



Linguistic analysis of Latinx patients' responses to a text messaging adjunct during cognitive behavioral therapy for depression

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ARTICLE INFO

Keywords:

CBT
Depression
Ecological momentary assessments
Latinxs
Sociocultural factors

ABSTRACT

Cognitive behavioral therapy (CBT) is efficacious to treat depression, however more research is needed to understand its functions among Latinxs. This study analyzed qualitative responses that were paired with a mood rating (1–9 scale) from daily ecological momentary assessments via text-messaging of 52 low-income, Spanish-speaking patients to assess the relationship between word use and changes in mood during group CBT. Based on previous research, we chose 11 linguistic dimensions from the Linguistic Inquiry and Word Count text analysis software that conceptually related to core CBT treatment elements and sociocultural factors of depression in Latinxs. Results showed that the use of words from the categories of *Friends*, *Religion*, *Positive Emotions*, and *Leisure* (proxy for behavioral activation) were significantly associated with a significant increase in mood. The use of *Negative Emotions* and *Health* words were significantly associated with a significant decrease in mood. Post-hoc analysis revealed that *Certainty* (proxy for cognitive inflexibility) words were related to a significant decrease in mood when *Negative Emotional* words were present. Findings contribute to our understanding of the role of sociocultural factors and core CBT elements in changes in mood among Latinxs. Lastly, this paper demonstrates the potential for analyzing language content during a digital health intervention to better understand user experiences.

Depression is the most common mental health diagnosis and racial and ethnic minorities, including Latinxs, tend to experience an increased burden of disease when diagnosed with depression (González et al., 2010). Cognitive behavioral therapy (CBT) is an efficacious treatment for depression among diverse populations (Butler et al., 2006). However, financial and contextual barriers have historically prevented Latinxs from accessing and utilizing empirically supported psychological treatments, such as CBT (Cabassa et al., 2006; La Roche & Christopher, 2008). Further, when treatment is received, rates of attrition remain high (Aguilera et al., 2018; Arnow et al., 2007; Mowbray et al., 2018). Currently, Latinxs are the largest ethnic minority in the United States, and it is estimated that by 2060 Latinxs will account for about 30% of the entire U.S. population (United States Census Bureau, 2017). As such, gaining a better understanding of the contextual factors and treatment processes that impact psychotherapeutic change among Latinx

populations can inform the implementation of culturally relevant practices that will optimize treatment effectiveness.

1. Sociocultural impacts on depression for Latinxs

Previous literature shows that a lack of culturally and linguistically appropriate services negatively influences retention in treatment (Aguilar-Gaxiola et al., 2012; Villatoro et al., 2014). Indeed, culture is an important frame through which Latinxs understand and address depression (Bignall et al., 2015; Jimenez et al., 2012). Latinxs tend to view depressive symptoms as a negative emotional reaction to environmental stressors, including interpersonal problems, stressful life events such as death or loss of income, and lack of emotional support (Berkman et al., 2005; Cabassa et al., 2007; Martinez et al., 2007). Latinxs of low-income backgrounds face additional stressors that

; CBT, cognitive behavioral therapy; EMAs, ecological momentary assessments; GCBT, group cognitive behavioral therapy.

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contribute to the onset and exacerbation of depression, including economic hardship and an increased prevalence of chronic medical conditions (Cook et al., 2007; Minority Health, 2019; Velasco-Mondragon et al., 2016). Further, many Latinxs centralize religious beliefs and social relationships as sources of care to cope with mental health problems (Martinez Tyson et al., 2011). Thus, studying the influence of socio-cultural factors, including culturally relevant stressors and coping strategies, on psychotherapy treatments for Latinxs can help improve interventions.

2. Core elements of cognitive behavioral therapy

CBT explores the influential relationship between cognitions, emotions, and behaviors (Beck et al., 1979; Muñoz & Miranda, 1986). Specifically, CBT for depression assumes that what is thought and what is done affects an individual's emotions. Therapists, consequently, focus on educating clients on two key skill sets when delivering CBT interventions: cognitive restructuring and behavioral activation. Cognitive restructuring focuses on teaching clients to identify, evaluate, and reframe dysfunctional cognitions, including cognitive distortions (Bernal & Reyes, 2008). Common cognitive distortions endorsed by individuals with depression include: (1) "negative filtering" (i.e., ignoring positive events while accentuating negative details in any situation and dwelling on it), (2) dichotomous thinking style (i.e., an "all-or-nothing" mentality), and (3) self-criticism (Bernal & Reyes, 2008; Muñoz et al., 2000). On the other hand, behavioral activation constitutes facilitating the scheduling and engagement of pleasant and healthy activities (Bernal & Reyes, 2008; Dimidjian et al., 2011). While the mechanisms through which CBT achieves its effectiveness are still unclear (Lemmens et al., 2016), the acquisition and application of these core elements of CBT treatment have been posed as being important factors (Hundt et al., 2013). However, when assessing the impact of CBT on depression outcomes, it is often difficult to assess changes in cognitions and behaviors during treatment (Lemmens et al., 2021) and this is not commonly done with diverse or low-income samples. The daily data collection of many digital health interventions affords possibilities for assessing the relationship between the proposed CBT mechanisms and outcomes, which can lead to improved personalization.

3. Tracking patterns of change

Mood tracking and identifying corresponding thoughts and behaviors are key elements of CBT homework. The process of mood, thought, and behavior monitoring teaches patients about the connection between cognitions, behaviors, and emotions to gain more control of mood management. Traditionally, between-session mood-tracking has relied on retrospective self-report through paper diaries. This method often results in obtaining inaccurate data due to the well-documented noncompliance of pen and paper tracking, as well as recall bias (Ferguson & Shiffman, 2011; Stone et al., 2003). Mobile phone-based tracking and messaging is increasingly being paired with psychotherapy, such as CBT, making it possible to obtain more frequent and accurate mood and therapy process data. For instance, ecological momentary assessments (EMAs) and interventions (EMIs) are repeated measures of data collected over time within naturally occurring settings, allowing for the investigation of dynamic patterns of symptom change (Ebner-Priemer & Trull, 2009; Lukasiewicz et al., 2007; Shiffman, 2009).

