



Insights from an expressive writing intervention on Facebook to help alleviate depressive symptoms



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ARTICLE INFO

Article history:

Received 18 February 2016

Received in revised form

12 April 2016

Accepted 19 April 2016

Keywords:

Facebook

Depression

Expressive writing

Sentiment analysis

Web application

ABSTRACT

Depression is one of the most common mental disorders. Studies have shown that various online social network (OSN) activities can be used as a marker for people's moods as well as symptoms of sub-syndromal depression, suggesting possibilities for online-based interventions. This study investigates one such potential by developing an expressive writing application within Facebook and by investigating how the designed intervention as well as various online social network activities contribute to improving one's emotional state. Experimental data show that negative emotional words and cognitive words in online expressive writing are the two most important factors in alleviating depressive symptoms. Furthermore, participants who have had previous experience expressing emotions in OSNs reported the greatest reduction in depressive symptoms. Our findings have implications that can assist in designing personalized online intervention platforms and for sophisticated writing therapy to maximize the effect of expressive writing.

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1. Introduction

Depression is a serious mental illness with a high prevalence. The one-year prevalence of major depressive disorder (MDD) is 5.3% and the lifetime prevalence is 13.3% (Kessing, 2007). Beyond the MDD patients, a portion of the general population also suffers from clinically relevant depression although they do not meet all the criteria of MDD—a case that is called subsyndromal depression (SSD) (Pan et al., 2011). Previous studies found that 7–12% of the general adult population have SSD and these people are 4.4 times more prone to developing MDD than those without SSD (Cuijpers &

Smit, 2004; Pietrzak et al., 2013).

Although SSD has a high prevalence rate and a considerable rate of morbidity (Horwath, Johnson, Klerman, & Weissman, 1994), symptoms of SSD are often unrecognized in the clinical field (Trudgen & Lawn, 2011; van Zoonen et al., 2015) and lack attention from people around patients (Trudgen & Lawn, 2011). Therefore, developing a method that can identify and intervene in sub-syndromal symptoms can have a large impact. Several recent studies have tried to find ways to intervene in people with sub-syndromal depressive symptoms through online media. One study reviewed the effects of Internet-based interventions for children, youth, and young adults with depression, where the effects of online-based platforms were similar to their offline counterpart (i.e., face-to-face interventions) on depressive symptoms (Ye et al., 2014). Another study verified the positive effects of cheer-up messages via mobile devices on enlightening subjects' emotional status (Whittaker et al., 2012). However, previous studies did not consider whether factors such as characteristics of individuals such as activities in their daily life determine the possible effect of intervention. Therefore, a more delicate design for an intervention

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experiment is needed to discern the various characteristics of participants.

As online social networks (OSN) have become a major communication platform, many people are using OSNs to express their thoughts and identities by uploading contents or logging behaviors (De Choudhury, Counts, Horvitz, & Hoff, 2014; Kosinski, Stillwell, & Graepel, 2013). Looking at the contents in OSNs may help researchers identify key features of SSD in the circumstance of social interaction (Baikie, Geerligs, & Wilhelm, 2012; Bradley & Lang, 1994; Lange, Van De Ven, Schrieken, Bredeweg, & Emmelkamp, 2000). For instance, popular networks like Facebook and Twitter and the data within these sites can bring novel opportunities that can help discover and track the mood changes in subjects with SSD. In addition, online intervention tools such as expressive writing have been developed to alleviate psychiatric symptoms. Expressive writing is a method that encourages writing about impressive experiences and feelings from key personal events. One study found that expressive writing decreases trauma-related symptoms as well as psychological functioning among post-traumatic stress disorder (PTSD) patients (Lange et al., 2000), and another study showed that expressive writing also benefits relieving depression and anxiety in patients with mood disorders (Baikie et al., 2012). In order to seize this novel opportunity through online intervention, we developed a non-clinical online application that is targeted at SSD subjects to help them improve their emotions. The application was connected to the Facebook Application Programming Interface (API) that can monitor Facebook activities and allowed us to follow each participant's footprints via his or her logged history of Facebook usage. The application also provided a set of web interfaces for expressive writing.

