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Research paper

# Effect of self-monitoring through experience sampling on emotion differentiation in depression

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ABSTRACT

*Background:* Major depressive disorder has been linked to an inability to differentiate between negative emotions. The current study investigates whether emotion differentiation improves when individuals with major depressive disorder are required to report on specific emotions multiple times a day through the experience sampling method (ESM) – a structured self-report diary technique.
*Methods:* Seventy-nine patients diagnosed with major depressive disorder participated in this study, of whom 55 used ESM for 6 weeks (3 days a week, 10 times a day). Changes from baseline to post assessment in positive and negative emotion differentiation were compared between the participants who did and those who did not use ESM.
*Results:* Engaging in ESM related to an improvement in both positive and negative emotion differentiation, but only the latter reached statistical significance. The relationship between the number of ESM measurements (dose) and emotion differentiation change (response) was not significant.
*Limitations:* The sample size for the dose-response analysis was relatively small (N = 55). It is unknown whether emotion differentiation improvements generalize beyond the emotions (N = 12) we probed in this study. Other factors could also have contributed to the change (e.g., meetings with the researchers).
*Conclusions:* The present study suggests that patients with depression using ESM for 3 days a week for 6 weeks can improve their negative emotion differentiation. Future studies should assess after what period of ESM changes in emotion differentiation become apparent, and whether these changes are persistent and relate to actual improvement in depressive symptoms.

## 1. Introduction

People can experience a vast range of emotions and oftentimes even feel multiple emotions at the same time. As some of these emotions can be quite similar, it can sometimes be difficult to discriminate between them. The ability to make nuanced distinctions and differentiate between emotions is called emotion differentiation (e.g., Barrett et al., 2001). Emotions can influence cognitive processes, which then help to regulate and shape behaviours (Baumeister et al., 2007). Barrett et al. (2001) showed that participants who were better in differentiating their negative emotions more often employed adaptive emotion regulation strategies. This was especially the case when emotions were experienced at a higher intensity. Similarly, it has been found that people who differentiate their emotions better are less likely to use alcohol to cope with negative emotions (Kashdan et al., 2010) and respond to anger in a less aggressive way (Pond et al., 2012). This suggests that negative emotion differentiation can be linked to more adaptive emotion regulation, that is, people who are better in

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differentiating their emotions may be more likely to make use of this knowledge to fit their response to a specific situation.

The research mentioned above mainly focused on negative emotion differentiation, but there are also multiple positive emotions that can be differentiated. Boden et al. (2013) found that negative and positive emotion differentiation are positively correlated. The research on positive emotion differentiation in relation to emotion regulation styles is, however, not as conclusive. Although there is some evidence suggesting that better differentiation of positive emotions is linked to a more future-oriented and proactive coping style (Tugade et al., 2004), there are also studies that report no effect of greater positive differentiation on emotion regulation (Barrett et al., 2001; Pond et al., 2012).

If better emotion differentiation leads to more adaptive coping, impairments in emotion differentiation can be expected to be related to worse emotion regulation. Indeed, Edwards and Wupperman (2016) showed that low overall emotion differentiation was associated with poorer emotion regulation, which in turn has been associated with more psychopathology (Aldao et al., 2010). Impairments in emotion differentiation can be seen in many different psychopathologies such as schizophrenia (Kimhy et al., 2014), autism (Erbas et al., 2013), borderline personality disorder (Zaki et al., 2013), anorexia nervosa (Selby et al., 2014), and major depressive disorder (Demiralp et al., 2012).

Given the important role of emotions and emotion regulation in the onset and maintenance of depression, research into emotion differentiation in this disorder is highly relevant (Joormann and Vanderlind, 2014). Demiralp et al. (2012) asked patients with depression and healthy controls to rate four positive and seven negative emotions eight times a day for seven days. They showed that people with depression showed less negative emotion differentiation than the healthy controls.

Furthermore, it was found that in non-clinical samples less negative emotion differentiation was related to elevated levels of depressive symptoms (Erbas et al., 2014; Plonsker et al., 2016; Starr et al., 2017). Lennarz et al. (2017) found that more negative emotion differentiation was correlated with less intense negative emotions, but they did not find significant correlations between emotion differentiation and depressive symptoms. However, this may be due to the relatively low depressive symptoms in their sample of adolescents. There are few studies that look at positive emotion differentiation in depression. The study that did look into this found no difference in positive emotion differentiation between patients with depression and healthy controls (Demiralp et al., 2012).

The main technique used to measure emotion differentiation is the experience sampling method (ESM; Larson and Csikszentmihalyi, 1983). When using ESM people are asked to rate the intensity of different emotions at several time-points during the day (Kashdan et al., 2015). The intraclass correlations between the self-reported emotions over time are then used to estimate emotion differentiation; more specifically, if the temporal fluctuations between different emotions are highly correlated it can be assumed that the person sees them as the same emotion and does not differentiate well (e.g., Tugade et al., 2004). Many emotion differentiation studies used this procedure only for a couple of days without looking at changes in emotion differentiation over time. It can be reasoned, though, that being asked to rate different emotions for an extended period multiple times a day can help to differentiate between emotions, because people are directed to think about the intensity of separate emotions rather than negative or positive affect in general. Given the literature on negative emotion differentiation impairments, this could be especially beneficial for people suffering from depression. The present study will be the first to investigate the effect of an extended period of self-monitoring through ESM on emotion differentiation in depression.

