (Rupp et al., 2019). Please see Rupp et al. for data concerning the intention-to-treat sample and for information on recruitment, inclusion, and exclusion criteria as well as diagnostic assessment. All participants fulfilled the DSM-5 criteria for OCD and had a minimum Y-BOCS score of 17. Table 1 gives a detailed description of the sample with separate data for each of the two treatment

[1]The EMA-based comparison of the two interventions we studied (DM and CR), which will focus on aspects such as general and specific working mechanisms as well as applicability of DM vs. CR, will be reported elsewhere.

TABLE 1 Sample description (baseline data from treatment completers)

Variable	CR (n = 20)	DM (n = 20)
Age, mean (*SD*)	31.35 (11.49)	31.05 (9.66)
Sex, *n* (%)		
Male	11 (55)	6 (30)
Female	9 (45)	14 (70)
Clinical characteristics		
Y-BOCS score (items 1–10), mean (*SD*)	25.05 (2.69)	24.30 (4.00)
BDI-II, mean (*SD*)	17.65 (9.29)	16.55 (10.66)
Persistence of OCD, years, mean (*SD*)	10.18 (9.01)	12.35 (9.64)
Number of comorbid disorders, mean (*SD*)	0.70 (1.42)	0.95 (1.19)
Participants under psychopharmacological medication, number (%)	10 (50)	7 (35)
Participants experienced in the intervention delivered, number (%)	3 (15)	1 (5)

Note. The sample description is based on baseline data recorded before treatment from n = 40 participants who completed the treatment and all assessments. Please note that as described in the text, one male participant from the CR group was excluded from data analysis. The number of participants experienced in the intervention delivered was determined by the therapists who asked participants during treatment whether they are familiar with the strategy, for example, due to previous CBT-like treatments.

Abbreviations: BDI-II = Beck Depression Inventory II. CR = cognitive restructuring. DM = detached mindfulness. SD = standard deviation. Y-BOCS = Yale-Brown Obsessive–Compulsive Scale.

groups. Participants were randomly assigned to the two treatment conditions (DM/CR).

Treatment, assessment, and introduction into the EMA smartphone procedure took place at the psychotherapeutic outpatient clinic of the Christoph-Dornier-Foundation in Münster. Participants received € 80 for completing the smartphone-based EMA questionnaires and were paid an additional € 10 per sampling period if they had answered a minimum of 80 % of all prompts.

2.2 | Design and procedure

Like Munsch et al. (2009), we compared a Pre-Treatment EMA sampling period with a Post-Treatment EMA sampling period. We chose a sampling period of 4 days with ten randomly presented prompts per day, separated from each other by a minimum of 30 min. Both sampling periods comprised Friday through Monday and were conducted immediately before the start and after the completion of treatment.

EMA sampling was done using a smartphone (Motorola Moto G2) and the software *movisensXS* (App Version: 1.0.0). Each day, random sampling started at 9:00 am and ended at 9:00 pm, applying either an acoustic alert (preferably) or a vibrating alert. Participants were able to produce fixed prompts, for example, by switching the phone to inactive mode during the day. Participants were given the opportunity to irrevocably dismiss or to postpone prompts for a maximum of five times.

2.3 | Items in the EMA questionnaire

Table 2 lists all items included in the EMA questionnaire, with Screens 1 and 2 presenting the preliminary items on stress, relaxation, frequency of obsessions, and perceived (i.e., subjective) burden, Screens 3 through 5 listing all emotion items, and Screens 6 through 10 showing all behavior items, that is, dysfunctional behaviors (Hypothesis 1) and behaviors related to what patients are taught in treatment (DM vs. CR). Since the comparison of DM and CR and participants' application of the associated strategies (Screen 11) will be the subject of a different publication, the list of behavior items relevant for the study at hand only comprises *Suppression*, *Compulsion*, *Monitoring*, and *Avoidance*. This publication will not present results for the remaining behavior items (CR/DM) and the items presented on Screen 11.