The ubiquitous ownership of mobile phones and the prevalent use of text-messaging (Pew Research Center, 2015) makes text-messaging a valuable method for EMA data collection for tracking mood in-between treatment sessions (Schueller et al., 2017). Text-messaging has been used in healthcare settings with resource poor, Spanish-speaking patients in urban hospitals to increase healthy behaviors (Arora et al., 2012) and in depression treatment (Aguilera et al., 2018). Furthermore, daily automated text message-based mood ratings are clinically useful

proxies for the Patient Health Questionnaire-9 (PHQ-9), a widely used clinical and research tool (Aguilera et al., 2015). In addition to mood, patients can send qualitative messages that reflect engagement in the key therapy processes, which can shed light on factors related to patterns of symptom change during CBT treatment (Rude et al., 2004).

4. Word use and depression

Assessing qualitative content during CBT using language processing methods can help elucidate treatment processes that are valuable in assessing effectiveness, and can inform treatment personalization. An innovative approach of conducting automated qualitative content analysis on natural language involves the Linguistic Inquiry Word Count (LIWC), a computerized text analysis software that quantifies and tokenizes text into pre-established psychologically meaningful word categories. Recent research using LIWC has assessed thoughts, behaviors, and emotions of people with depression, including Spanish-speakers, from written or spoken language (Kahn et al., 2007; Ramírez-Esparza et al., 2012). For example, several studies have found that depressive symptoms are associated with greater use of words from the LIWC category of *Negative Emotions* (e.g. "sad") and lower use of words from the LIWC category of *Positive Emotions* (e.g. "happy") (Molendijk et al., 2010; Rude et al., 2004). In addition, Grant (2010) found that the frequent use of words from the LIWC category of *Discrepancy* (e.g., "should") may reflect the cognitive distortion of self-criticism, which is typically endorsed amongst people with depression. Similarly, in a naturalistic study Al-Mosaiwi and Johnstone (2018) investigated the cognitive distortion of absolutist (dichotomous) thinking using the LIWC word category of *Certainty* (e.g., "always" or "never") and found higher usage of these words in depression recovery internet forums compared to those without. Lastly, LIWC has been used to explore cross-cultural and culture-specific language use in self-schemas of English and Spanish speakers with depression. In constructing the Spanish version of LIWC, Ramírez-Esparza et al. (2008) analyzed word used in internet forums for depression and found that Spanish speakers were likely to mention relational concerns at a higher rate than English-speakers; while English-speakers were more likely to mention medical concerns, at a higher rate than Spanish-speakers. This possibly highlights the relative importance of relational harmony in Latin American cultural contexts.

5. Aims and hypotheses

As text messaging and other EMA methods are becoming more frequently used tools in psychotherapy research, it is important to examine how analyzing natural language can elucidate the linguistic characteristics that relate to depression outcomes and responses to CBT. It is particularly important to ensure that these analyses incorporate diverse populations such as Spanish-speakers and people from low-income backgrounds. As such, using LIWC, this study analyzed qualitative responses from between-session text messaging to assess whether content related to sociocultural factors and core CBT treatment elements were associated with changes in mood over the course of group CBT (GCBT). Based on previous research on core CBT treatment elements, sociocultural factors that impact depression trajectory amongst Latinx populations, and previous text-analysis studies using LIWC, we hypothesized that the following would be associated with improvement in mood throughout treatment: 1) reduced reporting of environmental stressors (where environmental stressors were represented by the use of words from the LIWC word categories of *Health*, *Death*, and *Money*); 2) engagement in culturally relevant coping strategies, including seeking social support and religious beliefs (characterized by the use of words from the LIWC word categories of *Friends* and *Family*); 3) reduced reporting of negative filtering (characterized by the use of words from the LIWC word category of *Positive Emotions*); 4) engagement in behavioral activation strategies (characterized by the use of words from

the LIWC word category of *Leisure*); and 5) reduced reporting of the cognitive distortions of self-criticism and dichotomous thinking (where self-criticism and dichotomous thinking were represented by the use of words from the LIWC word categories of *Discrepancy* and *Certainty*, respectively).

6. Methods

6.1. Participants and procedures

The data herein are part of a larger study using a text-messaging adjunct (described below) to GCBT for depression with an aim to increase treatment engagement, adherence, and outcomes in low-income settings (Aguilera et al., 2017). For this analysis, we included ($N = 52$) predominantly low-income, Spanish-speaking adults who received outpatient GCBT for depression in a safety-net hospital. Participants were referred to the behavioral health team by their primary care providers if they expressed qualitative depressive symptoms (e.g., crying, lethargy, irritability, etc.) or screened positive for depression based on the Patient Health Questionnaire (PHQ-9). Following the referral, a behavioral health clinician administered an initial assessment. Participants were considered eligible for GCBT if they had a PHQ-9 score ≥ 10 as assessed by their primary care provider or at the start of GCBT. Participants were excluded if they expressed suicidal ideation with a plan or active/severe psychosis. During their first attended GCBT session participants provided written informed consent and were enrolled in the study. Additionally, participants completed a battery of assessments that included socio-demographic data and the PHQ-9. Following enrollment, participants received the PHQ-9 each week for 16 weeks during the GCBT sessions the participants attended. Study data were collected between January 2014 and March 2020. Phase 1 of the study ($n = 21$), which started in January 2014, was part of a clinical trial that compared attendance in sessions for standard GCBT compared to GCBT paired with the text messaging adjunct (Aguilera et al., 2017). Phase 2 started in September 2016 and was part of a naturalistic study ($n = 31$) where all participants received the text-messaging adjunct. Participants in Phase 1 were not compensated for their participation, while participants in Phase 2 were compensated with a \$25 gift card at the end of the study. The University of California, San Francisco IRB approved all phases of this study (#10-04985).