The aim of the current study is to investigate the influence of self-monitoring through ESM on emotion differentiation in depression. It is hypothesized that participants suffering from depression who use ESM for six weeks will be better at differentiating negative emotions than participants with depression who do not use ESM during this period. A similar effect is expected regarding positive emotion differentiation. However, since depression has not been as clearly associated with an impairment in positive emotion differentiation, it is expected that this effect will be of a smaller size. Furthermore, it is expected that the effect of ESM on emotion differentiation will be proportional to the number of times participants complete the ESM reports (i.e., a dose-response relationship), which is a proxy for the time spent reflecting on specific emotions.

## 2. Methods

### 2.1. Participants

The sample comprised 79 patients with a diagnosis of major depressive disorder according to the Diagnostic and Statistical Manual of Mental Disorders (4th ed., text rev.; DSM-IV-TR; American Psychiatric Association, 2000). The sample was derived from a larger sample of outpatients (N = 102), who were recruited by Kramer et al. (2014) between January 2010 and February 2012 at mental health care institutions in the cities of Maastricht and Eindhoven and through advertisements in local media. Patients were included if they were between the ages of 18 to 65. Further inclusion criteria were: a total score of at least 8 on the Hamilton Depression Rating Scale – 17 (HDRS; Hamilton, 1960); treatment with antidepressants or mood stabilizers; sufficient knowledge of the Dutch language; and adequate vision. Patients who met the criteria for a current or lifetime diagnosis of non-affective psychotic disorder or reported a (hypo-) manic or mixed episode within the past month were excluded. All participants provided written informed consent before their enrolment. For the purpose of this study, only those participants who filled out the 5-day ESM assessment before and after the 6-week intervention period were included.

### 2.2. Procedure

The original study was approved by the Medical Ethics Committee of Maastricht University Medical Centre. Potential participants were called by a psychologist or psychiatrist to see whether they were eligible for inclusion in the study. If potentially eligible, they were invited for a full screening on site during which the HDRS and the Structural Clinical Interview for DSM-IV Axis I Disorders (SCID-I; First et al., 1995) were administered. Participants were randomly assigned to one of three conditions (i.e., an ESM group, an ESM-with-feedback group and a control group). See Fig. 1 for an overview of the three study conditions. Randomization was stratified based on current psychotherapy (yes or no) and duration of pharmacological treatment (shorter or longer than 8 weeks prior to study entry). A more detailed description of the full procedure of the trial can be found in the paper by Kramer et al. (2014).

All participants were invited to do a 5-day baseline ESM assessment (Fig. 1). During this time they were notified by a beep on a palmtop (i.e., PsyMate; Myin-Germeys et al., 2011) to fill in a short questionnaire 10 times a day at random intervals in 90-minute time blocks between 7:30 and 22:30. Participants were instructed to fill in the questionnaire as quickly as possible after the beep; after 10 minutes it was no longer possible to fill in the questionnaire. The ESM questionnaires contained questions about the participant's current context, stress appraisals of this context, and current mood by asking participants to rate positive and negative affect items.

After this baseline period, participants in the ESM-with-feedback group and ESM group received 10 ESM questionnaires a day on 3 consecutive days a week for 6 weeks (Fig. 1). The ESM-with-feedback group ( N = 25) received weekly ESM-derived feedback with a focus on positive affect in face-to-face sessions with the researcher. The first two feedback sessions focused on daily life-activities, the following two