All EMA items were rated on a Likert scale ranging from 1 (*not at all*) to 7 (*very much*). Except for three additional items on the use of the strategies learned during treatment (Screen 11), the questionnaires for Pre-Treatment EMA and Post-Treatment EMA were identical. The original questionnaire was in German; however, Table 2 lists English translations of all items. Following the pathway implied by Salkovskis's (1985) model, the programming of the software involved that when participants rated the frequency of obsessions as "not at all," they were instantly redirected to the end of the questionnaire, thereby skipping all items on emotional states and behaviors. Items belonging to one category (e.g., emotions or behaviours) were randomly allocated to screens presenting a maximum of three items each. Please note that the variable *Relaxation* only served as a control variable to detect implausible response patterns.

2.4 | Feasibility and reactivity to EMA

Feasibility of and reactivity to EMA were assessed via a postmonitoring questionnaire that participants filled in a couple of days following each of the two sampling periods. The questionnaire comprised 23 items that were rated on a Likert scale from 1 (*not at all*) to 5 (*absolutely*). These items were designed to measure representativeness ("To what extent were the days you carried the smartphone with you representative of your everyday life?"), practicability (e.g., "Would you say that the frequency of prompts was too high?"), acceptability (e.g., "How unpleasant was it for you to fill in the questionnaires?"), and reactivity to EMA (e.g., "To what extent did you respond differently to obsessions because of the EMA study?").

2.5 | Preliminary data analysis and cleansing of data

All analyses were conducted via multilevel modelling using the statistical software R (R Core Team, 2018), especially the packages *lme4* (Bates, Mächler, Bolker, & Walker, 2015), *nlme* (Pinheiro, Bates,

TABLE 2 English translations of EMA items

Variable (short label)	English translation of item
Screen 1 Stress Relaxation	1) Since the last prompt, to what extent have you been under stress? 2) Since the last prompt, to what extent have you felt relaxed?
Screen 2 Obsessions Burden	1) Since the last prompt, how frequently have you experienced obsessions? 2) To what extent have you felt burdened by the obsessions you have experienced since the last prompt?
Screen 3 Anxiety Shame Sadness	1) To what extent were obsessions that you have experienced since the last prompt associated with the following feelings? *anxiety* *shame* *sadness*
Screen 4 Guilt Helplessness Disgust	1) To what extent were obsessions that you have experienced since the last prompt associated with the following feelings? *guilt* *helplessness* *disgust*
Screen 5 Tension/ Discomfort Frustration Uncertainty	1) To what extent were obsessions that you have experienced since the last prompt associated with the following feelings? *tension/discomfort* *frustration* *uncertainty*
Screen 6 Suppression (Dys) Come and Go (DM)	1) Please rate to what extent you responded to obsessions that you have experienced since the last prompt in the following ways—regardless of how effective you experienced your response: *I suppressed the obsession.* *I allowed the obsession to come and go.*
Screen 7 Realistic (CR) Compulsion (Dys)	1) Please rate to what extent you responded to obsessions that you have experienced since the last prompt in the following ways—regardless of how effective you experienced your response: *I reviewed to what extent my apprehensions are realistic.* *I performed a compulsion (overt or covert).*
Screen 8 Monitoring (Dys) Distance (DM)	1) Please rate to what extent you responded to obsessions that you have experienced since the last prompt in the following ways—regardless of how effective you experienced your response: *I monitored my actions with special attention.* *I positioned myself at a distance from the obsession.*
Screen 9 Responsibility (CR) Just a Thought (DM)	1) Please rate to what extent you responded to obsessions that you have experienced since the last prompt in the following ways—regardless of how effective you experienced your response: *I wondered how far I overestimated my own responsibility.* *I told myself that it is just a thought.*
Screen 10 Risk (CR) Avoidance (Dys)	1) Please rate to what extent you responded to obsessions that you have experienced since the last prompt in the following ways—regardless of how effective you experienced your response: *I questioned how far I overestimated the risk of something.* *I avoided objects or situations due to my obsessions.*
Screen 11 How often Difficulty Relief	1) How often have you applied the technique you learned in therapy to obsessions—regardless of how effective you experienced it? 2) How difficult did you find it to apply the newly learned technique? 3) To what extent did applying the newly learned technique create relief?