In our study, we tried to investigate the benefits of online expressive writing in connection with symptoms of depression, quantify which writing guidelines maximize benefits, as well as understand the modulating effects of factors related to previous Facebook activities (such as wall posts and the number of friends) on the designed intervention.

2. Materials and methods

2.1. EmotionDiary

We designed a web-based Facebook application called an EmotionDiary to conduct the experiment. We constructed two versions of the EmotionDiary: a PC version and a mobile version that allowed participants to participate in the experiment at their convenient times. For participants who gave us a written consent, the EmotionDiary application collected various activity data for those participants on Facebook.

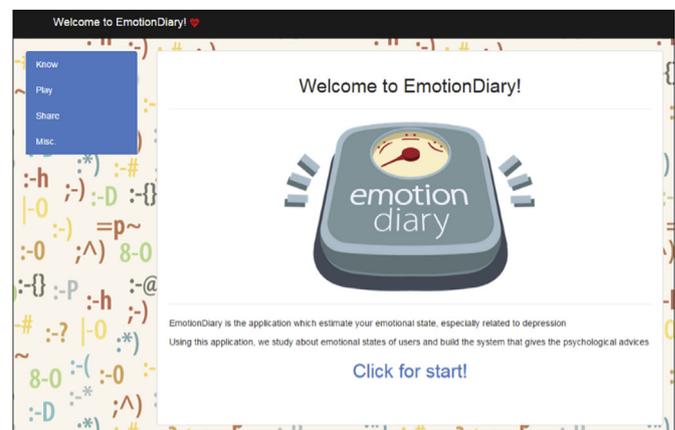
Through the EmotionDiary, participants recorded their overall emotional state on a daily basis. The app consists of four main web pages. On the first and second pages, participants can choose the general mood of the day and indicate the intensity of the chosen mood by clicking on the Self-Assessment Manikins (SAM) that is a pictorial rating system to acquire self-assessments of experienced emotions (Bradley & Lang, 1994). SAM is a standardized method and provides an easy way to measure the valence and intensity of subjects' mood regardless of age, education level, and cultural background (Bradley & Lang, 1994). Checking the valence and intensity of mood of the day is equivalent to an activity of emotional recognition, which acts as a preparatory stage for expressive writing. On the third page, participants engaged in expressive writing, which is the main focus of this study. This stage was carefully designed to guide participants to experience a train of thought on recognition, expression, and reappraisal of emotion, by asking the following three questions:

- "Please write about today's event that mainly affected your mood"
- "Please write about your feelings related to the event you mentioned"
- "Are there any words (e.g., compliment, encouragement, enlightenment) that you'd like to tell yourself? Please write freely"

Guided by these questions, participants wrote about an event that largely affected their emotion (a step for *recognition*), any emotion related to the event (a step for *expression*), and any emotional words that can be helpful for themselves (a step for *reappraisal*). In the final web page, participants were asked how much they were affected by the experience they wrote about and how well they perceived their emotional state by moving the heads of the slide bar. Screen snapshots on the main menu of the EmotionDiary app and its page for engaging in expressive writing are shown in Fig. 1. All interactions within the EmotionDiary app were recorded and stored in a database for later analysis, including the timestamp of each button click as well as the daily logs.

2.2. Recruitment and selection of participants

This study was conducted at a large university in South Korea and participants consisted of undergraduate and graduate students.



(a)

Please answer below questions

1. Please write about today's event that mainly affected on you
2. Please write about your feelings related to above event
3. You wrote your today's experience and feelings. If you have any words (compliment, encouragement, enlightenment, etc.) to tell yourself, please write freely.

(b)

Fig. 1. (a) Snapshot of the main menu of EmotionDiary. (b) Snapshot of EmotionDiary asking participants to write about events that most affected them that day, related feelings, and any words that can encourage themselves.