6.2. Intervention

6.2.1. Group cognitive behavioral therapy (GCBT)

A licensed clinical psychologist and a licensed clinical social worker or another psychologist led the GCBT sessions in Spanish. Therapists were all bilingual (at least one of two clinicians was bicultural) with expertise in delivering culturally sensitive care to Latinx populations. The treatment was based on an updated version of the Building Recovery by Improving Goals, Habits, and Thoughts (BRIGHT) manual, which has shown to be efficacious in treating depression in diverse populations and Spanish-speaking (Muñoz & Mendelson, 2005). The manual consists of four, four-week modules: cognitive restructuring (thoughts), behavioral activation (activities), interpersonal relationships (people), and healthy behaviors (health) (Miranda et al., 2006). Participants were scheduled for a 16-week treatment to complete all four four-week modules. Although, some participants continued attending GCBT for more than 16 weeks—if they wanted to review a module due to prolonged absence—our current analysis focused on the first 16-weeks of treatment for each participant.

6.2.2. Texting adjunct

As part of GCBT, participants were enrolled in the MoodText program using the HealthySMS platform, an automated system, to receive daily automated text messages at a random time between 8am and 9pm. Participants received one text-message inquiring about their mood.

Specifically, participants were asked: “[first_name], what is your mood right now on a scale of 1–9 (9 being best)? Please respond with a number and a message about what you are doing or thinking.” They were also provided in-person instructions with how to reply to messages. Participants were also sent a second daily message reiterating the elements of specific CBT topics (e.g., thoughts, behaviors, social interactions, etc.) reviewed in that week’s therapy session. These messages were not analyzed as part of this study. Participants who did not respond to at least 10 mood messages with a mood rating and qualitative information were not included in the analysis ($n = 18$).

6.3. Measures

6.3.1. Content analysis of EMAs

LIWC. To assess sociocultural factors and core CBT treatment elements, we analyzed qualitative responses to the daily mood text message using LIWC, a computerized text analysis software package (Pennebaker et al., 2001). The software package acts as tokenizer and word counter to systemically conduct word-by-word content analysis. Specifically, LIWC transforms strings of text into statistically manageable data. As a closed-vocabulary program, LIWC uses a dictionary composed of pre-established categories to calculate the relative frequency of words within a text file that fit into one or more of the pre-established word categories. The word categories within the dictionary theoretically represent a particular construct, including standard linguistic dimensions (e.g., function words), psychological processes (e.g., words related to emotional states, social relationships, and cognitions), biological processes (e.g., words relating to health and the body), and personal concerns (e.g., work, religion, leisure). For our analysis, we utilized the LIWC’s 2001 Spanish language dictionary (Ramírez-Esparza et al., 2007), which uses 7,515 words that are categorized into one or more 72 pre-established word categories. LIWC’s psychometric properties have been validated across different experimental settings (Tausczik & Pennebaker, 2010).

Selection of word categories. To address the specific hypotheses, we selected 11-word categories from LIWC’s Spanish dictionary that conceptually related to culturally relevant coping strategies and environmental stressors among Latinxs with depression, and core CBT treatment elements (i.e., cognitive restructuring and behavioral activation). These LIWC word categories were selected based on published literature on language use amongst depressed populations (Al-Mosaiwi & Johnstone, 2018; Molendijk et al., 2010; Grant, 2010; Rude et al., 2004); and published literature on sociocultural factors that affect depression trajectory amongst Latinx populations (Berkman et al., 2005; Cabassa et al., 2007; Martinez et al., 2007; Cook et al., 2007; Velasco-Mondragon et al., 2016; Minority Health, 2019; Martinez Tyson et al., 2011). We described this literature and its relevant findings in the introduction.

The word categories of *Family*, *Friends*, and *Religion* were selected to represent culturally relevant coping strategies, while the word categories of *Health*, *Money*, and *Death* were selected to represent environmental stressors. The word category of *Leisure* was selected to represent behavioral activation, based previous literature suggesting that this word category is related to the notion of activation (Tausczik & Pennebaker, 2010). We used the word category of *Certainty* (e.g., words such as “never” and “always”) to represent the cognitive distortion of dichotomous thinking, based on previous literature linking this word category and construct (Al-Mosaiwi & Johnstone, 2018). We used the word category of *Discrepancy* (e.g., words such as “should”) to represent the cognitive distortion of self-criticism based on previous literature linking this word category and construct (Grant, 2010). We classified *Positive* and *Negative Emotions* as both sociocultural factors and core CBT treatment elements. Previous research has shown a significant positive association between the use of words from the LIWC category of *Positive Emotions* and improvement in outcomes among people with depression, and a negative association between the use of words from the LIWC

category of *Negative Emotions* association and improvement in outcomes among people with depression (Molendijk et al., 2010; Rude et al., 2004). At the same time, Latinxs tend to view depression as a negative emotional reaction to environmental stressors (Berkman et al., 2005; Cabassa et al., 2007; Martinez et al., 2007). Sample keywords from the LIWC word categories used in this study are listed [Supplementary Appendix A](#).

6.3.2. Outcomes

Depression outcomes were primarily measured using the mood ratings responses participants provided to the daily automated text-messages. Ratings were made on a 1 (feeling the worst) to 9 (feeling the best) scale. To assess whether mood is related to a gold standard clinical measure, we also assessed symptom improvement using available data of PHQ-9 scores, which were administered on a weekly basis for 16 weeks. PHQ-9 is a widely validated instrument (Kroenke, Spitzer, & Williams, 2001). PHQ-9 scores each of the 9 DSM-IV criteria for depression as “0” (not at all) to “3” (nearly every day). It includes items such as, “Over the last 2 weeks, how often have you been bothered by any of the following problems? Little interest or pleasure in doing things”.