Note. Screen 11 was presented only in the Post-Treatment EMA. Because the German term "Anspannung," which generally fits very well with the emotional experience of OCD patients, does not translate easily into English, we listed both "tension" and "discomfort" as possible translations. The annotations "Dys," "DM," and "CR" are used to indicate which category the corresponding behavior item belongs to.

Abbreviations: CR = cognitive restructuring. DM = detached mindfulness. Dys = dysfunctional.

DebRoy, & Sarkar, 2018), *lmerTest* (Kuznetsova, Brockhoff, & Christensen, 2017), and *MuMIn* (Barton, 2018). All Likert-scales items were centred at 0, which required a transformation of data from 1–7 to 0–6.

Separate spaghetti plots for Pre-Treatment EMA and Post-Treatment EMA were computed for each participant and variable in order to get an overview of the distribution of missings, of ceiling and floor effects, etc.

Cleansing of data comprised the deletion of trials with a distance of less than 30 min from the preceding trial (due to fixed prompts, this could not be excluded a priori) and the deletion of all ignored, incomplete, and dismissed trials. It also included the deletion of all trials from one participant from the CR group who had exhibited an extreme tendency towards the centre of the scale on all variables both at Pre and Post sampling and the deletion of trials with implausible response patterns (e.g., same value, if not 4, for the variables *Stress* and *Relaxation*, or whenever *Obsessions* was rated as 1 with *Burden* rated higher than 1).

To evaluate whether the items on emotions and behaviors can be summarized to overall variables (such as "dysfunctional behaviours," "CR behaviors," and "DM behaviors") and with the intention of excluding any artefacts involving that items presented on the same screen are given a similar rating, we applied multilevel factor analysis (Muthén, 1994; Reise, Ventura, Nuechterlein, & Kim, 2005). Prior to hypothesis testing, we computed null models for all items serving as dependent variables, that is, all items except *Stress*, *Burden*, and *Relaxation*, which involved computing the corresponding intraclass correlations.

Hypothesis testing

Hypothesis testing involved computing multilevel models with trials on the first and participants on the second level. Parameters were estimated using restricted maximum likelihood. For all analyses, we applied a significance level of .01. All models were checked for multicollinearity by inspecting the correlations of fixed effects for each model. Homoscedasticity was checked through visual inspection of scatter plots of predicted values and residuals. All regression models including the *Pre–Post* factor were computed with and without incorporating random slopes for participants, followed by model comparisons via likelihood ratio tests (LRTs) and the inspection of AIC and BIC as fit indices.

All regression models computed to test Hypotheses 1–4 on the decrease and increase of behaviors, emotions, obsessions, and burden due to obsessions included both random intercepts and random slopes concerning the *Pre–Post* variable as we assumed that participants would differ concerning their response to treatment. To avoid confusion, the random intercepts and slopes are not included in the model equations below. As fixed effects, all models included the factor *Pre–Post*, the factor *Group* (DM vs. CR), and the interaction of the two factors. Even though the comparison of DM versus CR is not the focus of this publication, the factor *Group* was included as an important covariate, that is, as a control variable. Because Hypotheses 1, 2, and 4 all dealt with predicting behaviors, emotions, and perceived burden following obsessions, *Obsessions* was included as a covariate in each model in order to isolate any reduction effects that are solely due to a decrease of obsession frequency. Apart from that, in order to account for the crucial influence of antecedent stress, we added as another important covariate in all regression models the amount of stress reported at the preceding prompt, which we labelled $Stress_{t\text{-}1}$.

In sum, the equation underlying the models for Hypotheses 1 and 2 was:

Hypothesis 1 and 2.

$$Y_t = Intercept + Pre\text{–}Post + Group + Pre\text{–}Post \times Group + Stress_{t\text{–}1} + Obsessions + error,$$

where Y_t denotes each of the emotion and behavior items.