A total of 264 students initially applied to participate in our experiment. We selectively admitted a subset of applicants in order to reach potential SSD subjects by excluding both non-depressed and severely-depressed applicants through a pre-screening test. All applicants were asked to submit information about their self-reported Facebook usage, a self-reported 11-point Likert Scale on depression (0–10, 10 represents extremely depressed), the Beck Depression Inventory (BDI) (Erbauch, 1961), and the State-Trait Anxiety Inventory (STAI) (Spielberger, 1970). Through this screening process, 71 out of 264 participants who reported a scale between 8 and 23 in their BDI score (i.e., indicating users that have a moderate level of depression) and who used Facebook at least 20 min a day (i.e., guaranteeing positive data to examine) were chosen.

Two orientation meetings were held prior to the launch of the intervention. Participants were given a consent form to indicate their willingness to share their log data throughout the experiment and they were carefully told about the expressive writing guidelines and the reward policy. The entire intervention study was conducted following measures approved by the Internal Review Board (IRB) at the authors' institution (KH2013-03). While we asked all participants to attend at least one orientation meeting, three participants did not attend any and hence were not included in the experiment. This leaves us with 68 participants who have a moderate level of depression. A majority of them (41 out of 68) were males aged between 20 and 33 (mean = 24.5 ± 3.9), and the remaining 27 were females aged between 19 and 33 (mean = 24.33 ± 3.23). Two thirds of the participants were randomly chosen to be assigned to an experimental group and the rest to a control group, resulting in 45 participants in the experimental group (28 males and 17 females) and 23 participants in the control group (13 males and 10 females).

2.3. Experiment procedure

Participants took part in the daily writing tasks for two consecutive weeks except on weekends. All participants were asked to answer a series of questionnaires to measure their depression level twice: (1) prior to the launch of the experiment and (2) immediately following the final experiment. The questionnaires included the Center for Epidemiological Studies–Depression Scale (CES-D) (Radloff, 1977), the Resilience Appraisal Scale (RAS) (Johnson, Gooding, Wood, & Tarrier, 2010), as well as an 11-point Likert Scale measuring the degree of awareness, understanding, and dealings of one's own emotion. These surveys were conducted through the EmotionDiary app.

During two weeks of experiments, both participants in the experimental and control groups had to evaluate their emotions and perceptions of emotional status each day through the first, second, and last web pages within the EmotionDiary app. The only difference is found in the design of the third web page. Here, the experimental group was asked to identify and write about what they experienced that day and what emotion they felt, while the control group was asked to write a summary of a randomly chosen news article from the same day covering politics, sports, and entertainment. Therefore, expressive writing for the experimental group focused on one's own experience, whereas in the control group it focused on public affairs and notable societal events. Besides the purpose of writing, both groups were asked to engage in a daily writing task. At the end of two weeks, all participants were asked to take a final survey to share feedback about the experiment.

Each participant could receive up to a maximum of US\$50 (50,000 Korean Won) should they complete every task. Participants who completed all expressive writing tasks (i.e., 10 out of 10 days) received US\$40. Every day that participants missed a task, US\$10

was deducted. Participants who missed three or more days were excluded from further experimentation and no reward was given. As a result, all remaining participants experienced a minimum effect of the experiment by being involved in eight to 10 writing tasks. Finally, participants who answered depression surveys at the beginning and at the end of experiments received an additional US\$50.

