Internet Research

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Received 13 November 2013
Revised 3 December 2013
16 February 2014
14 May 2014
2 June 2014
Accepted 2 June 2014

Abstract

Purpose – The purpose of this paper is to predict tie strength using profile similarities and interaction data between users, and thus distinguish between strong and weak relationships on social network sites (SNSs).

Design/methodology/approach – This study developed a program and an online questionnaire to collect the data set from Facebook, and then integrated that data set with a subjective data set consisting of participants' opinions of the strength of their friendships on Facebook. The model developed here for predicting tie strength performed well when was applied on a data set of 6,477 SNSs' ties, distinguishing between strong and weak ties with over 50 percent accuracy.

Findings – The results developed an algorithm (predictive model) that quantifies and measures tie strength continuously to bridge the gap between theory and practice. The results found that the variables in the dimension of emotional intensity had stronger effects than other interaction variables.

Originality/value – This study developed a predictive model that helps explain the meaning of interaction on SNSs, providing an efficient method to examine tie strength on SNSs. The tie strength estimates can also be used to improve the range and performance of various aspects of SNSs, including link predictions, product recommendations, newsfeeds, people searches, and visualization. Such understanding of the structure of SNSs might lead ultimately to the design of algorithms that can detect trusted or influential users of SNSs.

Keywords Facebook, Social network sites, Algorithm, Tie strength

Paper type Research paper

1. Introduction

Tie strength is a network concept that has attracted arguably the most research attention and thus this area of study has seen the most substantial contributions (Gilbert and Karahalios, 2009; Granovetter, 1973; Haythornthwaite, 2002; Marsden and Campbell, 1984). Tie strength is a quantifiable property that characterizes the link between two nodes, determining the ways, means, and expressions of communications between the nodes, as well as the motivations, needs, and desires for the communication (Granovetter, 1973; Haythornthwaite, 2002; Chu and Kim, 2011). People with strong ties (e.g. close friends) are more likely to exhibit greater similarities, and share and exchange more intimate information, than peoples with weak ties (e.g. acquaintances) (Haythornthwaite, 2002). Treating all relationships as equal may increase the level of noise in examining tie strength and degrade the performance of the predicting models (Xiang *et al.*, 2010). Thus, understanding relational ties can help predict behavior more accurately and improve ways to disseminate information. However, in previous studies, participants were only asked to recall their closest friends, or in those studies questionnaires were used to measure the relationship strength (Granovetter, 1974; Mathews *et al.*, 1998; Petroczi *et al.*, 2007). Results of such studies based on one-sided statements have not been able to measure tie strength accurately because relationships

This research was sponsored by the National Science Council of Taiwan, under the project number NSC 101-2410-H-011-002.

Internet Research
Vol. 25 No. 2, 2015
pp. 218-238

1066-2243
DOI 10.1108/IntR-11-2013-0231

are two-way communications, and also because the strength of ties is a changeable variable that is influenced quantitatively by the interaction between people, which has been challenging to examine in the past. Moreover, previous studies have captured these diverse and overlapping networks of relationships poorly because they failed to verify the frequency and duration of interactions.

A solution for the accuracy problems that plagued previous studies on tie strength has emerged from the development of social network sites (SNSs) that contain information on personal and interactions among users. SNSs such as Facebook and Twitter are online platforms for interacting, collaborating, and creating and sharing of various types of digital content (Chen *et al.*, 2012; Shao, 2009). SNSs have changed the way people communicate online by enabling them to present information about themselves online and also connect with others (boyd and Ellison, 2007). For instance, Facebook users can post general messages and photos, send private messages, participate in groups and events, and add comments (Baltar and Brunet, 2012). People also share their purchasing experiences, product knowledge, or other new occurrences in their lives with friends using the Newsfeed feature, and use the SNSs to seek or receive such information (Araujo and Neijens, 2012; Chen *et al.*, 2012; van Noort *et al.*, 2012). Other users interact by posting comments, clicking "like," and sharing the information posted. These interactions not only further disseminate information through Facebook, but also store digital records that help verify relationships between users (Gilbert and Karahalios, 2009; Kalampokis *et al.*, 2013; Petroczi *et al.*, 2007). The data thus measure tie strength more reliably and accurately than previous questionnaires or observations. Because SNSs maintain users' "friends" lists and interaction histories, participants in studies on tie strength no longer have to recall their relationships with friends. Thus, unlike in previous studies, in this study the interaction data from Facebook were used to demonstrate that previous studies were unable to measure precise tie strength on SNSs quantitatively and continuously.