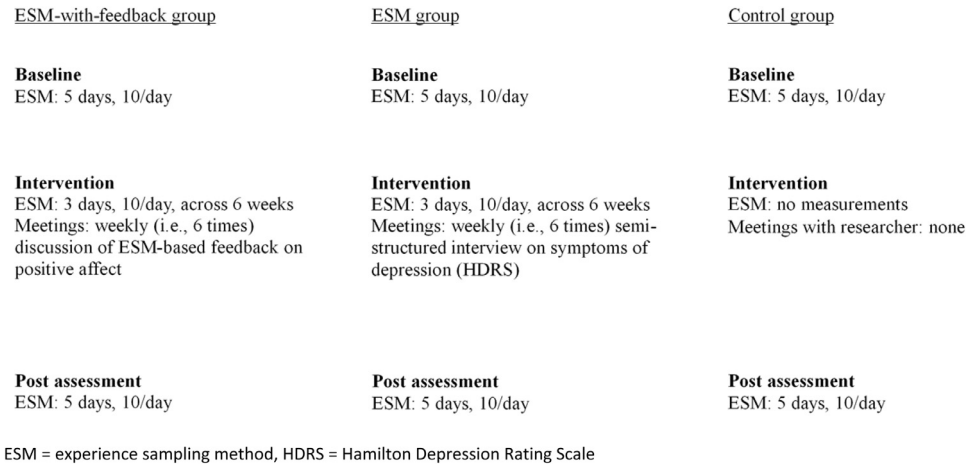


**Fig. 1.** Overview of study conditions.

sessions focused on daily life events and the way the patient dealt with these events, and the last two sessions concerned social interactions in daily life. The ESM group (N = 30) did not receive ESM-related feedback, but did have structured weekly contacts with the researcher during which the HDRS interview was repeated. In addition, there was a control group (N = 24), which did not participate in any ESM measurements during the 6-week intervention period. After this period, all participants were enrolled once again in a 5-day ESM period identical to the one at baseline (Fig. 1).[1]

The feedback received by the ESM-with-feedback group concerned overall negative and positive affect without differentiating between specific emotions. Therefore, it was not expected that the presence of feedback would influence emotion differentiation, and the ESM-with-feedback group and ESM group, who both engaged in ESM for 6 weeks, were combined into one ESM group for the main analyses.

### 2.3. Measures

We used participants' ratings on emotional adjectives during the 5-day baseline and post-assessment ESM periods to calculate emotion differentiation measures. Similar to previous studies (e.g., Demiralp et al., 2012; Lennarz et al., 2017), our set of emotional adjectives covered both the valence dimension (i.e., positive and negative) and arousal dimension of emotional experience (e.g., down and relaxed for low arousal, anxious and enthusiastic for high arousal).

#### 2.3.1. Negative emotion differentiation

During the 5-day baseline and post-assessment ESM period, participants were asked to describe their emotions by rating negative emotional adjectives (i.e., down, irritated, lonely, restless, agitated, suspicious, guilty and anxious) on a 7-point Likert scale (ranging from 0 = "*not at all*" to 7 = "*very*" ). All these adjectives except for "restless" and "agitated" were also included in the 6-week ESM period. Emotion differentiation variables were created by computing average intraclass correlation coefficients (ICC) with consistency of agreement between the emotion adjectives (e.g., Erbas et al., 2014). The ICC indicates how strongly (negative) emotions are correlated across time. Thus, a high ICC indicates low differentiation. In order to ease interpretation, ICC scores were subtracted from 1. In this way, higher values represent better emotion differentiation. In this study, two negative emotion differentiation variables were created for each participant: one for the baseline ESM period and one for the post-assessment ESM period.

#### 2.3.2. Positive emotion differentiation

The pre- and post-assessment positive emotion differentiation variables were created in the same way using the specific positive emotion adjectives (i.e., cheerful, satisfied, enthusiastic and relaxed). All these adjectives were also included in the 6-week ESM period.

### 2.4. Analysis

All the analyses were conducted in Stata 14. The emotion differentiation variables were created by computing the ICCs[2] using mixed-effect models based on consistency of agreement. The mixed effect model was chosen as this study treated the different emotions as fixed effects. In line with Erbas et al. (2014) the ICC measuring consistency of agreement was used as only the correlations among emotions were of interest. Then, the ICCs were normalized by a Fisher's Z transformation (e.g., Boden et al., 2013). Finally, the ICCs were subtracted from 1 for ease of interpretation. In this manner, four final emotion differentiation variables were created for each participant: a negative and a positive emotion differentiation score for both the baseline ESM period and the post-assessment ESM period.

First, the influence of ESM on emotion differentiation while taking into account emotion differentiation differences at baseline was investigated. In a randomized controlled study such as ours, including the baseline measure as a covariate has more power to detect a difference between two groups from baseline to post assessment than an analysis of variance of change (Van Breukelen, 2006). Therefore, two separate hierarchical regressions (for both negative and positive emotion differentiation) with emotion differentiation at post assessment as dependent variable were conducted. Baseline emotion differentiation was added to the model, followed by the variable Group (ESM or control) in order to analyse the influence of having had 6 weeks of ESM on the dependent variable.

Second, the dose-response relationship between the number of ESM questionnaires that were filled in during the 6-week ESM period and (change in) emotion differentiation at post assessment was investigated. To this end, two hierarchical regressions were conducted within the ESM group (for both negative and positive emotion differentiation). These models included emotion differentiation at post-test as the dependent variable, and emotion differentiation at baseline and the number of filled in questionnaires as predictors.

For all analyses, the assumptions of a hierarchical multiple

[1] There were some small deviations in the number of days people engaged in the ESM baseline and ESM post assessment ($M$ = 5.64, $SD$ = 1.24).

[2] In line with previous research, negative intraclass correlation coefficients were set to zero (e.g., Boden et al., 2013). The interpretation of the results did not change when the participants with a negative intraclass correlation coefficient (N = 11) were completely removed from analysis.