Testing Hypotheses 3 and 4 involved the following equations:

Hypothesis 3.

$$Obsessions = Intercept + Pre\text{–}Post + Group + Pre\text{–}Post \times Group + Stress_{t\text{–}1} + error.$$

Hypothesis 4.

$$Burden = Intercept + Pre\text{–}Post + Obsessions + Group + Stress_{t\text{–}1} + Pre\text{–}Post \times Group + Pre\text{–}Post \times Obsessions + error.$$

3 | RESULTS

3.1 | Preliminary data analysis

The inspection of the spaghetti plots indicated no effects concerning the distribution of missing values neither concerning Pre-Treatment EMA versus Post-Treatment EMA nor with regard to weekdays versus weekend or first versus second half of sampling period. The plots shed light on some participants' implausible response patterns that motivated data cleansing. The plots did not yield any evidence for autocorrelations. There were hardly any ceiling or floor effects evident across participants; however, the emotions disgust, shame, and sadness were hardly ever rated above 3. The spaghetti plots did not yield any evidence for reactivity to EMA since there was no trend showing that, across time, participants applied more CR and DM strategies.

The total number of trials was 3,027, with 1,399 Pre-Treatment EMA trials and 1,212 Post-Treatment EMA trials. Across Pre-Treatment EMA and Post-Treatment EMA and across all participants (n = 40), 356 prompts were ignored, 60 were dismissed, and 25 were interrupted ("incomplete"). The Pre–Post comparison concerning ignored trials bordered on significance, $t(39) = -2.021$, $p = .050$, $d = -0.647$, indicating that compliance was somewhat lower during the Post-Treatment EMA period as compared with the Pre-Treatment EMA period.

Data cleansing reduced the data set by 851 trials, which corresponds to 28.11 %. Thus, all subsequent analyses were conducted on a sample of n = 39 participants (n = 20 from the DM

group and n = 19 from the CR group). Thus, all subsequent analyses were based on a total of 2,176 trials (Pre: 1155, Post: 1021). As whenever *Obsessions* was rated as 1, meaning "no obsessions at all," all items concerning emotions and behaviors were skipped, the number of trials for all analyses on the emotion and behavior items was n = 940 at Pre-Treatment EMA and n = 730 at Post-Treatment EMA. With regard to the items concerning the use of the newly learned coping strategies, analyses were based on a sample size varying between n = 316 and n = 367 trials.

We did not find any evidence indicating poor acceptability, practicability, or representativeness, and neither did we find evidence for reactivity effects, with all items of the questionnaire exhibiting means below 3 following both sampling periods. Neither did we find any considerable pre to post differences on any of the items.

Concerning the multilevel factor analyses, at Pre-Treatment EMA, all nine emotion items could be represented by one factor. The loadings were between 0.37 for *Shame* and 0.77 for *Tension/Discomfort*. The one-factor solution demonstrated acceptable fit (RMSR = 0.06). At Post-Treatment EMA, the results were comparable (RMSR = 0.05). Artefacts due to the items' randomly allocated position on the screen could be ruled out.

At Pre-Treatment EMA, the behavior items were well represented by three factors (RMSR = 0.03): (i) *CR* behaviours (loadings 0.45–0.75); (ii) *DM behaviors* and *Suppression* (loadings 0.25–0.70); and (iii) *Avoidance*, *Monitoring*, and *Compulsion* (loadings 0.37–0.83). At Post-Treatment EMA, the same proportion of variance was explained by only two factors representing: (i) *DM behaviors* (loadings 0.48–0.83); and (ii) the other six variables (loadings 0.29–0.69), respectively. The two-factor solution fitted well (RMSR = 0.04). Although the factor structure changed, it did not display screen artefacts at either time.

Due to the results of the factor analyses, we decided to aggregate with regard to the emotion items (one-factor solution) but not in terms of the behavior items since at Post-Treatment EMA, the factor structure was too arbitrary and because we eventually found it more informative to look at each behavior item separately.

The computation of null models yielded intraclass correlations between 0.273 (*Compulsion*) and 0.473 (*Monitoring*). Thus, it seemed reasonable to model the multilevel structure of the data in all analyses.