Because resources such as time and money available to people for forming and maintaining relationships are finite, people direct these resources toward relationships that they deem important (Dindia and Canary, 1993). Thus, the nature and frequency of online interactions between a pair of users depends on the strength of their relationship (Houghton and Joinson, 2010; Xiang *et al.*, 2010). The data sets maintained by SNSs allow relationships between users to be examined directly by monitoring, for example, interaction activity on Facebook (through communication or tagging) (Kalampokis *et al.*, 2013). The stronger the relationship between two users, the higher the likelihood that the two interact through the SNSs being examined (Houghton and Joinson, 2010; Xiang *et al.*, 2010). Therefore, this study aimed to eliminate spurious interactions and examine the key factors for measuring tie strength on SNSs.

2. Research objective

The research objective in this study was to design an algorithm (predictive model) that can provide a quantitative and continuous measurement of the precise tie strength of relationships. To achieve the goals of the study, we developed a program and an online questionnaire to collect an objective data set from Facebook and integrate that data set with a subjective data set consisting of participants' opinions of the strength of their friendships on Facebook. Specifically, the model used a data set of 6,477 SNSs' ties and was able to distinguish between strong and weak ties with over 50 percent accuracy. The model contributes to the understanding of interactions on SNSs and provides an efficient method to examine tie strength on SNSs, and the parameters developed can be

applied to estimate the tie strength of new test pairs in real time. In addition, the tie strength estimates can also be used to improve the range and performance of various aspects of SNSs, including link predictions, product recommendations, newsfeeds, people searches, and visualization. Such understanding of the structure of SNSs might lead ultimately to the design of algorithms that can detect trusted or influential users of SNSs.

The remainder of this manuscript is organized as follows. The next section provides a synopsis of the extant literature to define tie strength, describes how stronger tie mean longer relationships with more emotional intensity, and discusses the structural variables and social distance in tie strength. The fourth section describes the methods used to examine the key factors for measuring tie strength on SNSs. The fifth section discusses the results of the tests of the hypotheses tested in this study. In the final section present, we offer directions for future research and discuss theories and managerial implications.

3. Theoretical background

3.1 Tie strength

People connect with each other and form relationship networks, with individuals and the relationships between them appearing like points and as lines (Scott, 1990) that have distinct strength (Granovetter, 1973). Because SNSs user has a finite amount of resources such as time to use in forming and maintaining relationships, they are likely to direct the resources toward relationships they consider important (Dindia and Canary, 1993; Van Noort *et al.*, 2012). Granovetter (1973) defined tie strength as a combination of the amount of time, emotional intensity, intimacy, and reciprocal services devoted to a relationship, with all these factors being independent but correlated. For decades, researchers have used this definition to examine interactions between tie strength and media usage (Haythornthwaite, 2002; Marsden and Campbell, 1984) and how diverse types of relationships affect people and organizations (Gilbert and Karahalios, 2009; Petroczi *et al.*, 2007; Steffes and Burgee, 2009; Xu *et al.*, 2012). For example, Steffes and Burgee (2009) described tie strength as the level of intensity of a social relationship between two people. Petroczi *et al.* (2007) further found that tie strength may affect the closeness, duration, and frequency of interactions between people, the breadth of the topics they discuss, and how much they confide in each other.