6.4. Data analysis plan

6.4.1. Data preparation

Qualitative responses to text messages were prepared for software readability. As a first step, we separated the qualitative responses from the mood ratings, which usually arrived as a single text message. Additionally, we reviewed the qualitative response for typographical errors so that LIWC could correctly categorize words. To avoid from making changes to the text that would alter meaning, the research team developed a protocol to correct typographical errors only for readability. Changes were only made if agreed upon by two raters. Unclear errors were not changed. Qualitative responses were then categorized with LIWC and the numerical scores of the LIWC output were then transferred into a dataset that was analyzed using R software (R Core Team, 2020). Since most of the messages were short (Median = 7 words, (1stQ = 4, 3rdQ = 14)), we used a binary categorization of the LIWC categories (0 or 1) rather than using the relative percentage score that LIWC generates by default. For example, if a message had at least one word from the *Religion* category, we classified the message as being part of the *Religion* word category (i.e., given a value of 1 on the religion category).

6.4.2. Analysis

To account for confounding variables that are often found in longitudinal studies (Gueorguieva & Krystal, 2004), we used Linear Mixed Models to study the relationship between the LIWC word categories and changes in mood. The analysis was carried out in two stages, each using a top-down approach (Zuur et al., 2009). Prior to conducting the analysis, we constructed a variable to represent the ratio of progress in treatment (i.e., number of days that had passed since the participant entered the study divided by 112, which signifies the number of days all participants were scheduled to complete the 16-week treatment). We named this variable *Time in Study*. In each stage, a by-subject random intercept and a by-subject random slope were included (i.e., the slope refers to the rate of change of mood with respect to study day). Because data, across both study phases, were collected from adults with a range of ages (26–68), and depression has shown changing trajectories over adulthood (Colman & Ataullahjan, 2010), both models controlled for age. Similarly, we controlled for sex in both models, because data—across both study phases—were collected from a predominately female sample, and females are twice as likely to than males to be given a diagnosis of depression (Albert, 2015).

In the first model, the six LIWC word categories representing socio-cultural factors (i.e., *Family*, *Friends*, *Religion*, *Health*, *Money*, and *Death*), the LIWC word categories of *Positive Emotions* and *Negative Emotions*;

age, sex, and the variable *Time in Study* were included as fixed effects. The first model informed the selection of control variables for the second model. Using a top-down approach (Zuur et al., 2009), we eliminated non-significant variables ($p > .05$) one at a time from the model. This procedure was repeated until all the variables of the model were significant. To control for age and sex, these variables were kept in the model throughout the process despite not being significant. At all the steps of eliminating variables, we checked for a decrease in the Akaike Information Criteria (AIC). The AIC is a widely used model selection criteria that considers both log-likelihood function, $\text{Log}(L)$, and number of parameters, k , when comparing models (i.e., $\text{AIC} = 2k - 2\text{Log}(L)$). In a top-down approach, the preferred model to keep for analysis is the one with the lowest AIC value.

The second model contained the significant variables from the first model, age and sex, and the three LIWC categories representing the core CBT treatment elements (i.e., *Certainty*, *Discrepancy*, and *Leisure*); as well as the interactions of the *Certainty* and *Discrepancy* word categories with *Positive* and *Negative Emotions* as fixed effects. After discarding the non-significant variables, we obtained the final model where we analyzed the associations between the LIWC word categories and changes in mood.

Finally, to study the association of the *Certainty* and *Discrepancy* word categories and mood, while considering the presence or absence of *Positive* and *Negative Emotions*, we used Estimated Marginal Means and Tukey’s test. These techniques allowed us to analyze the different configurations of the interactions and apply a correction for multiple comparisons. These calculations were carried out with the ‘emmeans’ package of the R language (Lenth et al., 2018).

7. Results

7.1. Participant characteristics

The final analyses included 52 participants. Participants were all Spanish-speaking (100%), predominantly female (78.5%), middle-aged ($M = 50$, $SD = 10.5$), and most had no more than a high school education (73.1%). The mean number of group sessions attended by a participant was 10 ($SD = 4$). Participants responded to a mean of 48 ($SD = 26$) messages during the whole study period. 11 participants opted out of texting at some point during the study by texting “STOP” or “PARAR”. See [Table 1](#) for other demographic and clinical characteristics.

7.2. Final model

To examine the relationship between word use and changes in mood we implemented Linear Mixed Models. From the analysis of the first model, we selected the following control variables for the second model: *Time in Study*, *Positive* and *Negative Emotions*, *Friends*, *Religion* and *Health*. Despite not being significant, we continued to control for sex and age.

In the final model we observed a significant relationship ($p = .012$) between the *Time in Study* variable and mood (see [Table 2](#)). This finding was associated with a significant increase in units of mood by 0.61 units after 112 days of the intervention, suggesting symptom improvements over time. Although the change was relatively small, by conventional standards, mood ratings are more constrained than PHQ-9 ratings as people tend to find a central point and then deviate from that). In a previous analysis, investigating the relationship between mood and PHQ-9 we found that small changes in mood correspond to larger changes in PHQ-9 ratings (Aguilera et al., 2015). This was reflected in data used for this analysis. Specifically, when we observed the evolution of mood throughout treatment for each participant, we were able to see that the rate of change of mood was much higher for participants that had an initial low mood (whereby the initial mood of a participant was defined as the average mood of its first 5 messages). [Fig. 1](#) shows Spearman’s correlation for the initial mood and the rate of change of mood. To assess whether mood is related to a gold standard clinical measure, we computed a correlation between mood and PHQ-9 scores.

Table 1
Sociodemographic characteristics of participants at baseline.

Characteristics	Full sample	
	n	%
Sex		
Female	41	78.8
Male	11	21.2
Ethnicity		
Latino(a) or Hispanic	52	100.0
Highest educational level ^a		
High School or less	38	73.1
More than high school	9	17.3
Marital Status ^b		
Single	20	38.5
Married or partnered	17	32.7
Divorced or legally separated	6	11.5
Widow	3	5.8
Employment ^c		
Part-time or more	13	25.0
Unemployed	19	36.5
Disabled/On disability	14	26.9
Retired	2	3.8
Mobile phone ownership	52	100
Preferred method of contact ^d		
Call	21	40.4
Text	15	28.8
Depends	10	19.2

Note. N = 52. Participants were on average 50.5 years old (SD = 10.5). The average PHQ-9 score at baseline was 13 (SD = 4.4) The average PHQ-9 score at exit was 7.6 (SD = 5.1).