**Table 1**
Baseline sample characteristics.

| Characteristics | ESM $n = 55$ | Control $n = 24$ | Test $F$ | $z$ | $p$ |
|---|---|---|---|---|---|
| Age [*M* (*SD*)] | 48.13 (9.91) | 50.33 (10.56) | | | |
| Sex, (female, %) | 52.17 | 54.17 | | | |
| Negative emotions [*M* (*SD*)] | | | | | |
| Lonely | 2.60 (1.75) | 2.37 (1.59) | | 0.68 | .496 |
| Down | 2.86 (1.64) | 3.08 (1.67) | | −0.78 | .435 |
| Irritated | 2.69 (1.79) | 2.81 (1.72) | | −0.28 | .776 |
| Anxious | 1.97 (1.52) | 1.89 (1.32) | | 0.51 | .610 |
| Suspicious | 2.00 (1.44) | 2.15 (1.41) | | −0.45 | .650 |
| Guilty | 2.14 (1.57) | 2.34 (1.53) | | −0.38 | .706 |
| Restless | 3.37 (1.84) | 3.55 (1.84) | | −0.61 | .542 |
| Agitated | 3.03 (1.97) | 3.14 (1.84) | | −0.29 | .771 |
| Positive emotions [*M* (*SD*)] | | | | | |
| Relaxed | 4.06 (1.60) | 3.94 (1.43) | | 0.70 | .481 |
| Satisfied | 3.67 (1.50) | 3.48 (1.28) | | 0.90 | .366 |
| Enthusiastic | 2.91 (1.54) | 2.74 (1.33) | | 0.76 | .447 |
| Cheerful | 3.14 (1.56) | 2.88 (1.30) | | 1.07 | .284 |
| Negative ED [*M* (*SD*)] | 0.17 (0.37) | 0.04 (0.27) | 2.22 | | .141 |
| Positive ED [*M* (*SD*)] | 0.12 (0.35) | 0.06 (0.36) | 0.47 | | .496 |

*Note.* ED = emotion differentiation.

regression (i.e., normality, linearity, homoscedasticity and no multicollinearity) were not violated.

## 3. Results

### 3.1. Sample characteristics

The baseline sample characteristics are reported in Table 1. There were no significant group differences in terms of mean levels of the affect items and positive and negative emotion differentiation ICCs.

### 3.2. The effect of ESM on negative emotion differentiation

To test the hypothesis that the ESM group would show an increase in negative emotion differentiation from pre- to post-assessment in comparison with the control group, a hierarchical multiple regression was conducted. In the first step, negative emotion differentiation at baseline was found to be a significant predictor of post-assessment negative emotion differentiation, $F$ (1, 77) = 8.47, $p$ = .005. This model accounted for 9.9% of the variation in the dependent variable. When Group was added in the second step, this model was significant and explained an additional 6.7% of the variation in negative emotion differentiation at post assessment, $F$ (1, 76) = 6.14, $p$ = .015. See Table 2 for the regression statistics. A post-hoc paired samples $t$-test was conducted to compare negative emotion differentiation within the ESM group between baseline ($M$ = 0.17, $SD$ = 0.37) and post assessment ($M$ = 0.37, $SD$ = 0.43), and showed that the ESM group improved significantly in their ability to differentiate their negative emotions, $t$ (54) = −3.17, $p$ = .003, $d$ = 0.43, 95% CI [−0.33, −0.07], whereas the control group did not, $t$ (23) = −0.41, $p$ = .683, $d$ = 0.08, 95% CI [−0.22, 0.14]. See Fig. 2 for a graphic representation.

The present study combined the ESM-with-feedback and ESM groups of the original study into one ESM group, because both involved 6 weeks of ESM and it was not expected that the general feedback in the experimental condition would additionally influence emotion differentiation. To verify this assumption, a post-hoc hierarchical multiple regression was conducted with negative emotion differentiation at post-test as dependent variable, baseline negative emotion differentiation as predictor in the first model, and group (ESM-with-feedback group versus ESM group) as an additional predictor in the second model, and no significant group difference, $F$ (1, 52) = 0.00, $p$ = .963 was found.

**Table 2**
Hierarchical multiple regression analyses predicting post-assessment negative and positive emotion differentiation from baseline positive and negative emotion differentiation, group status and number of beeps.

| Predictor | *B* | *t* | *p* | 95% CI |
|---|---|---|---|---|
| **Model 1** | | | | |
| Step 1 | | | | |
| Baseline negative differentiation | 0.40 | 2.91 | .005 | [0.13, 0.67] |
| Step 2 | | | | |
| Baseline negative differentiation | 0.34 | 2.55 | .013 | [0.08, 0.61] |
| Group | 0.25 | 2.48 | .015 | [0.05, 0.45] |
| **Model 2** | | | | |
| Step 1 | | | | |
| Baseline positive differentiation | 0.44 | 3.87 | <.001 | [0.21, 0.67] |
| Step 2 | | | | |
| Baseline positive differentiation | 0.43 | 3.78 | <.001 | [0.20, 0.65] |
| Group | 0.16 | 1.84 | .069 | [−0.01, 0.33] |
| **Model 3** | | | | |
| Step 1 | | | | |
| Baseline negative differentiation | 0.34 | 2.24 | .029 | [0.04, 0.64] |
| Step 2 | | | | |
| Baseline negative differentiation | 0.27 | 1.76 | .084 | [−0.04, 0.58] |
| Beeps | 0.00 | 1.59 | .117 | [0.00, 0.10] |
| **Model 4** | | | | |
| Step 1 | | | | |
| Baseline positive differentiation | 0.33 | 2.20 | .032 | [0.03, 0.63] |
| Step 2 | | | | |
| Baseline positive differentiation | 0.33 | 2.12 | .039 | [0.02, 0.63] |
| Beeps | 0.00 | 0.25 | .801 | [0.00, 0.01] |

*Note.* CI = confidence interval.