Tie strength plays a key role in our ability to access resources and complete tasks. Tie strength also affect the nature and frequency of online interactions between pair of users (Houghton and Joinson, 2010; Xiang *et al.*, 2010). Strongly tied pairs interact more frequently and intimately (Granovetter, 1983; Haythornthwaite, 2002), sharing more information, revealing more about themselves, supporting each other emotionally and reciprocally, and committing more time for each other (Granovetter, 1983; Haythornthwaite, 2002; Marsden and Campbell, 1984). These frequent interactions and time commitment not only offer emotional support and information to users, but also circulate information across their network of friends and therefore enhance access to help when necessary (Chu and Kim, 2011; Granovetter, 1983). Moreover, strongly tied pairs tend to trust each other (Lin and Bhattacherjee, 2008) and can influence their friends to use and adapt new media to increase the range of their relationship (Haythornthwaite, 2002; Houghton and Joinson, 2010). Strong ties also result in frequent word-of-mouth (WOM) referrals of information aligned with a recipient's wants and needs (Steffes and Burgee, 2009; Xu *et al.*, 2012).

Conversely, weak ties, which exist between acquaintances that interact less often and are less intimate than close friends, are an indispensable part of the SNSs structure

(Granovetter, 1983; Haythornthwaite, 2002). However, there are still many benefits associated with maintaining weak ties, such as inclusion and empowerment of casual friends (Granovetter, 1983). Moreover, information is also considered to be spread over greater social distance (path length) through weak ties. These features not only support the development of creative ideas and help people find employment, but also enliven the communication of knowledge by bringing in ideas of people outside specific groups (Chu and Kim, 2011). Thus, relationships with weak ties can link two densely knit clusters of close friends (Granovetter, 1983) and increase users' chances of connecting with diverse groups and people (Van Noort *et al.*, 2012).

3.2 The measure of tie strength

Tie strength is a quantifiable social network concept that measures the quality of relationships (Petroczi *et al.*, 2007). Many researches have adopted the criteria from Granovetter (1973) to measure tie strength which includes four tie strength dimensions: amount of time, intimacy, emotional intensity, and reciprocal services (Erickson *et al.*, 1978; Granovetter, 1974; Gilbert and Karahalios, 2009; Marsden and Campbell, 1984). Moreover, several researchers have also attempted to identify other indicators of the tie strength between people, such as structural variables (Ellison *et al.*, 2007; Lin *et al.*, 1981; Xiang *et al.*, 2010), emotional support variables (Marsden and Campbell, 1984; Wellman and Wortley, 1990), and social distance variables (He *et al.*, 2012; Lin *et al.*, 1981). In total, seven dimensions can be used to examine the strength of ties from previous studies.

Amount of time can be addressed by the frequency and duration of contact (Li and Hung, 1997; Lin *et al.*, 1981; Granovetter, 1973). According to the prior study, the higher interaction with one another, the stronger sentiments of friendship people feel (Benassi *et al.*, 1999; Krackhardt, 1992; Mathews *et al.*, 1998).

Emotional intensity means the recognition of entities to produce intrinsic emotions, which stresses more on cognition of the other (He *et al.*, 2012; Mathews *et al.*, 1998). Emotional intensity is relative to absolute strength, rather than a kind of direction such as positivity or negativity (Kwon *et al.*, 2013). People with high intensive relationships will spend more time together and produce longer duration than people with less intensive relationships (Granovetter, 1973; Mathews *et al.*, 1998).

Intimacy is defined as the deep affection between two entities acting as a sense of reliance and security (He *et al.*, 2012; Marsden and Campbell, 1984; Petroczi *et al.*, 2007). Intimacy relationships are willing to talk all the time with open mind to get or provide recognition and support. It requires considerably more commitment and presumably higher level of positive affect toward alter (Lewis *et al.*, 2008).

Emotional support refers to providing messages that involve emotional concerns, such as caring, understanding, or empathy to another individual and reassuring the person that is a valuable one to care about (Taylor *et al.*, 2004). According to previous studies, strong tie provides a powerful emotional support that not only improves personal mental health, but also unites individuals to overcome crisis (Kendler *et al.*, 2005).

Reciprocal services mean the difference forms of interaction or specific services on communication. Granovetter (1983) and Krackhardt (1992) had suggested that strong tie is motivated to share what information or resource they have, and thus provides a ready access to information circulating their network. Hence, strong tie includes more reciprocity services in exchanges (Granovetter, 1983).