3.2 | Descriptive data analysis

Table 3 displays descriptive data on all Pre-Treatment EMA items. Regarding emotions, *Tension/Discomfort* was by the far the highest rated item (M = 3.41, SD = 1.62), followed by *Uncertainty* (M = 2.69, SD = 1.82), *Anxiety* (M = 2.55, SD = 1.94), and *Frustration* (M = 2.45, SD = 2.03). Among the behavior items, *Compulsion* turned out as the most frequently used strategy (M = 3.12, SD = 1.84), whereas *Avoidance* exhibited the lowest mean rating (M = 1.80, SD = 1.75). Of note, our results suggest that participants already applied CR and DM strategies at Pre-Treatment EMA, with mean item ratings ranging from 1.18 (*Responsibility*) to 2.15 (*Come and go*).

TABLE 3 Descriptive data concerning all Pre-Treatment EMA items

Variable	*Mean*	*SD*	*Median*
Stress	2.50	1.75	2.0
Relaxation	2.96	1.68	3.0
Obsessions	2.37	1.72	2.0
Burden	2.28	1.82	2.0
Emotions			
Anxiety	2.55	1.94	2.0
Shame	1.16	1.68	0.0
Sadness	1.69	1.97	1.0
Guilt	1.47	1.87	1.0
Helplessness	2.30	1.99	2.0
Disgust	1.25	1.68	0.0
Tension/discomfort	3.41	1.62	4.0
Frustration	2.45	2.03	2.0
Uncertainty	2.69	1.82	3.0
Behaviours			
Dysfunctional			
Compulsion	3.21	1.84	3.0
Suppression	2.65	1.75	3.0
Avoidance	1.80	1.75	1.0
Monitoring	2.45	1.96	2.0
Detached mindfulness			
Come and go	2.15	1.72	2.0
Distance	1.78	1.67	1.0
Just a thought	1.58	1.62	1.0
Cognitive restructuring			
Realistic	1.80	1.73	1.0
Responsibility	1.18	1.46	1.0
Risk	1.53	1.61	1.0

Note. All calculations refer to Pre-Treatment EMA data only. Calculations are based on recoded items (0–6 instead of 1–7). All items had minimal values of 0 and maximal values of 6.

3.3 | Hypothesis testing

With the maximum correlations of fixed effects varying between 0.70 and 0.71 in each of the regression models computed, multicollinearity did not constitute a problem. Similarly, inspection of scatter plots did not yield any evidence for heteroscedasticity. For all regression models involving the Pre–Post factor as a predictor, we found a better fit (based on AIC, BIC, and LRT) for the model including random slopes than for the corresponding one excluding them so that only the models including random slopes are reported.

Detailed results concerning Hypotheses 1–4 can be retrieved from Tables 4–7. The main results concerning the hypotheses can be summarized as follows: Regarding the reduction of dysfunctional behaviors (Hypothesis 1, see Table 4), we found a significant Pre–Post reduction effect in terms of *Avoidance* and a nonsignificant trend

TABLE 4 Regression models concerning Hypothesis 1 (decrease of dysfunctional behaviors)

Compulsion				
	b	***SE***	***t***	***p***
Intercept	1.32	0.28	4.77	**<.001**
Pre–Post. *Post*	−0.60	0.24	−2.49	.017
Group.*DM*	0.22	0.37	0.62	.541
$Stress_{t-1}$	0.02	0.02	0.68	.498
Obsessions	0.61	0.03	22.61	**<.001**
Pre–Post.*Post* × Group.*DM*	0.16	0.33	0.48	.636
Observations: *n* = 1,598, Participants: *n* = 39				

Suppression				
	b	***SE***	***t***	***p***
Intercept	2.80	0.30	9.20	**<.001**
Pre–Post.*Post*	−0.22	0.36	−0.61	.545
Group.*DM*	−0.32	0.41	−0.80	.425
$Stress_{t-1}$	0.01	0.02	0.24	.807
Obsessions	−0.02	0.02	−0.91	.366
Pre–Post.*Post* × Group.*DM*	−0.61	0.50	0.34	.237
Observations: *n* = 1,598, Participants: *n* = 39				

Avoidance				
	b	***SE***	***t***	***p***
Intercept	1.01	0.29	3.52	**.001**
Pre–Post.*Post*	−0.61	0.18	−3.25	**.003**
Group.*DM*	−0.24	0.38	−0.61	.540
$Stress_{t-1}$	−0.03	0.02	−1.33	.185
Obsessions	0.33	0.02	13.52	**<.001**
Pre–Post.*Post* × Group.*DM*	0.27	0.26	1.05	.304
Observations: *n* = 1,597, Participants: *n* = 39				