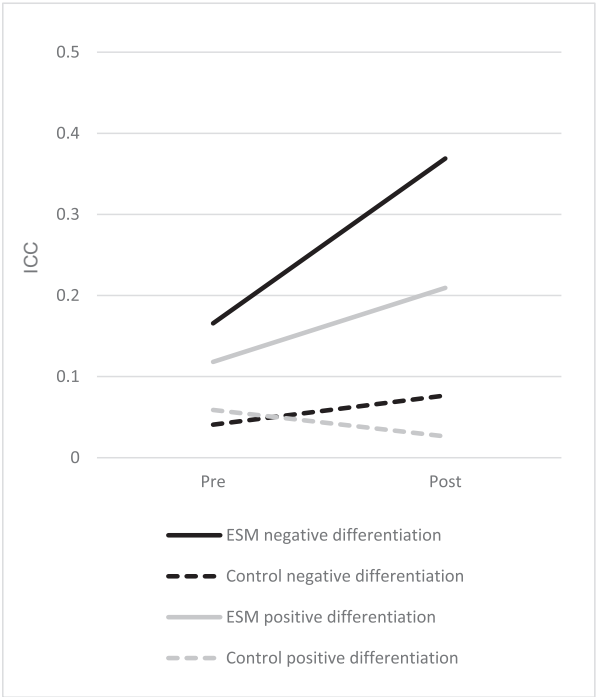


**Fig. 2.** Emotion differentiation change from pre- to post-assessment.
Note. ESM = experience sampling method, ICC = intraclass correlation

### 3.3. The effect of ESM on positive emotion differentiation

When this procedure was repeated for positive emotion differentiation (see Table 2), the first step in which positive emotion differentiation at baseline was added was significant, $F$ (1, 77) = 14.98, $p$ < .001, explaining 16.3% of the variation in positive emotion differentiation at post assessment, adding the group variable in the second step lead to 3.6% more explained variation but this was not a significant improvement in prediction, $F$ (1, 76) = 3.40, $p$ = .069. The ESM group

did show some (non-significant) improvement in positive emotion differentiation, $t$ (54) = −1.52, $p$ = .136, $d$ = 0.20, 95% CI [−0.21, 0.03]. The control group did not significantly improve from pre to post-test, $t$ (23) = 0.60, $p$ = .558, $d$ = 0.12, 95% CI [−0.08, 0.15]. See Fig. 2 for a graphic representation.

Similar to the results for negative emotion differentiation, a post-hoc hierarchical multiple regression including group as a second predictor in addition to baseline emotion differentiation, showed that there was no significant difference between the ESM-with-feedback group and ESM group, $F$ (1, 52) = 0.27, $p$ = .603.

### 3.4. The effect of number of filled in questionnaires on negative emotion differentiation

On average, participants in the ESM group responded to 149.76 beeps ($SD$ = 21.33) ranging from 87 to 224. To investigate whether there was a (positive) relationship between the number of filled in questionnaires (beeps) on emotion differentiation within the ESM group, another hierarchical multiple regression analysis (Table 2) was conducted. Baseline negative emotion differentiation predicted post-assessment negative emotion differentiation, $F$ (1, 53) = 5.03, $p$ = .029. This model could explain 8.7% of the variation in the dependent variable. Adding the number of filled in questionnaires as a second predictor did not significantly increase the explained variance, $\Delta R^2$ = 0.04, $F$ (1, 52) = 2.54, $p$ = .117.

### 3.5. The effect of number of filled in questionnaires on positive emotion differentiation

To see if positive emotion differentiation at post assessment was influenced by the number of filled in questionnaires, a fourth hierarchical multiple regression analysis was conducted (Table 2). The first step in which baseline positive emotion differentiation was added was significant, $F$ (53, 1) = 4.86, $p$ = .032, and explained 8.4% of the variance. When the number of filled in questionnaires was introduced in the second step, there was no significant change in the percentage of explained variance, $\Delta R^2$ = 0.00, $F$ (1, 52) = 0.06, $p$ = .801.