Structural variables are defined as a function of social homogeneity, shared affiliation, and overlap of social circles (Alba and Kadushin, 1976; Ellison *et al.*, 2007;

Xiang *et al.*, 2010). According to previous studies, strong ties tend to bond similar people to each other, and these similar people tend to cluster together such that they are all mutually connected (Gilbert and Karahalios, 2009; Granovetter, 1973). Thus, if strong ties connect A to B and A to C, B and C are probably similar to each another because they are both similar to A, and thus increase the likelihood of a friendship once B and C have met (Granovetter, 1973).

Social distance means the difference in socioeconomic status, education level, political affiliation, and race and gender (Lin *et al.*, 1978, 1981). According to Gilbert and Karahalios' (2009) study, strong ties are the connections between people who with the same age and interests, and share certain life activities.

3.3 The measure of tie strength on SNSs

Previous work on SNSs has assumed that the characteristics of ties are maintained in social media environments as they are in the offline environment (Haythornthwaite, 2002). Petroczi *et al.* (2007) concluded that relationship indicators in virtual groups are similar to those in offline networks. Like offline ties, strong online ties are expected to demonstrate more varieties of interaction and exchange, or strongly emotional support (Haythornthwaite, 2002). When tie strength between two SNSs users increases linearly from weak to strong, their motivation to communicate, the extent and types of information and resources they exchange, and the amount of mutual support they offer increases (Haythornthwaite, 2002). The SNSs data sets can be used to examine the relationships between users, for example, interaction activities on Facebook (through communication or tagging) (Kalampokis *et al.*, 2013). Gilbert and Karahalios (2009) suggested that interaction data on Facebook, such as posted messages and photos, private messages sent, and participation in groups and events, may help in predicting relationship strength well. Although the text is the general means to exchange information, mining Facebook text content might raise private concerns. Most of the emotional support is obtained from text exchange which is private and sensitive. Therefore, to avoid the privacy dispute, this study excluded emotional support dimension, and then used the dimensions of amount of time, emotional intensity, intimacy, reciprocal services, structural variables, and social distance to predict tie strength on Facebook.

4. Methods

4.1 Study design and program development

To figure out sufficient variables which can predict tie strength on SNSs, this study chose the Facebook as the object that is rich in active users and interaction records.

To collect data on user interactions and profiles from Facebook, this study developed a program and an online questionnaire base on the Facebook application. The program was developed using PHP and JavaScript as programming language to operate on Microsoft Windows Server 2008 R2 Standard, Apache 2.2.4, and MySQL 5.0.45. For accessing the social network data set on Facebook, the program used Facebook Software Development Kit (SDK) and the Facebook Query Language (FQL) object to connect to the participants' Facebook accounts.

In this program, participants were requested to permit program to access their Facebook account. This program collected the basic information and interaction records automatically after being authorized. This study was able to avoid situation such as those in which participants of studies indicated that they do not remember

specific actions they have performed or the characteristics they have in common with their friends (Marsden, 2003). In addition, a questionnaire was also generated for participants on this Facebook platform.

After authorizing the program, participants were asked to fill the questionnaire regarding their friends. The testing time was ongoing for 30 minutes based on pervious study (Gilbert and Karahalios, 2009). In statistics, 30 is a good rule of thumb in most cases for normality assumption (Lehmann and Romano, 2006). This is just an agreed upon approximation of an infinite normal distribution. Six-item questionnaire rated one friendship in less a minute. 30 minutes is long enough to collect sufficient data records without tiring participants.

In the 30-minute rating process, the program was designed to assign friends to participants by two rules. One was a random of overall friends, which listed in even order. Moreover, according to the concept of social network structure, the amount of strong tie is fewer than weak tie (Pollet *et al.*, 2011). Therefore, to obtain an equal proportion of strong and weak tie friend samples, another rule was designed to select friends from who interacted with participants in a week, which listed in odd order. Participants were unaware of this setting while rating their friends on the page. They only saw photos of a friend with friend name and the six-item questionnaire in each page to help participants assessing their tie strength. This page kept recreating for different friends in 30 minutes (see Figure 1).

4.2 Study procedure

Undergraduates were recruited to complete an experimental survey. They did the survey on internet. First of all, participants logged in their Facebook and enter the program of this study. They saw an authorization terms at initial page. They had right to leave if they did not want to authorize our program accessing their personal records. After granted permission from participants, they were rating their friends on pages in a continued 30 minutes. The study procedure is illustrated in Figure 2.