- ^a Results for question are missing data from 5 participants.
- ^b Results for question are missing data from 6 participants.
- ^c Results for question are missing data from 4 participants.
- ^d Results for question are missing data from 6 participants.

We observed a Pearson’s correlation of -0.49 ($p < .001$), reaffirming the suggestion of symptom improvement over time. This correlation was based on all available data points of mood (collected on a daily basis) and PHQ-9 scores (collected on a weekly basis) collected during the 16-week treatment. The scatter plot is shown in Fig. 2.

7.3. Word use and changes in mood

After adding the LIWC word categories representing core CBT treatment elements (i.e., *Certainty*, *Discrepancy* and *Leisure*) and their interactions with *Positive* and *Negative Emotions* to the second model, and discarding the non-significant effects, we obtained the fixed effects shown in Table 2. Specific results are discussed below, and the interpretations of these findings are discussed in the discussion section of this paper. The percentage of appearance of the LIWC categories in the

Table 2
Linear Mixed Model fixed effects on mood for the final model after eliminating non-significant variables.

	Estimate	SE	df	t	p	95% CI	
						Lower	Upper
(Intercept)	7.48	0.82	54.0	9.18	1.29 e -12	5.89	9.09
Time in Study	0.61	0.23	33.5	2.66	0.012	0.16	1.09
Positive Emotions	0.16	0.04	2412.5	3.59	0.000339	0.08	0.25
Negative Emotions	-0.62	0.06	2394.9	-10.60	<2e -16	-0.73	-0.50
Friends	0.28	0.09	2384.8	3.31	0.000943	0.11	0.45
Religion	0.25	0.06	2388.6	3.98	7.0e -05	0.13	0.38
Health	-0.15	0.06	2387.3	-2.69	0.007	-0.26	-0.04
Age	-0.02	0.02	51.4	-1.17	0.249	-0.05	0.01
Sex. (M)	0.47	0.39	51.0	1.21	0.233	-0.29	1.23
Certainty	-0.20	0.11	2389.3	-1.74	0.082	-0.42	0.03
Leisure	0.13	0.04	2395.5	3.36	0.0009	0.05	0.21
PosEmo: Certainty	0.40	0.13	2387.8	3.09	0.0021	0.14	0.65
NegEmo: Certainty	-0.35	0.14	2384.3	-2.57	0.010	-0.61	-0.08

Note. As an exception, the age and sex variables were kept as controls, and the *Certainty* variable was kept since its interaction with the emotions was significant. For each fixed effect the estimate (β) and p-value are shown.

data are provided in Table 3.

7.3.1. The effects of sociocultural factors on mood

Among the LIWC word categories representing sociocultural factors the use of words from the categories of *Friends* and *Religion* were associated with a significant increase in units of mood (on a 1–9 scale) by 0.28 units ($p = .001$) and 0.25 units ($p < .001$), respectively. Conversely, the use of words from the *Health* category was associated with a significant decrease in units of mood (on a 1–9 scale) by 0.15 units ($p = .007$). We found no significant associations between the word categories of *Family*, *Money*, and *Death* and changes in mood.

7.3.2. The effects of core CBT treatment elements on mood

Among the LIWC word categories representing core CBT treatment elements the use of words from the category of *Leisure* was associated with a significant increase in units of mood (on a 1–9 scale) by 0.13 units ($p < .001$). The use of words from the category of *Positive Emotions* was associated with a significant increase in units of mood (on a 1–9 scale)

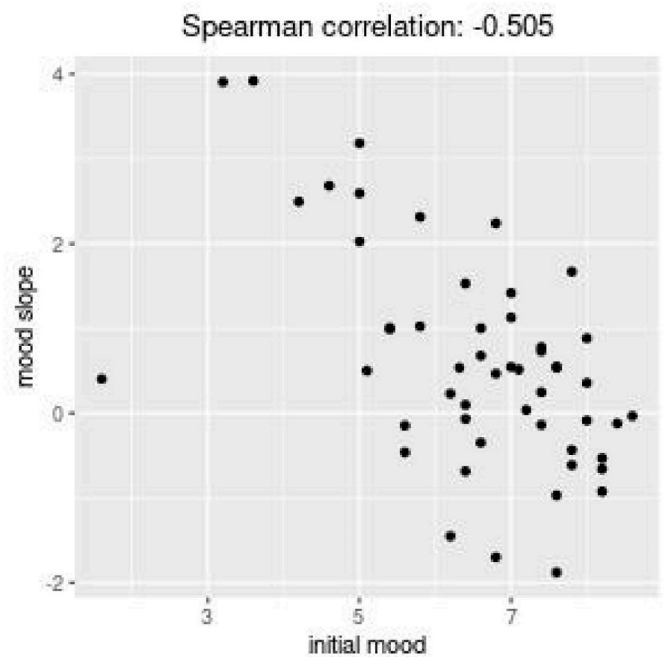


Fig. 1. Relationship between initial mood and rate of change of mood throughout treatment. Spearman $r = -.51$.

