How Does Online Social Network Change My Mood? An Empirical Study of Depression Contagion On Social Network Sites Using Text-mining  

Research-in-Progress

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Abstract

Depression is one of the most common mental health problems among young adults, which is often associated with many other negative health and social problems. Despite numerous studies about depression and its transmission in the offline environment, there are few studies investigating how depression is transmitted on Social Network Sites (SNS). In this study, we build a new theory about depression contagion on SNS. We propose that negative (positive) contents can enhance (attenuate) users’ depression levels. Furthermore, two factors: communication specificity and tie strength are expected to moderate the relationship between content valence and depression level. We use sentiment analysis to measure content valence, and design a novel mixed approach to measure users’ depression symptoms and moods. The results of the study will help us find some methods to alleviate depression that may occur via communication on SNS.

Key words: depression contagion, social network sites, content valence, communication specificity, tie strength
Introduction
Depression is one of the most common mental health problems among young adults (Blanco et al. 2008; Hunt and Eisenberg 2010), which is often associated with many other negative health and social problems, such as increased rates of substance use, poor academic achievement, co-morbid psychiatric conditions and suicide (Bramesfeld et al. 2006; Deas and Brown 2006; Garlow et al. 2008; Rao 2006; Rao and Chen 2009). According to a study in 2009, about 30% of college students reported frequently feeling depressed in their daily life, and unfortunately, this number is still increasing every year (Association 2009; Gallagher et al. 2010). Confounding the situation, a number of studies have demonstrated that depressive symptoms and mood can be easily transmitted from person to person (Joiner and Katz 1999). Howe et al. (1985) showed that students assigned to a depressed roommate were more likely to become depressed than those assigned to a non-depressed roommate after a three-month period. Similarly, Joiner (1994) also showed the same contagion effect of depression among college roommates when baseline levels of depression and negative life events were controlled. Furthermore, Fowler and Christakis (2008) found that emotion was transmitted not only to direct relationships (such as roommates or friends), but also to indirect relationships (such as friends’ friends).

Furthermore, with the advent of more efficient communication technology, online Social Network Sites (SNS) provide a platform for depression contagion (Hancock et al. 2008). Compared to offline interpersonal communication, depression contagion through online communication is no longer limited by physical distance and time. As a result, depression can be spread even when people are geographically and temporally separated. Moreover, since whatever you post or send with a negative emotion may have an influence on the mood of your friends, the contagion effect is amplified as it traverses through the social graph through multi-pathing and “echo chamber” effects (Wallsten 2005). Therefore, in view of the above points, it is worthwhile for us to conduct a study about depression contagion on SNS.

Interestingly, the transmission of depression on SNS can come in a different form between online and offline. While original emotional contagion theory emphasized the nonverbal cues, such as facial expressions and gestures, as the primary emotional signals in the transmission of depression (Barsade 2002; Neumann 2000), in the online environment, people can only communicate through text, which is believed to be less associated with emotion (Mehrabian 2007). On the other hand, as a low energy display of emotion, depression is sometimes not sensed by others in offline communication (Prkachin 1977). However, in the environment of social network sites, the accuracy of depression transmission is greatly enhanced when users express their emotions by text. Therefore, our first research question is whether depressive symptoms and mood can be transmitted through text in the SNS environments. That is, whether positivity/negativity of contents influences users’ depression levels.

Moreover, we notice that besides content, some other factors, such as who send the message, and how the message is sent, also influence depression contagion process on SNS. For example, the same negative message sent personally by a close friend seems to have more influence on the user’s mood than it is broadcasted by an acquaintance. Thus, our second research question is under what circumstances depression contagion is more likely to occur on SNS. In other words, what factors may amplify or attenuate the relationship between positivity/negativity of message contents and users’ depression levels.

To answer our research questions, we obtained data of 10000 undergraduate students randomly selected from US universities on a large SNS. We will use sentiment analysis to measure message content valence. To accurately measure depression levels, we design a novel mixed approach combining the detection of depressive symptom references displayed on the SNS and user’s online and offline activity trends. Finally, an econometric model is also provided in the paper.