2.4. Analysis

As a measure to determine the effect of online expressive writing on moods, we conducted sentiment analysis via K-LIWC (Korean Linguistic Inquiry and Word Count) (Lee, Shim, & Yoon, 2005). The K-LIWC is a Korean version of the well-known tool LIWC (Linguistic Inquiry and Word Count) that automatically detects sentiment for English and a few other languages (Pennebaker, Francis, & Booth, 2001). Linguistic characteristics of the Korean language were carefully considered in the design of K-LIWC (Lee et al., 2005). We considered the following four categories of K-LIWC for analysis: emotional, positive, negative, and cognitive words. This selection was based on prominence of those features as well as owning a direct relationship to our experimental design, which tries to analyze writing components in recognition, expression, and reappraisal steps in the intervention. Other features of K-LIWC were not directly associated with the experimental design, and hence were excluded in order to avoid overlapping effects. The overlapping effects could occur since words in sentiment tools may simultaneously belong to not one but multiple categories. For example, “motivation” is translated into Korean, “Dong-gi”. However, a word “Dong-gi” has three kinds of meanings such as motive, colleague who joined the company at the same time, sake which can be classified under the cognitive process, social process, achievement categories, respectively. Therefore, it is difficult to measure the true effects of the target features on depressive symptoms. The same set of linguistic characteristics was later observed along with any changes in depression scores. This study used K-LIWC to automatically extract and examine the frequency distribution of words employed in expressive writing content and no attempt was made to manually investigate the logs of individuals.

Then, a possible model was set to quantify the changes of depressive symptoms ($CESD_{\Delta}$) before and after the experiment which is as follows: $CESD_{\Delta} = CESD_{post} - CESD_{pre} / CESD_{pre}$ where $CESD_{pre}$ and $CESD_{post}$ indicate the score of CES-D measures prior to and posterior to the experiment respectively. The independent variables of the regression model included the previous wall post history on Facebook, the division for whether the user participated in intervention or was in the control group, user gender, age, friend count, as well as the emotional writing content generated from the EmotionDiary app. Multiple regression analysis with 1000 bootstrap replication was applied to measure the overall model fit of the model and estimates of each component.

Additionally, we tried to find whether specific Facebook features (e.g., friend count) have changed during the expressive writing tasks. Through the Facebook API, we gathered various features from 6 months prior to experiments (Time 1), every day throughout the 2-week experiment (Time 2), and 2 weeks after the experiment ended (Time 3). The gathered features included the post count, inbound comment count (i.e., the number of comments received from other people), outbound comment count (i.e., the number of comments posted to other people), and inbound like count (i.e., the number of likes received from other people). These counts were averaged over a 2-week period and used as dependent variables in the regression model. The Generalized Linear Mixed Model Analysis (GLMM) was used for regression, which estimates the fixed and

random effects in predictors for repeated sample data. A model was set so that it has fixed factors for the group division, time stamp, and group by time interaction, while controlling the effects of age, gender, and friend count. Considering different variance distribution at two time points, covariance structure of repeated measure (i.e., time) was set to a heterogeneous autoregressive model.

3. Results

3.1. Participants' characteristics

Among 68 participants, 44, equivalent to 65% of participants completed more than 8 out of 10 days of writing tasks successfully. Among them, 27 were in the experimental group (11 females and 16 males) and 17 were in the control group (7 females and 10 males) ($\chi^2 = 0.001, p = 0.98$). Before the intervention, there was no significant difference in the CES-D scores, resilience scores, and Facebook usage between the experimental and control groups (Table 1). Participant dropout rate of our study was 35% (24 out of 68).

3.2. The features related to changes of depressive symptoms

Partial correlation analysis indicated that changes in CES-D measures ($CESD_{\Delta}$) were negatively correlated with changes of resilience scores ($r = -0.37, p = 0.02$), the number of emotional words ($r = -0.33, p = 0.04$), negative words ($r = -0.32, p = 0.048$), and cognitive words ($r = -0.36, p = 0.02$) seen in EmotionDiary. In addition, changes in the score of subjective emotion awareness showed positive correlations with the number of emotional words ($r = 0.35, p = 0.03$), positive words ($r = 0.33, p = 0.04$), and cognitive words ($r = 0.38, p = 0.02$). There was a high correlation between the number of emotional words and cognitive words in the EmotionDiary ($p < 0.001$). These correlation results are summarized in Table 2.