4.3 Measurements

Information was collected in two ways. The subjective tie strength perception was from the online questionnaire. The objective tie strength data set was participants' interaction records, which downloaded from Facebook.

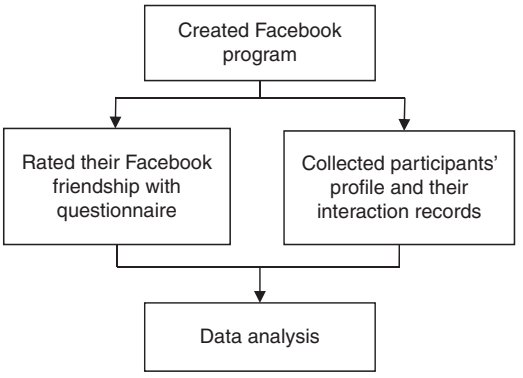

Figure 1.
Study design of this study

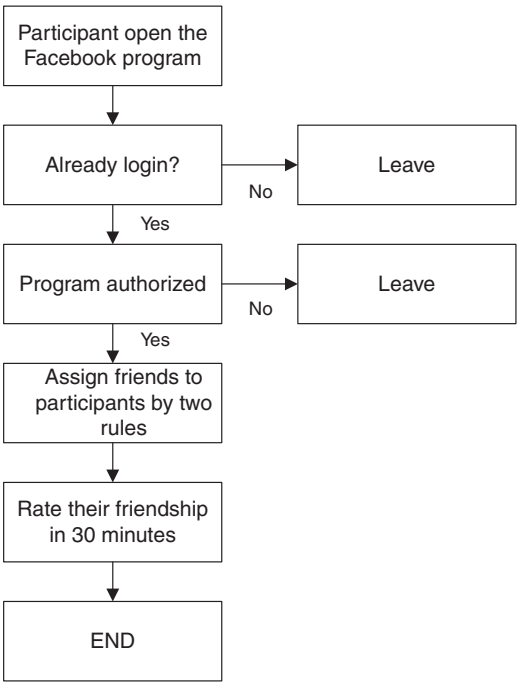

Figure 2.
Study procedure

Subjective tie strength data: online questionnaire. The questionnaire included six items, with item one to five being based on the items of Gilbert and Karahalios (2009) that combine ideas from Granovetter (1973) and Marsden and Campbell (1984). The first item asked about the relationship strength directly: "How strong is your relationship with this person?" Items two to five were based on tie strength dimensions developed from the point of view of Granovetter (1973), but without the item about the amount of time spent on the relationship, because Facebook provided an objective data set to evaluate the amount of time. The items were: How would you feel about asking this friend to loan you $100 or more? How helpful would this person be if you were looking for a job? How upset would you be if this person "unfriend" you? If you left Facebook for another SNSs, how important would it be to bring this friend along? The sixth item was a manipulation check item. This item was, "How often would you contact this friend via Facebook?" The purpose of this item was to delete the friendships only close in physical world or other SNSs and used to stabilize the results.

Because the tie strength exist in a continuum (Granovetter, 1973), the questionnaire was designed as a continuum, with all items being answered by dragging a bar across a slider to estimate friendships; the bar could be moved from 1 to 100 degrees to indicate the tie strength. Previously, sufficient data were unavailable for analysis using this continuum concept, but now the Facebook database that includes all types of interaction records that help us analyze the influence of tie strength on interactions.

Objective tie strength data: interaction records. Facebook provides personal information (such as gender, relationship status, and political and religious views) and

data on users' interactions with their friends (Kalampokis *et al.*, 2013). In this study, interaction activities were distinguished from users' profile data and these two types of information were integrated; the relationship strength was considered to be a hidden factor affecting similarities in user profiles and also a hidden reason for interactions between users. A series of relative variables was identified to classify the interaction information that could be quantified and compared, and to classify the Facebook variables into the six dimensions (amount of time, emotional intensity, intimacy, reciprocal services, structural variables, and social distance) discussed above (see Table I). In total, 58 Facebook variables in six dimensions were identified as potential predictors of tie strength.