Theoretical Background and Research Hypotheses

What is Depression?
Depression is one of the oldest mental disorders. The recognition of depression can be traced back to more than 2000 years ago, but yet there is no completely satisfactory explanation of its puzzling and paradoxical features (Beck and Alford 2009). Depression is one of the most prevalent mental disorders. Up to 20% of individuals, from children to the elderly, from male to female, from western culture to eastern culture, are affected by depressive disorders (APA 2000; Keck 2010). Finally, depression is also
one of the most dangerous mental disorders. Depressive disorders are associated with a lot of negative consequences, such as marital problems, occupational problems, academic problems, alcohol or other substance abuse and suicide (APA 2000; Deas and Brown 2006; Garlow et al. 2008; Rao 2006).

According to Diagnostic and Statistical Manual of mental disorders volume IV (DSM-IV), depressive symptoms include depressed mood, hopelessness, loss of interest, sleep difficulties etc. (see Table 1; APA 2000). A person can be diagnosed with major depressive episode (MDE), if five or more depressive symptoms are present during the same two-weeks period, and at least one of the symptoms is depressed mood or loss of interest (APA 2000). Based on these depression diagnostic criteria, we design our own measurement of depression by performing text mining of user-generated content as well as analyzing their activities on SNS. We will discuss the details of our measurement in methodology section.

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<td>1</td>
<td>Feeling depressed, sad, hopeless, discouraged, or “down in the dumps”</td>
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<td>2</td>
<td>Feeling less interested in hobbies, “not caring anymore”, or not feeling any enjoyment in activities that were previously considered pleasurable</td>
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<tr>
<td>3</td>
<td>Severe appetite changes (increase or decrease), a significant loss or gain in weight</td>
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<td>4</td>
<td>Sleep disturbance, such as insomnia (common) or hypersomnia (not common)</td>
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<td>5</td>
<td>Psychomotor changes, such as agitation or retardation</td>
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<td>6</td>
<td>Decreased energy, tiredness and fatigue</td>
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<td>7</td>
<td>Sense of worthlessness or guilty, such as unrealistic negative evaluation of one’s worth or guilty preoccupations or ruminations over minor past failings</td>
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<td>8</td>
<td>Impaired ability to think, concentrate, or make decisions</td>
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<td>9</td>
<td>Thoughts of death, suicidal ideation, or suicide attempts</td>
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### Depression and SNS

With the advent of the Internet, many researchers attribute users’ depressive symptoms to the excessive use of it (Kraut et al. 1998; Selfhout et al. 2009). They argued that the penetration of Internet technology decreased users’ communication with family members in the household, causing them to be cut off from genuine social relationships, and increasing their levels of depression and loneliness (Kraut et al. 1998). More recently, a new construct called “Facebook depression” was proposed by some researchers (O’Keeffe and Clarke-Pearson 2011). It is defined as depression that develops when individuals spend a great deal of time on SNS (O’Keeffe and Clarke-Pearson 2011). They maintained that users’ level of depression was positively related to frequency of activities on SNS, because SNS encouraged people to spend more time in virtual world at the expense of deeper discussion and companionship with friends and family (Moreno et al. 2011; Putnam 2001; Rosen et al. 2013).

However, other researchers found no significant relationship (Jelenchick et al. 2013), or even a negative relationship between frequency of SNS activities and depression (Simoncic 2012). They emphasized that SNS reinforced people’s connection with their surrounding social networks and possibly reduced the isolation and boredom that results from lack of friendships (Sum et al. 2009). Regarding these conflicting findings of relationship between SNS usage and depression, Gotlib and Hammen (2009) implied that when we explore the causes of depression on SNS, we should not only focus on the time spent engaging in social networking, but also on the quality or nature of social network experiences. This is in line with Davila et al. (2012)’s study which showed that young adults’ depressive symptoms were only associated with quality (i.e., positive vs. negative) of social networking interactions, but not quantity. Similarly, Valkenburg et al. (2006) also showed that adolescents’ self-esteem and well-being were solely influenced by the tone of their friends’ feedback to profiles, but not influenced by either the frequency of reactions to profiles or relationships formed on the site.