## 4. Discussion

The aim of the present study was to investigate whether partaking in ESM measurements, which involves repeatedly thinking about and reporting on distinct emotional states, influences emotion differentiation in individuals with depression. The results of the study confirm the hypothesis that individuals suffering from depression who fill in ESM questionnaires 3 days a week for 6 consecutive weeks improve in their ability to differentiate between their negative emotions in comparison to a control group not partaking in a prolonged period of ESM measurements. The study also shows a similar effect for positive emotion differentiation, but this effect did not reach statistical significance. The study did not find evidence for a dose-response relationship between the number of filled in ESM questionnaires and improvement in positive or negative emotion differentiation.

This is the first study to suggest that self-monitoring of different specific negative emotions with ESM can help to improve negative emotion differentiation in patients suffering from depression. Recently, research into using ESM as an intervention method has been accumulating (Myin-Germeys et al., 2016). Improving negative emotion differentiation skills by frequently filling in questionnaires might be one of the mechanisms through which ESM could ameliorate depressive symptoms. It is known that patients with depression have a deficit in their negative emotion differentiation skills in comparison to healthy controls (Demiralp et al., 2012). Furthermore, it has been suggested that better negative emotion differentiation can be linked to more adaptive emotion regulation (Barrett et al., 2001), which, in turn has been linked to recovery of depression (Arditte and Joormann, 2011). It could thus be the case that the improvement in negative emotion differentiation found in this study enables individuals suffering from depression to better attribute their negative emotions to a specific situation and with that provide them with the means to pick the best emotion regulation strategy. Further research is needed to indicate what part of the ESM period triggered the change in emotion differentiation and whether the improvement in negative emotion differentiation can be linked to improvement of depressive symptoms and if ESM could thus be an effective intervention for depression.

In the present study, patients with depression filling in ESM 3 days a week for 6 weeks improved in positive emotion differentiation when compared to the control group, but this effect was small and not significant. The smaller effect of continuously monitoring emotions on positive emotion differentiation compared to negative emotion differentiation was in line with the hypotheses. Based on the findings by Demiralp et al. (2012) that positive emotion differentiation did not differ between individuals suffering from depression and healthy controls, this could be due to less room for improvement in positive differentiation in depression. Alternatively, given that there were more negative (N = 8) than positive (N = 4) affect items in the ESM measurements, the present study might have enabled participants to train negative emotion differentiation more. All things considered, it cannot be discarded that focusing on positive emotions multiple times a day might have an effect on emotion differentiation. However, given the meagre evidence linking positive emotion differentiation to better emotion regulation (e.g., Barrett et al., 2001), a focus on negative emotions seems most suited when considering using ESM as an emotion differentiation intervention.

Although the present study found that patients with depression who filled in ESM measurements for 6 weeks showed a small improvement in (negative) emotion differentiation, no statistical evidence was found for a dose-response relationship with the actual number of filled in ESM measurements. However, this result should be interpreted with caution. There might not have been sufficient variance in the number of filled in ESM questionnaires across the ESM group to be able to detect a dose-response relationship; all participants filled out at least 87 measurements with a median of 151 measurements. Possibly, thinking about specific emotions for 87 times is already sufficient to improve emotion differentiation with only a very small additional effect of filling in more measurements beyond that point. The sample size of the ESM group (N = 55) might not have been sufficiently large to detect such a small effect. Future studies should use a larger sample size to determine whether there is a dose-response relationship between filled in ESM measurements and change in emotion differentiation, and to investigate at what point a change in emotion differentiation becomes apparent.

Although the results of this study could indicate that it is possible to train negative emotion differentiation with ESM, it is important to consider some alternative explanations as well. One of the things that should be considered is that apart from filling in ESM questionnaires for 6 weeks another difference between the ESM group and the control group were the weekly meetings with the researcher. These meetings could have enhanced participants' attention to their emotional states. However, specific emotions and emotion differentiation were neither the focus of the weekly meetings in the ESM group nor the ESM-with-feedback group. It seems unlikely that HDRS interviews (ESM group) and feedback on general positive affect (ESM-with-feedback group) could explain the changes we found in the differentiation of negative emotions. That said, the design of our study does not allow drawing firm conclusions on which part of the ESM-intervention caused the change in emotion differentiation.

Another thing that should be considered is that the intervention was directed at reducing emotional intensity, and that may have influenced results. Likewise, changes in depression could have potentially mediated results, given depression's established relationships with negative emotion differentiation (e.g., Demiralp et al., 2012). However, in our study changes in emotional intensity or depression were not related to

negative or positive emotion differentiation. Moreover, the results for the effect of prolonged ESM on differentiation remained the same when changes in emotional intensity cq. depression were taken into account (see Supplement 1).

The present study has some other limitations as well. One of them being that even though it can be reasoned that the participants in this study trained negative emotion differentiation as a skill, it is not certain that improvement in negative emotion differentiation can be generalized beyond the eight adjectives used in this study. It should be noted, however, that the affect items that were measured are the ones often used in ESM research. Furthermore, it is important that an ESM questionnaire does not contain too many items. Another limitation is the sample size of this study, which may not have been large enough to detect some effects, particularly the dose-response relationships, which may have been underpowered due to the size of the ESM group (N = 55).