Amount of time was measured by duration of interaction and contact (Krackhardt, 1992; Li and Hung, 1997). To define it on Facebook, amount of time can be represented by the days since the last communication and the days since the first communication, as duration of contact.

Emotional intensity reflects the recognition of entities to produce intrinsic emotions, such as having at least one posting between two participants and used the number of posting on each strand and frequency to indicate strength (Muncer *et al.*, 2000).

Tie strength dimension	Content
Amount of time	Day since first communication (the first time leaving message, comment or tag)
	The last time interaction
Emotional intensity	Communication with friend
	Number of wall post made by the friend.
	Number of comment made by the friend. (On participants' wall post, album, photo, video or note.)
	Number of likes clicked by the friend. (Click like on participants' wall post, comment, album, photo, video or note)
	Number of messages was send.
Intimacy variables	Relationship status in common
	Participant's number of friends
	Appearances together in photo (Number of tag with the friend
	Listed in the same check-in with the friend
Reciprocal services variables	Links exchanged by wall post
	Application in common
Structural variables	Interest in common
	Book, interest, activity, movie, music, TV, art, sport
	Listed in the same network
	Fans page, public or privacy group
	Number of event that was joined together.
	Relation between participant and the friend (family member, colleagues, classmates, friends)
	Number of mutual friends
Social distance	Identity
	Gender, age, blood type
	Language setting.
	Current location and hometown.
	Believing
	Philosophy, religion, politics view
	Work and Education (degree) history

Table I.
The factors influence the tie strength dimensions of Facebook interaction information

On Facebook, the time users spend with their friends and the duration of each contact can be represented by interaction records (Chen *et al.*, 2012; Gilbert *et al.*, 2008). Hence, this study used the number of wall post, comment, message, and like click from friend to measure emotional intensity on Facebook.

Intimacy means one pays special attention to someone and wants to share something particularly with him (He *et al.*, 2012). On SNSs, Gilbert and Karahalios (2009) and Xiang *et al.* (2010) suggested that the total number of pictures that a user tags represents their intrinsic tendency to tag pictures, which can affect the strength of their relationship with other users. The act of publicly posting a photo of someone and listing in the same check-in suggested that ego wishes their relationship with alter to be socially recognized (Xiang *et al.*, 2010). Therefore, this study used relationship status in common, participant's number of friends, appearances together in photo (number of tag with the friend), listed in the same check-in with the friend to measure the level of intimacy on Facebook.

Reciprocal services capture a basic way in which difference forms of interaction or specific services on SNSs, which includes links exchanged and applications in common (Cheng *et al.*, 2011; Gilbert and Karahalios, 2009). Gilbert and Karahalios (2009) indicated that Facebook applications usually provide a tightly scoped service and often spread between friends by WOM. Similarly, links exchanged by wall post was also difference between strong and weak ties, which measures by the number of URLs passed between friends. Thus, the reciprocal services variables on Facebook can be measured by links exchanged through wall post and applications.

Structural variables include social homogeneity, shared affiliation, and overlap of social circles (Alba and Kadushin, 1976; Ellison *et al.*, 2007; Xiang *et al.*, 2010). On SNSs, people who pay attention to similar content, topic, groups, or produce resemble behaviors are probably possess high tie strength (He *et al.*, 2012; Muncer *et al.*, 2000; Petroczi *et al.*, 2007; Shi *et al.*, 2007). In addition, Adamic and Adar (2003) also suggested that having mutual friends seems to foster relationship developments. According to the prior studies, the structural variables on Facebook can be measured by interest in common (book, interest, activity, movie, music, TV, art, sport), listed in the same network (fans page, public or privacy group, and the number of event that was joined together), relation between participant and the friend (family member, colleagues, classmates, and friends) and the number of mutual friends.

Social distance variables include socioeconomic status, education level, political affiliation, and race and gender (He *et al.*, 2012; Lin *et al.*, 1978, 1981). According to the prior studies (Gilbert and Karahalios, 2009; Lewis *et al.*, 2008), the information listed in Facebook profile such as identity information (gender, age, blood type), language setting (current location and hometown), believing (philosophy, religion, politics view), and work and education history, can be used to measure social distance.