Combining this view and emotional contagion theory, we propose that frequency of SNS activities and time spent on SNS do not directly lead to depressive symptoms. Instead, emotional contagion is the primary mechanism for the emergence of depression on SNS. In other words, most of the depressive
symptoms and mood on SNS are due to the valence of message content, which is defined as the degree to which the emotional tone of the message is positive or negative (Bolls et al. 2001). Since SNS provides great convenience for interpersonal communication, at the same time, it also hugely magnifies the contagion effect of depressive symptoms and mood on the Internet. Therefore, regardless of other determinants of depression, friends’ posting or messaging activities on SNS can greatly affect a user’s level of depression. We will discuss the contagion effect of depression in detail in the following sections.

**Depression Contagion on SNS**

A large number of studies have demonstrated that both depressive symptoms and mood are contagious in the direct face-to-face contact (Joiner and Katz 1999). Theoretically, “emotional contagion” is “a process in which a person or group influences the emotion or behavior of another person or group through the conscious or unconscious induction of emotion states and behavioral attitudes” (Schoenewolf 1990 p.50). That is, individuals have a tendency to mimic the facial expressions, vocal expressions, postures, and instrumental behaviors of others around them, and consequently to converge emotionally (Hatfield et al. 1993). Original emotional contagion theory emphasized the critical role of nonverbal cues (e.g., facial and postural expressions) in the transmission of emotion (Barsade 2002; Neumann 2000), because they believed emotional contagion occurred through a fast process of automatic, continuous, synchronous nonverbal mimicry and feedback (Hatfield et al. 1992). In addition, some researchers indicated that words were central to understanding ideas, but played a less important part in understanding emotions (Mehrabian 2007).

Considering the critical difference between face-to-face communication and computer mediated communication (Sproull and Kiesler 1986), the absence of “social context cues” (e.g., aspects of the physical environment and actors’ nonverbal behaviors) in online environment seems to undermine the effect of depression contagion on SNS. However, in many cases, researchers found that users’ moods were still influenced by their friends’ postings or messages online where nonverbal cues are largely stripped out (Hancock et al. 2008; Hancock et al. 2007). To explain this phenomenon, social information processing theory argued that this was because individuals were able to express their thoughts, attitudes and feelings in text-based interactions with their word choice, punctuation use, and timing (Walther 1992). Therefore, despite the lack of nonverbal cues, depressive symptoms and mood can still spread on SNS. Moreover, the contagion effect tends to be even stronger on SNS than that on face-to-face communication, because there is less limitation of time and physical distance on the Internet.

According to interpersonal theory of depression, excessive reassurance seeking behaviors play a critical role in depression contagion (Coyne 1976a; Coyne 1976b; Joiner 1994; Katz et al. 1999). As depressed people always excessively seek reassurance from significant others to alleviate their doubts as to their own worth or as to whether others truly care about them, interactions with depressed individuals tend to be negative and unpleasant (Coyne 1976a; Coyne 1976b). Similarly, reassurance seeking behaviors also exist in the context of online environment. Since SNS provides a more convenient and efficient platform for individuals to communicate with each other, depressed people tend to express more negative emotions by sending postings or messages on SNS compared to those on face-to-face interactions. Therefore, in this sense, text becomes the media through which depressed individuals induce negative mood in their friends.

Essentially, negative contents produced by a user’s friends (i.e., friend-generated contents) can influence the user’s level of depression. On the one hand, if the friend-generated contents are some negative events related to the user, the user will feel sad after reading the bad news. With the accumulation of sadness induced by all kinds of negative events, the user will probably become depressed. On the other hand, even if the negative message contents are not closely related to the user, the user is still likely to be depressed through priming mechanisms. Theoretically, priming is an implicit memory effect in which exposure to simple stimuli, such as words, influences subsequent perceptions and behaviors (Musch and Klauer 2002). It has been argued that affective priming can influence individuals’ subsequent mood, behavior and cognition (Kruglanski and Higgins 2007). On SNS, certain memory structures which are activated when users read message contents will be triggered again when users respond to related target stimuli next time. Therefore, after the user reads negative message contents, depressive symptoms and mood expressed through negative words may prime a similar emotion of the user. Simply put, the more negative message contents a user reads, the more likely the user is going to be depressed. Thus, we have H1a:
**H1a:** Negativity of message content is positively related to user's depression level.