3.3. Possible models to explain changes of depressive symptoms

The effect of the intervention and the usage of emotional and cognitive words in the EmotionDiary on the change of depressive moods were evaluated by multiple regression analysis. The number of negative words in the EmotionDiary was an independent factor for predicting any changes in depression scores ($T = -2.97, p = 0.01$). Analysis showed that interaction (Group X Negative words in the EmotionDiary X Negative words in OSNs) to be significant factor to explain changes in depression scores ($T = 2.85, p = 0.005$). This interaction was also important in the usage of cognitive words (Group X Cognitive words in the EmotionDiary X Cognitive words in OSNs) ($T = 3.26, p = 0.02$). All of our models

explained more than 41% of changes in depression scores and have appropriate model fit (all $p < 0.05$). The interaction graph shows that participants who were familiar with expressing negative emotion on Facebook prior to the experiment indicated a significant drop in depressive symptoms through the use of the EmotionDiary (Supplement Figure 2(a)). These regression results are summarized in Table 3.

Among the numerous Facebook features that were examined throughout the experiment period, significant trends were found only in the number of outbound comments ($p = 0.004$). All other activity measures such as the post count, inbound comment count, and inbound like count did not indicate any significant trends related to the main effect of group and group by time interaction (Supplement Table 1, Supplement Figure 1).

4. Discussion

Expressing emotional and cognitive words via the EmotionDiary app was related not only to alleviating depressive moods for participants who likely showed symptoms of SSD, but also to enhancing self-awareness. This pattern was evident even when we controlled for user age, gender, and friend count. In addition, the experimental group showed positive effects of expressing emotion through EmotionDiary when participants had previously expressed their moods on Facebook. These results suggest that expression and reappraisal of emotion using EmotionDiary can help relieve depressive moods, especially for people who are familiar with recording their emotions in OSN.

One consideration we had was to examine whether the EmotionDiary experiment, albeit conducted over a short period of time, changed any general activities within Facebook. For this, we analyzed participants' Facebook activity logs, including friend count, status updates, comments written and received, likes received, and pages liked. We compared whether or not any of these activities changed after the intervention experiment. Although we did not find any significant changes in general OSN activities based on the group effect and group by time interaction, several prosocial activities such as the number of likes and comments, revealed a trend of increasing activities for the experimental group (Supplement Figure 1). This finding suggests the need for future study, only this time with a larger sample and a longer experimental duration.

Previous studies have proved the effectiveness of expressive writing on psychological wellbeing, as well as on symptoms of depression and anxiety (Baikie et al., 2012; Gortner, Rude, & Pennebaker, 2006; Lepore, 1997; Meston, Lorenz, & Stephenson, 2013; J. M.; Smyth, 1998). Expressive writing helps reveal deeply held thoughts and feelings related to events that induce emotional responses. In this intervention study, sentiment analysis was

Table 1
Characteristics of experiment and control group before intervention (N = 44).

Variable	Expressive writing (N = 27)		Control (N = 17)		Analysis	
	Mean	SD	Mean	SD	T	P
Age	25.11	2.74	25.12	3.71	-0.01	0.99
CES-D	18.81	10.01	15.59	7.79	1.13	0.27
Resilience	42.33	8.54	44.35	6.67	-0.83	0.41
Awareness (Q1)	7.02	2.07	6.68	2.08	0.53	0.60
Understand (Q2)	7.33	1.81	6.28	2.26	1.87	0.07
Dealing (Q3)	5.09	2.45	5.18	1.98	-0.12	0.91
Number of posts ^a	13.56	14.35	24.82	28.94	-1.49	0.15
Number of likes ^a	175.04	160.12	189.59	223.98	-0.25	0.80
Number of inbound comments ^a	126.11	100.81	142.94	184.91	-0.34	0.73
Number of outbound comments ^a	62.41	40.58	39.71	33.89	1.92	0.06

^a These quantities were drawn from the previous 6-month of Facebook usage.

Table 2

Partial correlation coefficients among the main variables after controlling for age, gender, friend counts, and group (N = 44).