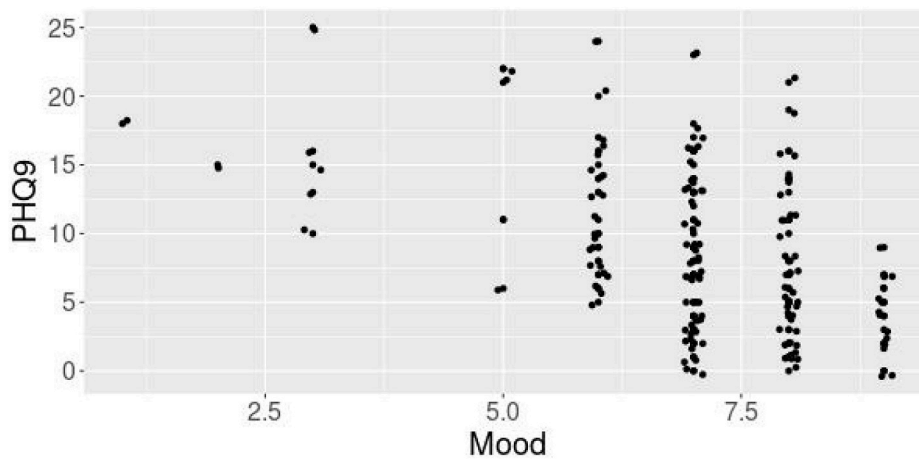


Fig. 2. Relationship between mood and PHQ-9. Pearson’s $r = -0.49$

Note: This correlation was based on all available data points of mood (which was collected on a daily basis) and PHQ-9 (which was collected on a weekly basis) collected during the 16-week treatment. Mood and rate of change of mood throughout treatment. A small jitter effect was applied to avoid overlapping dots.

Table 3

Percentages of appearance of the LIWC categories in the messages.

Friends	Religion	Health	Death	Money	Certainty	Discrepancy	Pleasure	Family	Positive Emotions	Negative Emotions
4.34	10.40	12.53	1.08	4.22	8.80	7.39	27.27	4.63	33.29	14.30

by 0.16 units ($p < .001$). Conversely, the use of words from the *Negative Emotions* category was associated with a significant decrease in units of mood (on a 1–9 scale) by 0.62 units ($p < .001$). We found no significant independent associations between mood and the word categories of *Discrepancy* and *Certainty*. However, we observed significant association between mood and the interaction of the LIWC word categories of *Certainty* and *Positive* and *Negative Emotions*.

To study the interactions between the word categories of *Certainty* and *Positive* and *Negative Emotions*, we ran a post-hoc analysis using the Estimated Marginal Means, which allowed us to estimate mood in all configurations of these variables, marginalizing the remaining ones. That is, we studied the means obtained from a statistical model that depended only on the variables: *Certainty*, *Positive Emotions*, and *Negative Emotions*. Fig. 3 shows the difference in the estimated mood between the text-messages that contained and did not contain *Certainty* for the different configurations of *Emotions* (all Estimated Marginal Means and contrasts are shown in Table A2 and Table A3 in Supplementary Appendix A., respectively). Our results showed that the use of *Certainty* was associated with a significant decrease in units of mood in by 0.54 units only when *Negative Emotional* words were simultaneously present and *Positive Emotional* words were simultaneously absent ($p = .003$).

8. Discussion

8.1. Summary of principle findings

Overall, we found that mood ratings recorded via text messaging increased over time in GCBT depression treatment suggesting symptom improvement over time. We also found that mood ratings and PHQ-9 scores were significantly related, further supporting improvements in depression severity during treatment. The hypothesis that reduced reporting of environmental stressors would be associated with improved mood was only partially supported. Specifically, out of the three-word categories selected to characterize this construct, only the use of words in the *Health* category was associated with a significant decrease in units of mood. The hypothesis that engagement in culturally relevant coping strategies would be associated with improved mood was only partially supported. Specifically, out of the three-word categories

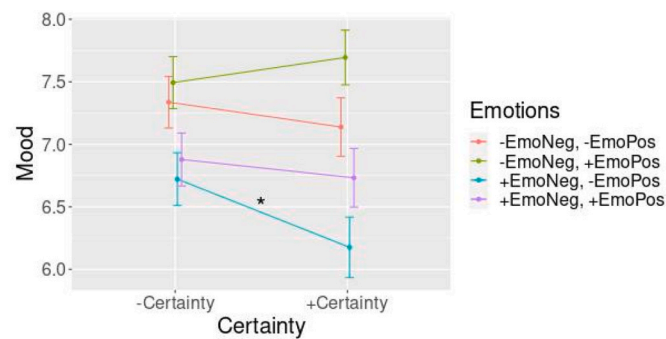
selected to characterize this construct, only the use of words in the *Family* and *Friends* categories were associated with a significant increase in units of mood.

When considering core CBT treatment elements, consistent with our hypothesis reduced reporting of negative filtering, characterized by the use *Positive Emotional* words, was significantly associated with a significant increase in units of mood over the course of treatment. We selected the use of words from the *Leisure* category to characterize engagement in behavioral activation strategies and found that the use of *Leisure* words was associated with a significant increase in units of mood. Additionally, we selected the *Discrepancy* word category to characterize the cognitive distortion of self-criticism, and the *Certainty* word category to characterize the cognitive distortion of dichotomous thinking. The hypothesis that reduced reporting of words relating to self-criticism and dichotomous thinking would be associated with improved mood was only partially supported. We did not find a significant association between the use of words from the *Discrepancy* category and mood. Finally, usage of words from the *Certainty* category was associated with a significant decrease in units of mood, but this relationship was dependent on the presence of *Negative Emotional* words and the simultaneous absence of *Positive Emotional* words.