Further research is needed to investigate whether the effect of filling in ESM questionnaires on negative emotion differentiation improvement is large enough to cause a clinically relevant improvement in depressive symptoms. In the present study, this could not be tested as the most substantial improvements in depressive symptoms in the sample occurred after post assessment (Kramer et al., 2014), when there were no more ESM measurements to be able to determine whether improvements in emotion differentiation were sustained. Future studies should follow an ESM and a control group (not enrolled in prolonged ESM-measurements) as was done in the present study but with additional brief ESM periods and emotion regulation questionnaires at the follow-up measurements to investigate whether the change in negative emotion differentiation sustains over time and can be linked to better emotion regulation strategies and improvements in depression. In sum, further research is needed to address stability of emotion differentiation, persistence of changes in emotion differentiation and how changes in emotion differentiation relate to follow-up behaviours or outcomes. Future research should also examine whether patients themselves report on change in emotion differentiation and to what elements of the ESM intervention they attribute this change, for instance through interviews with patients after the ESM period. More insight into the patient perspective on the ESM intervention would be very valuable, because it could contribute to a better understanding of what mechanisms might underlie changes in emotion differentiation and depression outcomes (Bastiaansen et al., 2018).

The results of this study also indicate that when used for an extended period of time, the use of ESM to study emotion differentiation can have an effect on emotion differentiation. This could have implications for all studies using ESM as a measurement tool. The phenomenon that merely filling in measurements such as ESM questionnaires can have an effect on the actual responses that are being recorded is called measurement reactivity. It is recognized that measurement reactivity in ESM is an important phenomenon that demands attention (Myin-Germeys et al., 2018), and the results of the present research give more insight into measurement reactivity. Reactivity can be reduced by decreasing an individual's continuous self-awareness. This can be achieved by randomizing the time-sampling procedure and using non-intrusive devices (Delespaul, 1995). Conversely, when using ESM to modify behaviours, for example to train emotion differentiation, reactivity might be of use, and the ESM procedure should be adapted accordingly.

In sum, the present study suggests that patients with depression using ESM 3 days a week for 6 weeks can improve their negative emotion differentiation. In light of the recent attention to ESM as an intervention, the results of the present study are promising and give more insight into a possible mechanism through which ESM can ameliorate depressive symptoms. More research is needed, to replicate these results and see what part of the prolonged ESM period caused the change in negative emotion differentiation. Furthermore, future studies should investigate if the improvement in negative emotion differentiation is actually accompanied by a decrease in depressive symptoms and an increase in the use of adaptive emotion regulation strategies. Furthermore, the results of this study indicate that measurement reactivity is important to consider when ESM is used for an extended period of time.

## Conflict of interest

None.

## Author statement

Contributors

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Co-designed the study, managed the literature searches, undertook the statistical analysis, and wrote the first draft of the manuscript.

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## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jad.2018.10.092.

## References

Aldao, A., Nolen-Hoeksema, S., Schweizer, S., 2010. Emotion-regulation strategies across psychopathology: a meta-analytic review. *Clin. Psychol. Rev.* 30, 217–237.

American Psychiatric Association, 2000. Diagnostic and statistical manual of mental disorders, 4th ed. Washington, DC: Author , *text rev.*.

Arditte, K.A., Joormann, J., 2011. Emotion regulation in depression: reflection predicts recovery from a major depressive episode. *Cogni. Ther. Res.* 35, 536–543.

Barrett, L.F., Gross, J., Christensen, T.C., Benvenuto, M., 2001. Knowing what you're feeling and knowing what to do about it: mapping the relation between emotion differentiation and emotion regulation. *Cognit. Emotion* 15, 713–724.

Bastiaansen, J., Meurs, M., Stelwagen, R., Wunderink, L., Schoevers, R.A., Wichers, M., Oldehinkel, A., 2018. Self-monitoring and personalized feedback based on the experiencing sampling method as a tool to boost depression treatment: a protocol of a