Monitoring				
	b	***SE***	***t***	***p***
Intercept	1.77	0.35	5.01	**<.001**
Pre–Post.*Post*	0.02	0.33	0.08	.935
Group.*DM*	−0.47	0.48	−0.98	.334
$Stress_{t-1}$	0.05	0.02	2.33	.020
Obsessions	0.26	0.03	10.02	**<.001**
Pre–Post.*Post* × Group.*DM*	0.05	0.46	0.12	.237
Observations: *n* = 1,598, Participants: *n* = 39				

Note. The first line of each table lists the dependent variable of the corresponding model. *p* values <.01 are printed in bold. Concerning the predictors "Pre–Post" and "Group," the corresponding reference category is given in italicized letters (*Post*/*DM*).

Abbreviations: DM = detached mindfulness.

TABLE 5 Regression model concerning Hypothesis 2 (decrease of emotions)

All emotions (1-factor-solution)				
	b	***SE***	***t***	***p***
Intercept	0.82	0.21	3.86	**<.001**
Pre–Post.*Post*	−0.10	0.13	−0.73	.473
Group.*DM*	0.14	0.29	0.46	.647
$Stress_{t-1}$	0.05	0.01	4.39	**<.001**
Obsessions	0.35	0.01	27.09	**<.001**
Pre–Post.*Post* × Group.*DM*	−0.19	0.19	−1.01	.319
Observations: *n* = 1,597, Participants: *n* = 39				

Note. The first line of the table lists the dependent variable of the regression model. *p* values <.01 are printed in bold. Regarding the predictors "Pre–Post" and "Group," the corresponding reference category is given in italicized letters (*Post*/*DM*).

Abbreviations: DM = detached mindfulness.

TABLE 6 Regression model concerning Hypothesis 3 (decrease of obsessions)

Obsessions				
	b	***SE***	***t***	***p***
Intercept	2.22	0.23	9.51	**<.001**
Pre-Post.*Post*	−0.67	0.18	−3.67	**<.001**
Group.*DM*	−0.26	0.32	−0.82	.419
$Stress_{t-1}$	0.10	0.02	4.68	**<.001**
Pre-Post.*Post* × Group.*DM*	0.27	0.26	1.06	.295
Observations: *n* = 2,176, Participants: *n* = 39				

Note. The first line lists the dependent variable of the regression model. *p* values <.01 are printed in bold. Concerning the predictors "Pre-Post" and "Group," the corresponding reference category is given in italicized letters (*Post*/*DM*).

Abbreviations: DM = detached mindfulness.

towards a reduction (p = .017) concerning *Compulsion*. There was no such effect or trend regarding *Monitoring* and *Suppression*, and neither was there any significant *Pre–Post* × *Group* interaction effect in any of the four regression models. Neither did we find any Pre–Post reduction effect concerning OCD related emotions (1-factor solution resulting from the factor analyses), as postulated by Hypothesis 2 (see Table 5). By contrast, we did find a strong and significant reduction effect concerning the frequency of obsessions as implied by Hypothesis 3 (see Table 6). With the *Pre–Post* × *Group* interaction being nonsignificant, this reduction effect was shown to be independent of the treatment condition. In terms of Hypothesis 4, which dealt with the relationship between the frequency of obsessions and the subjective burden experienced due to obsessions, the only significant predictor next to *Obsessions* was the *Pre–Post* × *Obsessions* interaction (see Table 7). This interaction indicates that during Post-EMA, the amount of experienced burden due to obsessions is less strongly associated with an increase in obsession frequency than during Pre-EMA, which means that Hypothesis 4 was confirmed.