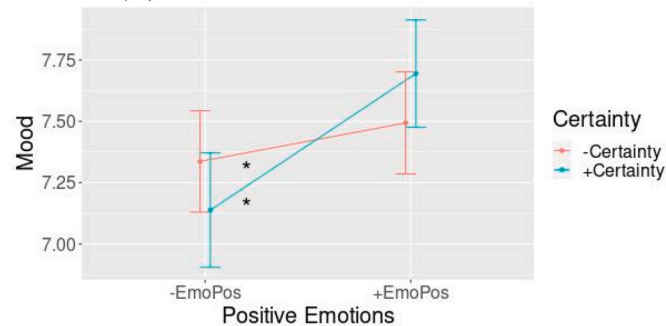
8.2. Sociocultural factors

8.2.1. Environmental stressors

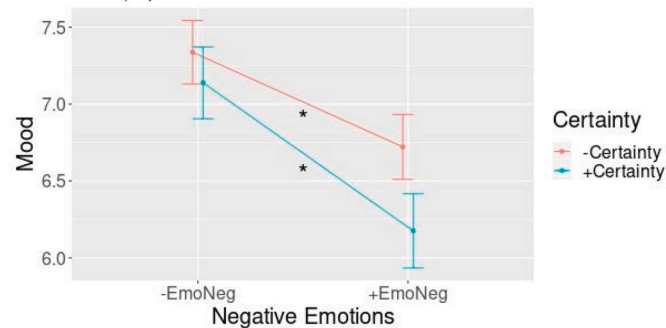
Latinxs in the US tend to subscribe to a “situational” model of depression, which views depressive symptoms resulting from environmental stressors (Martinez Tyson et al., 2011). Although causality cannot be inferred from these data, our findings indicate that health may be a particularly salient stressor amongst our sample of low-income Latinxs. Notably, mentions of chronic medical conditions (i.e., the use of words in the *Health* category) were associated with a significant decrease in units of mood. This makes sense considering that this study took place in a primary care setting (i.e., a safety-net hospital) with patients that tend to have comorbid chronic illnesses. Previous literature has reported that Latinxs of low-income backgrounds tend to have an increased prevalence of chronic medical conditions. Further, reports show that individuals with chronic medical conditions are at higher risk



Panel (a)



Panel (b)



Panel (c)

Fig. 3. Estimated Marginal Mean of Mood for the interaction between Certainty and Emotions.

Note. Panel (a) shows the association between mood and certainty related words, when positive and negative emotional words are simultaneously present or absent. Panel (b) shows the association between mood and positive emotional words when certainty related words are simultaneously present or absent. Panel (c) shows the association between mood and negative emotional words when certainty related words are simultaneously present or absent. Significant comparisons are shown with asterisks * ($p < .05$). The significance was computed using Tukey’s method for multiple comparisons. EmoNeg and EmoPos stands for the LIWC categories of positive and negative emotions, and the negative (–) and positive signs (+) on LIWC categories indicate whether the message contains or not words from that category.

for depression (California Senate Office of Research, 2017; Minority Health, 2019; Velasco-Mondragon et al., 2016). On the other hand, Ramirez-Esparza et al., 2008 found that Spanish speakers reported fewer medical concerns than English speakers. It is likely that this finding is dependent on the context and the sample. In this sample, participants had high rates of chronic medical illness in addition to depression.

The absence of a significant association between the word category of Money and mood contradicts previous research. About a quarter of Latinxs in the U.S. live in poverty, and economic hardship is consistently associated with depression (Cook et al., 2007; Minority Health, 2019).

While relevant to our sample, the theme of economic difficulty hardly arose in responses to open ended questions about mood, thoughts, and behaviors. Similarly, the absence of a significant association between the word category of Death and mood contradicts previous research. Latinxs of low-income backgrounds are disproportionately vulnerable to death (Velasco-Mondragon et al., 2016). It is possible that these linguistic measures (Money and Death) are not fully captured because the text is naturalistic, and we did not specifically ask about these factors. Lastly, these are relatively low frequency topics (see Table 3) in our data and thus this approach may not be the best way to assess the relationships between mood and low frequency topics.

8.2.2. Culturally relevant coping strategies

Previous research has found that Latinxs tend to rely more on religion and social support to cope with depressive symptoms as compared to non-Latinx whites. Our findings indicate that religion and friends may be particularly salient sources of care to cope with depression amongst our sample of low-income Latinxs. We found that the mentions of words relating to friends and religion (i.e., the LIWC word categories of Friends and Religion) were associated with a significant increase in units of mood. Although causality cannot be inferred from these data, one possible explanation is that engagement in culturally relevant coping strategies, including leveraging social support and relying on religious beliefs may play a role in alleviating depressive symptomatology and promote positive outcomes in Latinxs with depression. The absence of a significant association between the word category of Family and mood is consistent with previous research that demonstrates that the positive support from friends, when compared to familial support, leads to more mental health improvements in Latinx populations (Kawachi & Berkman, 2001; Rodriguez et al., 2003). In addition to being supportive, family may also be a source of stress, making mention of the category dependent on the context. Further research is needed to determine the impact of familial relationship on mood over the course of group CBT for low-income Latinx. Our finding that mentions of words relating to Religion was associated with a significant increase in units of mood is also consistent with previous studies. Distinctly, religious Latinxs often endorse the belief that faith in God can help relieve depression (Cabassa et al., 2007; Givens et al., 2007; Sadule-Rios et al., 2014).

The identification of sociocultural relevant factors (i.e., Health, Friends, and Religion) associated with mood changes lends support to the integration of these factors into CBT with Latinxs. These factors can be integrated into the CBT model. For example, encouraging pleasant activities to improve healthy behavior, such as walking, that involve friends may be particularly salient for Latinxs. Additionally, religion is salient to many patients and should be integrated into the context of CBT. For example, clinicians can discuss how attending religious services may serve as behavioral activation or how religion can serve as a source of hope or a way to encourage healthy thoughts. It is not necessary to get into detailed religious discussions with patients but acknowledging the role of religion for patients who present this information as relevant can improve the cultural relevancy of therapy.