pragmatic randomized controlled trial (ZELF-i). BMC Psychiatry 18 (276).
Baumeister, R.F., Vohs, K.D., DeWall, C.N., Zhang, L., 2007. How emotion shapes behavior: Feedback, anticipation, and reflection, rather than direct causation. *Personality Social Psychol. Rev.* 11, 167–203.
Boden, M.T., Thompson, R.J., Dizén, M., Berenbaum, H., Baker, J.P., 2013. Are emotional clarity and emotion differentiation related? *Cognit. Emotion* 27, 961–978.
Delespaul, P., 1995. Assessing Schizophrenia in Daily Life: The experience Sampling Method. Maastricht University Press, Maastricht, the Netherlands.
Demiralp, E., Thompson, R.J., Mata, J., Jaeggi, S.M., Buschkuehl, M., Barrett, L.F., . . ., Deldin, P.J., 2012. Feeling blue or turquoise? Emotional differentiation in major depressive disorder. *Psychol. Sci.* 23, 1410–1416.
Edwards, E.R., Wupperman, P., 2016. Emotion regulation mediates effects of alexithymia and emotion differentiation on impulsive aggressive behavior. *Deviant Behav.* 1–12.
Erbas, Y., Ceulemans, E., Boonen, J., Noens, I., Kuppens, P., 2013. Emotion differentiation in autism spectrum disorder. *Res. Autism Spectr. Disord.* 7, 1221–1227.
Erbas, Y., Ceulemans, E., Lee Pe, M., Koval, P., Kuppens, P., 2014. Negative emotion differentiation: Its personality and well-being correlates and a comparison of different assessment methods. *Cognit. Emotion* 28, 1196–1213.
First, M.B., Spitzer, R.L., Gibbon, M., Williams, J.B., 1995. Structured Clinical Interview for DSM-IV Axis I Disorders. New York State Psychiatric Institute, New York.
Hamilton, M., 1960. A rating scale for depression. *J. Neurol. Neurosurg. Psychiatry* 23, 56–62.
Joormann, J., Vanderlind, W.M., 2014. Emotion regulation in depression the role of biased cognition and reduced cognitive control. *Clin. Psychol. Sci.* 2, 402–421.
Kashdan, T.B., Barrett, L.F., McKnight, P.E., 2015. Unpacking emotion differentiation transforming unpleasant experience by perceiving distinctions in negativity. *Curr. Directions Psychol. Sci.* 24, 10–16.
Kashdan, T.B., Ferssizidis, P., Collins, R.L., Muraven, M., 2010. Emotion differentiation as resilience against excessive alcohol use an ecological momentary assessment in underage social drinkers. *Psychol. Sci.* 21, 1341–1347.
Kimhy, D., Vakhrusheva, J., Khan, S., Chang, R.W., Hansen, M.C., Ballon, J.S., . . ., Gross, J.J., 2014. Emotional granularity and social functioning in individuals with schizophrenia: an experience sampling study. *J. Psychiatr. Res.* 53, 141–148.
Kramer, I., Simons, C.J., Hartmann, J.A., Menne-Lothmann, C., Viechtbauer, W., Peeters, F., . . ., Delespaul, P., 2014. A therapeutic application of the experience sampling method in the treatment of depression: a randomized controlled trial. World Psychiatry 13, 68–77.
Larson, R., Csikszentmihalyi, M., 1983. "The experience sampling method". *New Directions Methodol. Social Behav. Sci.* 15, 41–56.
Lennarz, H.K., Lichtwarck-Aschoff, A., Timmerman, M.E., Granic, I., 2017. Emotion differentiation and its relation with emotional well-being in adolescents. *Cognit. Emotion* 1–7.
Myin-Germeys, I., Birchwood, M., Kwapil, T., 2011. From environment to therapy in psychosis: a real-world momentary assessment approach. *Schizophr. Bull.* 37, 244–247.
Myin-Germeys, I., Kasanova, Z., Vaessen, T., Vachon, H., Kirtley, O., Viechtbauer, W., Reininghaus, U., 2018. Experience sampling methodology in mental health research: new insights and technical developments. World Psychiatry 17, 123–132.
Myin-Germeys, I., Klippel, A., Steinhart, H., Reininghaus, U., 2016. Ecological momentary interventions in psychiatry. *Curr. Opin. Psychiatry* 29, 258–263.
Plonsker, R., Gavish Biran, D., Zvielli, A., Bernstein, A., 2016. Cognitive fusion and emotion differentiation: does getting entangled with our thoughts dysregulate the generation, experience and regulation of emotion. *Cognit. Emotion* 31, 1–8.
Pond, R.S., Kashdan, T.B., DeWall, C.N., Savostyanova, A., Lambert, N.M., Fincham, F.D., 2012. Emotion differentiation moderates aggressive tendencies in angry people: a daily diary analysis. Emotion 12, 326–337.
Selby, E.A., Wonderlich, S.A., Crosby, R.D., Engel, S.G., Panza, E., Mitchell, J.E., . . ., Le Grange, D., 2014. Nothing tastes as good as thin feels: Low positive emotion differentiation and weight-loss activities in anorexia nervosa. *Clin. Psychol. Sci.* 2, 514–531.
Starr, L.R., Hershenberg, R., Li, Y.I., Shaw, Z.A., 2017. When feelings lack precision: low positive and negative emotion differentiation and depressive symptoms in daily life. *Clin. Psychol. Sci.* 5, 613–631.
StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP.
Tugade, M.M., Fredrickson, B.L., Feldman Barrett, L., 2004. Psychological resilience and positive emotional granularity: examining the benefits of positive emotions on coping and health. *J. Personality* 72, 1161–1190.
Van Breukelen, G.J., 2006. ANCOVA versus change from baseline had more power in randomized studies and more bias in nonrandomized studies. *J. Clin. Epidemiol.* 59, 920–925.
Zaki, L.F., Coifman, K.G., Rafaeli, E., Berenson, K.R., Downey, G., 2013. Emotion differentiation as a protective factor against nonsuicidal self-injury in borderline personality disorder. *Behav. Therapy* 44, 529–540.