TABLE 7 Regression model concerning Hypothesis 4 (link between Burden and Obsessions)

Burden				
	b	*SE*	*t*	*p*
Intercept	0.24	0.12	2.05	.045
$Stress_{t-1}$	0.02	0.01	1.80	.071
Group.*DM*	−0.23	0.15	−1.60	.119
Pre–Post.*Post*	0.09	0.11	0.84	.406
Obsessions	0.88	0.02	49.74	**<.001**
Pre–Post.*Post* × Group.*DM*	0.06	0.14	0.43	.672
Pre-Post.*Post* × Obsessions	−0.10	0.03	−3.92	**<.001**
Observations: *n* = 2,176, Participants: *n* = 39				

Note. The first line lists the dependent variable of the model. *p* values <.01 are printed in bold. Concerning the predictors "Pre-Post" and "Group", the corresponding reference category is given in italicized letters (*Post*/*DM*).

Abbreviations: DM = detached mindfulness.

4 | DISCUSSION

4.1 | Description of Pre-Treatment EMA items

The descriptive analysis of all Pre-Treatment EMA items served as a baseline measure concerning OCD symptoms and associated factors. Overall, our descriptive results are in line with what was to be expected given the knowledge about dysfunctional behaviors and emotions in OCD. In support of the diagnostic criteria listed by DSM-5 (APA, 2013) and the theoretical models discussed above (e.g., Rachman, 1997, 1998; Salkovskis, 1985, 1999), our EMA data highlight the salient role of compulsions and the emotional state of tension/discomfort as defining elements of OCD, with most other dysfunctional behaviors (such as thought suppression) and emotions (such as uncertainty and anxiety) obviously playing a relevant, but secondary role. Taking into account Salkovskis's model and the well-established finding that avoidance plays an enormous role in OCD (e.g., Abramowitz & Jacoby, 2014), the low mean score for the item *Avoidance* came as a surprise. This, however, should be interpreted with caution because, in the EMA questionnaire, we asked participants to what extent they *responded* to obsessions by avoiding triggering stimuli. Yet avoidance can equally well be thought of as a strategy of actually *preventing* that obsessions arise, which, of course, could not be captured using our approach, probably resulting in the low mean score for the *Avoidance* item.

Also, our findings highlight the important role of dysfunctional thought suppression attempts and excessive action monitoring, as well as the prevalence of anxiety and uncertainty as emotions that result from obsessions and precede compulsions. The relatively high values concerning frustration and helplessness might actually reflect secondary emotions resulting from the emotional burden created by both obsessions and compulsions—rather than primary emotions that trigger compulsions. By contrast, we found rather low values regarding guilt and disgust. Whereas the role of inflated responsibility beliefs in OCD is an established finding (e.g.,OCCWG, 1997; Salkovskis et al., 2000 ; Shafran, Watkins, & Charman, 1996), Rachman, Thordarson, Shafran, and Woody (1995) already noted that the association between guilt and OCD is complex and varies across situations and individuals. With regard to disgust, Berle and Phillips (2006) concluded that disgust is rather specific to contamination-related forms of OCD—which only a small subset of patients in our sample were affected by. The descriptive results concerning the CR and DM behavior items will be discussed in an upcoming paper.

4.2 | Conclusions concerning treatment sensitivity

Regarding Hypothesis 1, that is, the decrease of dysfunctional strategies, we found a strong though nonsignificant trend towards an effect of treatment concerning the reduction of compulsions and a significant effect regarding avoidance behavior in patients' everyday lives. This result is noteworthy given the fact that participants were taught about the detrimental effects of compulsions and avoidance but not explicitly instructed to refrain from it. In spite of psychoeducation including information on the inefficacy of thought suppression, however, we did not find a pre to post reduction of suppression attempts. This, however, may be due to the fact that thought suppression is an ingrained behaviour difficult to refrain from within such limited time. The fact that there was no pre to post reduction concerning excessive action monitoring, however, did not come as a surprise for this behavior was not explicitly addressed during treatment. Interestingly, we did not find any differences between the two treatment conditions regarding these pre to post effects, which is in line with our results for the main outcome measure employed in the clinical trial, that is, the Y-BOCS (Rupp et al., 2019).

This also holds for the reduction of obsessions, that is, the other cardinal symptom of OCD, which was equally well achieved by both treatment conditions (Hypothesis 3). Also note that the regression model computed for Hypothesis 3 clearly proves the strong association between the frequency of obsessions and antecedent stress levels, with $Stress_{t-1}$ being the only significant predictor next to *Pre–Post*. Hence, this result confirms a well-established finding (e.g., Findley et al., 2003; Horowitz, 1975; Lin et al., 2007) by using a new approach, that is, the EMA method.