	1	2	3	4	5	6	7	8	9
1. CES-D	1	−0.36*	−0.02	0.07	0.14	−0.33*	−0.32*	−0.27	−0.36*
2. Resilience		1	0.22	−0.09	−0.13	0.13	0.09	0.14	0.18
3. Awareness (Q1)			1	0.41**	0.24	0.35*	0.22	0.33*	0.38*
4. Understand (Q2)				1	0.32*	0.04	−0.09	0.16	−0.03
5. Dealing (Q3)					1	−0.11	−0.03	−0.12	−0.05
6. EW in EL						1	0.85***	0.92***	0.90***
7. NW in EL							1	0.60***	0.85***
8. PW in EL								1	0.76***
9. CW in EL									1

CES-D: Center for Epidemiologic Studies Depression Scale; EW: Emotional Words; NW: Negative Emotional Words; PW: Positive Emotional Words; CW: Cognitive Words; EL: Emotion Log.

1 to 2 variables were calculated as (post-intervention – pre-intervention)/pre-intervention.

3 to 5 variables were calculated as (post-intervention minus pre-intervention).

6 to 9 variables represented the numbers of words during intervention.

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$.**Table 3**

Multiple regression analysis for explaining changes of depression scores (CES-D) using the quantity of emotional expression in previous OSN and the EmotionDiary app. (N = 44).

	Unstandardized Coefficients	SE	Standardized Coefficients	T	P (P ^a)	R ²	F
	Beta(95% CI) ^a		Beta				
Model 1 (EW)						0.42	2.71*
(Constant)	0.158 (−0.40, 0.35)	0.08		2.04	0.05 (0.06)		
Age	0.001 (−0.06, 0.06)	0.02	0.006	0.04	0.97 (0.97)		
Gender	0.268 (−0.06, 0.59)	0.14	0.259	1.89	0.67 (0.14)		
Group	0.158 (−0.17, 0.69)	0.16	0.152	0.99	0.33 (0.32)		
Friends number	0.000 (−0.00, 0.00)	0.00	0.034	0.21	0.84 (0.83)		
EW_OSN	0.005 (−0.01, 0.01)	0.00	0.392	1.26	0.22 (0.22)		
EW_EL	−0.003 (−0.01, 0.00)	0.00	−0.324	−2.05	0.05 (0.06)		
EW_OSN x Group	0.013 (−0.01, 0.04)	0.01	0.643	1.79	0.08 (0.08)		
EW_EL x Group	0.003 (−0.01, 0.01)	0.00	0.171	1.13	0.27 (0.33)		
EW_OSN x EW_EL x Group	0.000 (−0.00, 0.00)	0.00	0.978	3.31	0.00 (0.00)		
Model 2 (NW)						0.42	2.78*
(Constant)	0.125 (−0.07, 0.33)	0.08		1.58	0.12 (0.17)		
Age	−0.008 (−0.07, 0.04)	−0.06	−0.055	−0.34	0.74 (0.75)		
Gender	0.262 (−0.06, 0.58)	0.14	0.254	1.88	0.07 (0.12)		
Group	0.183 (−0.12, 1.01)	0.16	0.175	1.15	0.26 (0.34)		
Friends number	0.000 (−0.00, 0.00)	0.00	0.022	0.14	0.89 (0.91)		
NW_OSN	0.006 (−0.02, 0.03)	0.01	0.234	0.69	0.49 (0.60)		
NW_EL	−0.009 (−0.02, −0.00)	0.00	−0.431	−2.97	0.01 (0.01)		
NW_OSN x Group	0.013 (−0.02, 0.11)	0.02	0.269	0.82	0.42 (0.50)		
NW_EL x Group	0.007 (−0.01, 0.04)	0.01	0.172	1.21	0.23 (0.26)		
NW_OSN x NW_EL x Group	0.001 (−0.00, 0.01)	0.00	0.493	2.85	0.01 (0.01)		
Model 3 (CW)						0.41	2.60*
(Constant)	0.179 (−0.11, 0.37)	0.08		2.36	0.02 (0.07)		
Age	0.008 (−0.05, 0.06)	0.03	0.058	0.33	0.74 (0.76)		
Gender	0.238 (−0.08, 0.61)	0.15	0.230	1.62	0.11 (0.21)		
Group	0.284 (−0.10, 0.85)	0.16	0.273	1.81	0.08 (0.14)		
Friends number	0.000 (−0.00, 0.00)	0.00	0.018	0.11	0.92 (0.92)		
CW_OSN	0.004 (−0.01, 0.01)	0.00	0.445	1.18	0.25 (0.32)		
CW_EL	−0.003 (−0.01, 0.00)	0.00	−0.291	−1.94	0.06 (0.11)		
CW_OSN x Group	0.012 (−0.00, 0.04)	0.01	0.751	1.79	0.08 (0.14)		
CW_EL x Group	0.003 (−0.01, 0.01)	0.00	0.196	1.30	0.20 (0.28)		
CW_OSN x CW_EL x Group	0.000 (−0.00, 0.00)	0.00	1.241	3.26	0.00 (0.02)		