8.3. Core CBT treatment elements

CBT for depression is based on the modification of dysfunctional cognitions and increasing engagement of pleasant and healthy activities (i.e., behavioral activation) as mechanisms that lead to improvement in depressive symptomatology (Bernal & Reyes, 2008; Hundt et al., 2013). Consistent with Arntz et al. (2012), our findings showed that the use of the words in the Negative Emotion word category was associated with a significant decrease in units of mood; while the use of the words in the Positive Emotion word category was associated with a significant increase in units of mood. Moreover, we found that the use of the words in Certainty word category was associated with a significant decrease in units of mood, but unlike but unlike Al-Mosaiwi and Johnstone (2018) the association was dependent on the absence of Positive Emotional words

and the presence of *Negative Emotional* words. This result is justified given that the *Certainty* word category is composed of words like “always” and emotional valence affords different connotations. For example, the phrase “I will always be happy” has a positive connotation and would most likely be related to higher mood, while the phrase “I will always be sad” has a negative connotation and would likely be related to lower mood. We did not find support for our hypotheses that the use of words in the *Discrepancy* word category would be associated with improved mood. One explanation is that the literature regarding this word category is mixed. Although one study found evidence that *Discrepancy* may capture the dysfunctional cognition of self-criticism (Grant, 2010), another study suggested that *Discrepancy* words may represent aspirations for change as opposed to present shortcomings of oneself (Van der Zanden, 2014). Specifically, studies found that the use of *Discrepancy* words is associated with improvement in outcomes for depression. Finally, our finding that usage of words relating to the *Leisure* word category was associated with a significant increase in units of mood is consistent with the underlying theory that the behavioral components of CBT reduce depression symptoms (Bernal & Reyes, 2008). This suggests that engagement in behavioral activation strategies may be an important core CBT treatment element for low-income Latinx with depression who are currently attending treatment.

8.4. Implications and future directions

The addition of EMAs via text-messaging to capture daily mood in CBT for depression affords data that can give a better understanding of the underlying mechanisms that impact psychotherapeutic change. This can be beneficial during treatment as well as for researching underlying core treatment targets. Previous research has shown associations between linguistic dimensions and outcome improvement (Zinken et al., 2010). However, linguistic analyses have typically been conducted cross sectionally or with non-clinical samples. Furthermore, those analyses are predominantly among white populations, English speakers, and typically do not include individuals with low socioeconomic status or educational attainment. This study was, to our knowledge, the first to examine word use in a sample of Latinx patients enrolled in CBT for depression at a safety-net hospital. Findings from this study contribute to our understanding about sociocultural factors, including important environmental stressors and culturally relevant coping strategies, and core CBT treatment elements that most relate to mood in low-income, Spanish-speaking Latinxs. By identifying sociocultural factors, improved interventions may be able to address the underlying environmental stressors and incorporate sociocultural coping strategies to better personalize treatment.

This study also has implications for the ways in which data are collected from clients in depression treatment. Research on patterns of psychotherapeutic change often relies on retrospective scales. EMA data collection via text-messaging has the potential to offer a more accurate picture of the dynamic patterns of symptom change while serving as a clinical tool (Aguilera et al., 2015; Schueller et al., 2017). Texting eliminates the need for prospective pen and paper assessments, reduces recall bias, and does not require additional internet-based applications for patient use. On demand natural language analysis of text message responses may be used to alert clinicians to key issues during the course treatment and help clinicians better tailor treatment. Future research should focus on investigating the utility of EMA data collection via text-messaging to uncover patterns of psychotherapeutic change and opportunities for personalizing treatments. Lastly, methods that can automate natural language analysis can facilitate the development of useful digital health tools, such as chatbots, that can intervene in real-time.

8.5. Limitations

Mood messages were sent during typical waking hours (8am-9pm),

so it is possible that we did not capture experiences from individuals that have an active nightlife. Also, text-messages were capped at 160 characters, which limited the content that participants sent. Due to limitations of the LIWC analyses, we excluded several one-word or emoji answers from our analysis. We also limited participation to individuals who, throughout the 112-day study, replied to at least 10 of the daily mood text messages. Thus, our data may have captured a narrower range of depression experiences.

The use of LIWC to analyze mood responses also presents limits. Notably, LIWC relies on categorizing language into different word categories; thus, it is unable to consider context and nuances of language. Further, we utilized the LIWC word categories of *Discrepancy*, *Certainty*, and *Leisure* to characterize the cognitive distortion of self-criticism, the cognitive distortion dichotomous thinking, and behavioral activation—respectively, based on relevant literature that linked these constructs to these LIWC word categories; however, this literature was limited (i.e., we only found one relevant study for each category). Future research is needed to determine whether the LIWC word categories of *Discrepancy*, *Certainty*, *Leisure* are good proxies for self-criticism, dichotomous thinking, and behavioral activation—respectively. Focusing on a Spanish-speaking and low-income sample is a strength of our study, but our results might not be generalizable to all Latinxs. Nonetheless it is crucial to study diverse populations and non-English speakers. Finally, the study was conducted with a relatively small sample size; however, the longitudinal design of the study allowed for many data points per participant.

9. Conclusions

This study is amongst the first of its kind, to our knowledge, to explore sociocultural factors and core CBT treatment elements in a clinical setting using EMAs via text-messaging in a sample of Spanish speaking, low-income Latinxs. The results suggest that the linguistic dimensions of *Health*, *Friends*, *Religion*, *Positive* and *Negative Emotions*, dichotomous thinking, and behavioral activation are related to mood among low-income, Spanish speaking Latinxs. These factors may be important targets of treatment for established treatment approaches and future interventions that focus on low-income Latinxs who have depression. As digital health interventions are more widely implemented, data can serve multiple clinical and research purposes to personalize and adapt interventions.

Credit author statement

Rosa Hernandez-Ramos: Conceptualization, Methodology, Data curation, Writing – original draft, Visualization; Edgar Altszyler: Data curation, Formal analysis, Writing- Reviewing and Editing; Caroline A. Figueroa: Supervision Writing- Reviewing and Editing; Patricia Avila-Garcia: Project administration Writing- Reviewing and Editing; Adrian Aguilera: Supervision, Resources, Writing- Reviewing and Editing.

Declaration of conflicting interests

Authors declare no conflict of interests.

Acknowledgements

Adrian Aguilera was supported by National Institutes of Mental Health - K23MH094442 and a Robert Wood Johnson New Connections Award. We thank all patients who participated in this study for their time and trust in sharing their experience with us. We recognize research team members Suchitra Sudarshan, Alexander Chavarria, and Lilita Ramirez who helped with the recruitment, testing, and data collection of this study; and Chris Karr who helped develop and manage the automated text messaging service.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.brat.2021.104027>.

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