Contrary to our expectations, in neither treatment condition did we find evidence in favor of Hypothesis 2, that is, the reduction effect concerning unpleasant emotions. This, however, might indicate that, as proposed by all contemporary models of cognitive therapy, altering emotional states is a lengthy process requiring time and practice, for example, in terms of replacing dysfunctional thoughts with functional ones—which was not provided in our comparably short interventions.

Yet, we found confirming evidence for Hypothesis 4 as our results suggest that, in both treatment conditions, the association between the frequency of obsessions and the subjective burden experienced because of them was less intense after as compared with before treatment. This may be interpreted as reflecting one major effect of treatment, that is, experiencing less burden even in

the light of persisting obsessions, which may be traced back to the availability of new coping strategies concerning obsessions.

4.3 | Strengths

In sum, this is the first study that examined OCD symptoms using an EMA approach. Further, it is the first study in OCD research that used EMA as an outcome measure to study the treatment sensitivity of the EMA method. Notably, we were able to demonstrate treatment sensitivity regarding a reduction of subjective burden experienced as a consequence of obsessions—as well as a reduction of obsession frequency as such. Additionally, even though neither of the two treatment conditions directly targeted the reduction of dysfunctional behaviors, we also found a pre to post decrease of avoidance behavior and a trend towards a lower frequency of compulsions. Thus, we were able to add to previous research using diary methods as an outcome measure for OCD (e.g., Boersma et al., 1976; Foa et al., 1980), thereby addressing the call for more outcome data focusing on frequency of target behaviors (Mavissakalian & Barlow, 1981; Taylor, 1995).

Moreover, our results are in line with current OCD models (Rachman, 1997, 1998; Salkovskis, 1985, 1999; Wells, 2011) in terms of dysfunctional behaviors and OCD-related emotions. What adds to this is the fact that in all regression models except the one for *Suppression*, the covariate *Obsessions* turned out to be a significant predictor both of emotions and dysfunctional behaviors—which is exactly what those models imply with regard to the pathway that is triggered by obsessions and finally results in compulsions.

4.4 | Limitations

Due to reasons of practicability, the EMA questionnaire was limited in length, so that each construct could only be measured using very few items or even one single item. Especially with regards to stress, future research should address the different forms and facets of stress. Moreover, the generalizability of our Pre-Treatment EMA results is limited by the fact that we did not have control groups of mentally healthy participants or anxiety disorder patients to compare with our OCD sample concerning variables such as compulsions and avoidance. Future research should address this limitation in order to elucidate the differences that set an OCD sample apart from other clinical or mentally healthy samples.

Furthermore, although the postmonitoring questionnaire and the spaghetti plots did not raise any concerns regarding reactivity, our results concerning behaviors should be interpreted with care because certain reactivity effects cannot be fully ruled out. Future research might address this issue by adding a second baseline EMA period prior to treatment, so that a reactivity effect due to EMA itself can be separated from the actual treatment effect.

Also, our results are limited by the a priori assumption that compulsions and OCD-related behaviors are always preceded by obsessions, which is reflected in the skipping rules of the EMA programming. Whereas this decision was made on the basis of the theoretical models cited above and the fact that both treatment conditions focused on dealing with *obsessions*, this of course made it impossible to study emotions and behaviors occurring in the absence of clearly identifiable obsessions.

From a statistical point of view, another limitation concerns the fact that our regression models only examined means while neglecting measures of variability in the data. Therefore, even though the spaghetti plots did not yield any signs of autocorrelations, our analyses do not allow any final conclusions concerning the question to what extent the variability of emotions and behaviors changes as a result of treatment.

5 | CONCLUSIONS

This study adds to the existing research on OCD symptoms as it provides ecologically valid data confirming traditional models of OCD. Also, it is the first to implement EMA as an outcome measure for a clinical trial on OCD and, as such, was able to show that EMA is sensitive to treatment effects in OCD. Further research is needed to replicate and generalize our results.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

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