On the contrary, positive message contents have the opposite effect on depression as the negative ones. On the one hand, if the message contents are closely related to the user, good news brings the user a pleasant mood, which has a great effect on attenuating levels of depression. On the other hand, if the contents are not related to the user, the priming effect will attenuate user's depression. Therefore, after the user reads positive message contents, no matter related to him/her or not, he/she is going to feel less depressed, and show less depressive symptoms. Thus, we have H1b:

**H1b:** Positivity of message content is negatively related to user's depression level.

So far, we have demonstrated that depressive symptoms and mood are contagious through text-based communication on SNS. More specifically, negative/positive message contents have an effect on increasing/decreasing users' levels of depression. However, the contagion effect seems to be different in different situations. Thus, we would like to investigate under what circumstances depressive symptoms and mood are more likely to be transmitted from one person to another. Previous literature has posited that emotional contagion is enhanced with the increase of attention on the partner (Barsade 2002; Hancock et al. 2008). In the context of SNS, since depression is transmitted via messages or postings, the amount of attention on the message contents are affected by both communication mode and source of the contents. Therefore, we will discuss the moderating effect of communication specificity and tie strength on the depression contagion in the following sections.

**Directed Communication versus Undirected Communication**

At the essence, there are two modes of communication different in specificity on SNS: directed communication with certain individual friends and undirected communication with a wide audience (Goh et al. 2013). Directed communication, which consists of personal, one-on-one exchanges, includes private messages and synchronous chat. Undirected communication is a novel feature of SNS. It is not targeted at a particular other, and includes broadcasting status updates, links and photos (Burke et al. 2011). Generally, directed communication provides more intimate and related information to the receivers than undirected communication (Gilbert and Karahalios 2009). In addition, for a directed message, because it evokes norms of reciprocity, receivers feel obligated to reply, and thus pay more attention to it. Nevertheless, for a broadcast message, because the author does not know who has read it, receivers feel no obligation to reply, and thus pay less attention to it (Burke et al. 2011). Therefore, a directed message to a target user is usually expected to capture more attention than an undirected one to the mass population (Amaldoss and He 2009).

Prior literature posits that attentional processes mediate the degree to which depression contagion occurs (Hatfield et al. 1992; Hatfield et al. 1994). That is, greater contagion takes place when more attention is paid to the partner. Based on this view, we propose that the effect of depression contagion is stronger in directed communication than that in undirected communication. Specifically, if a user receives a one-on-one message, because she thinks she is obligated to reply to it, she will pay much attention to the message and read it carefully. Thus, the priming effect is stronger and more enduring when a lot of attention is allocated to the message (Becker et al. 1997; Kruglanski and Higgins 2007), and the user is more likely to be influenced by the valence of the contents. On the contrary, if a user sees a broadcast status update, because there is too much irrelevant information on SNS (Tam and Ho 2005), she may just take a glance at it, or even skip the posting. In this case, the priming effect is weak or even no priming occurs. Accordingly, the user is less likely to be influenced by the posting.

In addition, another reason, which may explain the moderating effect of communication specificity on depression contagion, is because more related and intimate contents are usually contained in directed communication than those in undirected communication (Burke et al. 2011). Since people tend to pay more attention to the information related to themselves, they are more likely to be influenced by the message in directed communication. So the effect of depression contagion in directed communication is stronger than that in undirected communication. Therefore, we have H2a and H2b:

**H2a:** Communication specificity moderates the relationship between negativity of message content and user's depression level, such that the impact is stronger if negative contents come from directed communication than if negative contents come from undirected communication.
H2b: Communication specificity moderates the relationship between positivity of message content and user’s depression level, such that the impact is stronger if positive contents come from directed communication than if positive contents come from undirected communication.

**Strong Tie versus Weak Tie**

In addition to communication specificity, we argue that tie strength also moderates the relationship between negativity/positivity of message contents and depressive symptoms. SNS is “designed to connect people with friends, family and other strong ties, as well as to efficiently keep in touch with a larger set of acquaintances and new ties” (Burke et al. 2011 p.571). According to prior literature, strong ties refer to relationships associated with frequent contact, deep feelings of affection and obligation, whereas weak ties refer to relationships with infrequent contact, superficial and easily broken bonds (Kraut et al. 1998). Generally speaking, both strong and weak ties are capable of providing individuals with social support. However, they are still different in more specific ways. That is, weak ties focus on offering people access to novel information and social resources which are unavailable in their closest, local groups (Granovetter 1973), while strong social ties enable specific reciprocity, emotional support and companionship from close others (Wellman and Wortley 1990). Considering the fact that people receive most emotional and social support as well as big help from close relationships (Wellman and Wortley 1990), they tend to pay more attention and care more about those with strong ties.