EW: Emotional Words; NW: Negative Emotional Words; PW: Positive Emotional Words; CW: Cognitive Words; EL: Emotion Log; OSN: Online Social Network.

* $p < 0.05$.^a These values were evaluated by 1000 times bootstrapping.

applied to clarify which content factors in expressive writing had significant influences on depressive symptoms. The number of emotional words (including both negative and cognitive words) used in expressive writing was positively correlated with reduction in depressive symptoms. Findings from this study are in line with a previous study that found the benefits of expressive writing arise from emotion processing and cognitive adaptation processes (Sloan & Marx, 2004). The written disclosure of traumatic experience can be helpful in reducing symptoms of depression or PTSD (M.

Schoutrop, Lange, Hanewald, Duurland, & Bermond, 1997; M. J. Schoutrop et al., 2002; Sloan & Marx, 2004), and cognitive appraisal can help manage stressful experiences (J. Smyth, True, & Souto, 2001). A study on LIWC-based sentiment analysis further demonstrated that an increase in the use of cognitive words (such as insightful and causal thinking) is closely related to improved physical health (Pennebaker, 1997). In addition, expressing negative emotion is beneficial when it is accompanied by appropriate cognitive reappraisal (Kennedy-Moore & Watson, 2001). Hence, the

effect of expressive writing hence is a complex process that involves disclosure and cognitive appraisal.

The careful design of the EmotionDiary app could successfully assist participants in expressing negative emotional words and cognitive words, which respectively linked to expression and cognitive reappraisal. Both factors as numerous psychological studies found have significant effects when it comes to improving mood.

The design of EmotionDiary, which was done on top of an existing OSN platform, allowed for an additional layer of analysis by allowing us to identify whether the effect of expressive writing was associated with any OSN activities. To the best of our knowledge, efforts to jointly observe expressive writing intervention with activities on social networks have not been attempted heretofore. Regression analysis was used to detect associations between the effect of online intervention and general OSN behaviors, which indicated that a previous history of sharing emotion on OSN was a factor for in explaining a reduction in depressive symptoms. Notably, participants who were familiar with expressing emotion in OSN reported the highest reduction in depressive symptoms after the intervention. There are several possible explanations for this. Participants who were familiar with expressing their emotion on OSN could follow the intervention instructions easily and might have felt more comfortable with the platform. It may have been difficult for participants who were not used to expressing emotions online to follow the expressive writing guidelines of the study. While expressive writing is a safe and easy way to reduce depressive symptoms, the writing process can cause distress for some people (Baikie et al., 2012). Findings from the current study have suggested appropriate guidelines for examining OSN information in order to identify individuals who would most benefit from expressive writing interventions.

Recent studies have revealed that an increased use of Facebook may result in negative effects on people's moods (Tandoc, Ferrucci, & Duffy, 2015). In this light, one might raise the question of whether increased online activity via the EmotionDiary app might not also lead to negative effects. Our response would be that the expressive writing experience found on EmotionDiary differentiates itself largely from that of Facebook in general. While EmotionDiary is built on top of Facebook, the key difference is the precise writing template given to users, which triggers the three-step process of recognition, expression, and reappraisal – all of which form a design specifically created with intervention in order to help people improve their moods. While some users may use the general wall post features within OSNs to share their daily thoughts with peers, such writing does not necessarily involve all three processes (e.g., reappraisal) due to the lack of a structured template and, hence, may not lead to an improvement in their moods.

Regarding the potential negative influence of social media indicated in previous studies (Jin, 2013; Tandoc et al., 2015), it may be possible that people grow tired and depressed due to an overload of content in social media resulting from an increase in usage, combined with a lack of properly structured guidelines and moderations. Some studies have found that the size of communication networks as well as the range of online content one engages in become narrow when people are depressed (Jin, 2013; Park et al., 2015). Several other studies have also found that people, especially young adults, who use Facebook frequently tend to feel more depressed or lonely in their real, non-virtual lives (Kross et al., 2013; Rosen, Whaling, Rab, Carrier, & Cheever, 2013; Sabatini & Sarracino, 2014). Another piece of research identified that what aggravates depressive moods is not the use of Facebook itself but rather the feeling of envy that occur from viewing other people's daily posts. Interestingly, the same level of detail and observation

would not be accessible in the real world and therefore does not lead to depression in the offline world (Tandoc et al., 2015). Because of a lack of moderation, the overload of information people are forced to absorb on OSNs further hinders their ability to process negative emotions appropriately. The intervention in this study acts as a break point for active OSN users in order that they might evaluate and reappraise their mood by providing a structured expressive writing template designed by psychiatrists.

One of the limitations of this study was the actual size of the experiments. While the study started with 264 applicants, we had to limit it to a final set of 44 participants to ensure that (1) we could identify subjects with potential SSD, (2) all participants completed more than 80% of the expressive writing tasks, and (3) all participants agreed to give full consent to sharing data. The final set of experimental data indicated that participants who completed the tasks showed a significant drop in depressive symptoms, indicating the success of the designed intervention. In terms of size, it would be interesting to extend the study for a longer period of time to investigate a longer-term effect on one's moods. Another limitation arose in the text analysis of the expressive writing content. An automated sentiment analysis tool was used to identify changes in linguistic patterns within the EmotionDiary, as well as within general Facebook posts. However, only a few posts or comments were generated by each participant during the intervention period. This could be due to the short time period (i.e., 2 weeks) or due to the decreased needs to express one's own emotions after expressing their inner feelings through the EmotionDiary app. Similarly, the data did not indicate any group differences in Facebook activities. This was possibly due to the relatively short intervention period; it may require a longer period of time for the elevated mood of users to be reflected in OSN behaviors. All our participants used Facebook at a moderate level and were not heavy users of the service as was the case in several previous studies. To overcome the above limitations, a future study might recruit an adequate number of participants over a longer time-period (i.e., several months).

One potential opportunity to explore is the design of the intervention. While we provided an identical writing template to every user, there is room for improvement. Previous studies reported a limited level of effectiveness in improving moods when an automated control of writing style was used (Bond & Pennebaker, 2012; Owen, Hanson, Preddy, & Bantum, 2011). These findings suggest that a well-structured template that is personalized for individuals could further maximize the effect on expressive writing.

Despite the above-mentioned limitations, the current study makes an important contribution by confirming the potential for expressive writing intervention in reducing the depressive symptoms of participants through an app within Facebook. We also found certain OSN activities determined the effect any given of intervention. These findings are promising to designers of online healthcare platforms, who seek build personalized or group-specific intervention services. The success of the EmotionDiary platform opens new opportunities to extend and adjust other conventional intervention methods to the online world.

Acknowledgement

This work was supported by grants from the KAIST Future Systems Healthcare Project from the Ministry of Science, ICT and Future Planning (N01150030, N10150017 to B. Jeong), the Creative Vitamin Project through the ICT R&D Program (I0114-14-1016 to M. Cha), and the Institute for Information & Communications Technology from the Ministry of Science (R0184-15-1037 to M. Cha).

Appendix A. Supplementary data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.chb.2016.04.034>.

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