Furthermore, previous literature has shown that friendship has an influence on peer socialization, defined as individuals changing their behavior to resemble those of their peers (Kiuru et al. 2012). For example, Prinstein (2007) found that high levels of positive friendship quality enhanced peer socialization of depressive symptoms. Brechwald and Prinstein (2011) indicated that friendship reciprocity, as a possible reflection of the cohesion and affinity between individuals, was a potential moderator in the process of peer influence. Therefore, in our study, we propose that tie strength between the sender and receiver has an effect on the depression contagion on SNS.

Specifically, if a user sees a message or posting sent by a friend with strong tie, because this person is important to him/her and the message is very likely to be related to him/her, he/she probably pay more attention to the content and read it carefully. In this case, the priming effect is strong (Becker et al. 1997), and there is much chance that the user is influenced by the negativity or positivity of the message contents. On the contrary, if a user sees a message or posting sent by an acquaintance with weak tie, because there is tons of information produced by those with weak tie every day, he/she may just take a glance at it, or even skip the message/posting. In this case, weak or even no priming occurs, and the user is less likely to be influenced by the negativity/positivity of message content. Therefore, we have H3a and H3b:

H3a: Tie strength moderates the relationship between negativity of message content and user’s depression level, such that the impact is stronger if negative contents come from source with strong tie than if negative contents come from source with weak tie.

H3b: Tie strength moderates the relationship between positivity of message content and user’s depression level, such that the impact is stronger if positive contents come from source with strong tie than if positive contents come from source with weak tie.

Figure 1 presents our research model, which indicates that negativity or positivity of message content enhances or diminishes levels of depression on SNS, while communication specificity and tie strength are two factors that tend to amplify or attenuate this relationship.
Methodology

Sample and Data Collection

We obtained data through collaboration with a large SNS. The raw data consists of three parts: user profile information, user friendship information, and the text of user actions such as posts and messages. From this data set, we randomly select 10,000 undergraduate users from US universities as our sample. Their action content was recorded from November 18th 2010 to October 6th 2011, inclusively. By using longitudinal panel data, we go beyond the cross-sectional research common in this area, and can make stronger causal claims about how depression is transmitted over SNS. Due to the data scarcity, and because it usually takes a relatively long time for the depressive symptoms and mood to be transmitted (Howes et al. 1985; Joiner 1994), we choose a week, instead of a day, as the time unit of data analysis.

Measures

Previous studies have employed a wide variety of methods to measure positive or negative emotion (Berger and Milkman 2010; Gruzd et al. 2011; Sum et al. 2009). One of the most common approaches is to use a survey instrument. The second approach is to use human coders to rate a specific piece of text based on a detailed coding system. The third approach is sentiment analysis, which leverages a computer program to automatically process and analyze text to determine its polarity. Since sentiment analysis is more objective, and more scalable to large datasets than the other two approaches (Gruzd et al. 2011; Pang and Lee 2008), we use sentiment analysis to measure the negativity/positivity of message content in our study.

We choose to use a system called SentiStrength developed by researchers from a European university for the sake of its specificity in analyzing informal short online messages. It has been tested to show high accuracy of predicting positive and negative emotions from SNS messages (Thelwall et al. 2010). After SentiStrength assesses each message, it will give two separate and independent numbers for the certain message: a positive polarity value (1 to 5) and a negative polarity value (-1 to -5). Then, we add these two separate numbers together to get a final polarity value. Normally, a message with a final polarity value greater than or equal to 2 is considered a positive message, whereas a message with a final polarity value less than or equal to -2 is considered a negative message. All messages with final polarity values of 1, 0 and -1 are regarded as neutral. Therefore, negativity of message content is measured by calculating the proportion of negative messages in all messages received by a user. Similarly, positivity of message content is measured by calculating the proportion of positive messages in all messages received by a user.

Although most of the prior studies use self-report survey to measure individuals’ depression levels (e.g., Aseltine et al. 1994; Jelenchick et al. 2013; Joiner 1994), this method may not be accurate due to the phenomenon called “Social Desirability Bias”. That is, because individuals want to be viewed positively, they usually under-report negative phenomena, such as stealing, lying and depression (Crowne and
Marlowe 1960; Williams et al. 1992). To solve this problem, Moreno et al. (2011) suggested using displayed higher levels of self-disclosure and uninhibited emotional expression, people were more willing to display depressive symptoms and mood on SNS than in reality (Moreno et al. 2011; Walther and Parks 2002). Therefore, they modified DSM criteria for an MDE by applying it to Facebook: five or more status updates that met DSM criteria as a symptom for depression within a two-week period, and at least one update regarding depressed mood or loss of interest/pleasure (Moreno et al. 2011).

However, a following study, which evaluates the association between depression symptom references on SNS and self-reported depression using a clinical scale, showed that we could only use public depression symptom disclosures on SNS to detect mild depression symptoms (Moreno et al. 2012). For moderate or severe depression patients, they may not be willing to display their symptoms on SNS. To solve this problem, we employ a more comprehensive approach to measure depression. First, we use a batch of keywords, such as “hopeless” or “sad”, to detect depression references on SNS. Different from Moreno et al. (2012)’s approach, we do not only focus on status updates on SNS but also take private messages into consideration. Because we believe that moderate or severe depression patients may not disclose a lot of depression symptoms in public postings, but it is highly likely that they express it in private messages to their close friends.

Second, since one of the most important symptoms of depression is diminished interest or pleasure in all or almost all activities, a severe depressed person is usually not interested in using SNS as well as other offline activities. Thus, when we measure depression levels, we also take individuals’ trend of online and offline activities into consideration. A sudden drop in online or offline activities is regarded as another indicator for depression. To measure the frequency of offline activities, we use the number of picture tag approvals on the SNS as a proxy, because a person is tagged in a photo usually after he/she conducts offline activities with his/her friends.

In addition, communication specificity for a certain user is measured by computing the proportion of one-on-one negative (positive) messages in all negative (positive) messages received by the user during a week. Tie strength between two individuals is usually calculated by the number of personal messages to the user during a certain period of time (Kossinets and Watts 2009). In our study, we measure the tie strength for a certain user by taking the average tie strength of those who send positive (negative) messages to the user during a period of time.

**Econometric Model Specifications**

Therefore, we have the econometric model as following:

\[
Depression_{it} = \beta_1 \text{Negativity}_{i,t-1} + \beta_2 \text{Positivity}_{i,t-1} + \beta_3 \text{Negativity}_{i,t-1} \times \text{Specificity}_{i,t-1} + \beta_4 \text{Positivity}_{i,t-1} \times \text{Specificity}_{i,t-1} + \beta_5 \text{Negativity}_{i,t-1} \times \text{TieStrength}_{i,t-1} + \beta_6 \text{Positivity}_{i,t} \times \text{TieStrength}_{i,t-1} + \theta_i + \alpha_i + \epsilon_{it}
\]

On the left-hand of the equation, dependent variable *Depression* is measured by three indicators: i.e., increase of depression symptom references on the SNS, decrease of SNS activities, and decrease of offline activities for user *i* at week *t*. On the right-hand side of the equation, *Negativity*, *Positivity*, *Specificity* and *TieStrength* are negativity of message content, positivity of message content, communication specificity, and tie strength, respectively, for user *i* at week *t-1*. \(\theta_i\) refers to time dummies. \(\alpha_i\) denotes the individual-specific effect. \(\epsilon_{it}\) denotes the residual error term.

**Conclusion**

In this study, we build a new theory about depression contagion on SNS. By combining depression literature with human-computer interaction and social network literature, this study has the potential to make both theoretical and practical contributions. First, we compare the mechanism of depression contagion between online and offline. We indicate that depression contagion really occurs on SNS, and it tends to be the primary reason for being depressed on SNS. Second, we further investigate under what circumstances the contagion effect is stronger. Two possible moderators: communication specificity and tie strength are discussed in the paper. Third, we leverage sentiment analysis to analyze the large sample data, and propose a novel mixed approach to measure depression. By using this new method, we can not
only observe the contagion of depressive mood but also the contagion of depressive symptoms. Forth, by using longitudinal data, we make stronger causal claims about how depression is transmitted on SNS. Finally, based on future results of the study, we are able to find some methods to alleviate depression that may occur via communication on SNS.

References