Moreover, because Facebook allowed access to each type of interaction records for distinct periods, this study had to decide carefully which type of interaction might be useful for our study (see Table II).

4.4 Participants

In this study, 145 undergraduates (68 males and 77 females) were recruited to visit the laboratory to control experimental conditions. They were convenience samples. The participants were on average 20.78 years old (SD = 0.98), ranging from 18 to 22, and the mean number of Facebook friends they had was 302 (SD = 95.89). Our sample

Platform	Interaction types and Limitation
Wall post	Information of the post on participant's wall
	Access limitation: the last 3000 post on participant's wall in the last 90 days
	Likes and comments: friends who click like or comment of the post on participant's wall, and who click like on those comments
	Tag: friends who been tagged in post on participant's wall
Albums, photos and video	Information of all the albums, photos and videos uploaded by participant
	Likes and comments: friends who click like or comment on participant's album, photo or video, and friends who click like on those comments
	Tag: friends who been tagged in the photo or video uploaded by participant
Notes	Information of all the notes uploaded by participant.
	Likes and comments: friends who click like or comment on participant's notes, and friends who click like on these comments
Check-in	Information of all the check-in made by participant
	Likes and comments: friends who click like or comment on participant's check-in, and friends who click like on those comments
	Tag: friends who been tagged in the check-in made by participant
Message	Information of the messages sends via mailbox or chatting room
	Access limitation: the message thread which is activated in the last 90 days, maxima 500 messages can be access in each message thread
	Friend who contact with participant
	Number of message sends between participant and their friends
Group, page and event	Friends who joined in the same group, page or been invited in the same event with participant

Table II.
Type of interaction and the period of records this study utilized.

is similar from the results of the online user demographic report of Tong *et al.*'s (2008) study (53 percent female; 20.18 years old), and the average number of Facebook friends is also closed to Lampe *et al.*'s (2008) study (currently above 300). The average Facebook usage experience of participants is 3.42 years (SD = 1.37). The frequency of posting is 3.12 times/day (SD = 0.42). The frequency of comment is 4.12 times/day (SD = 1.23). The results showed a data set of 6,813 rated Facebook friendships in 145 samples.

5. Results

Before examining the relationship between the interaction variables and the tie strength, certain friendship data were excluded to predict tie strength more accurately. The first exclusion rule is counting the score different between first item and sixth item. If the score of sixth item is lower than 50 and the score of first item is higher than 50, it means that the Facebook is not their major communication tool. These data records would bias the model and should be deleted. The second exclusion rule is based on Robers and Dunbar (2011) and Haythornthwaite (2002). They suggested that kin relationships would remain stable over time even if they interacted seldom. Accordingly, the kin relationships would also bias the result of this model. In this study, the program automatically detected and deleted the kin relationships. After all, 336 friendships were excluded in analysis. In total, 6,477 rated friendships, with the participants listing 3,675 male friends and 2,802 female friends. At last, a data set of 42,323 wall posts, 96,696 photos, 48,898 photo tags, 2,715 albums, 629 check-in records, 366 notes, 93 videos, 154,765 messages, 124,337 comments, and 217,998 likes were collected and analyzed.

The subjective data set was downloaded from program is the independent variable and the objective score which was rated by participants is the dependent variable. They were analyzed by ordinary least squares (OLS) regression. The five regression results were showed according to item one to five. These models fit the data well. For the first item, the model fit the data with Adj. $R^2 = 0.52$, $p < 0.05$. The other four model fit were Adj. $R^2 = 0.46$, $p < 0.05$ in item two; Adj. $R^2 = 0.51$, $p < 0.05$ in item three; Adj. $R^2 = 0.41$, $p < 0.05$ in item four; and Adj. $R^2 = 0.35$, $p < 0.05$ in item five. The regression results were discussed below. The five items were named as "strong_regression," "loan_regression," "job_regression," "unfriend_regression," and "bring_regression," respectively.

5.1 Amount of time

The results in this category showed negative correlation between amount of time and job_regression. However, the amount of time did not correlate with the other four items (see Table III). Therefore, the amount of time is not the main variable to predict tie strength on Facebook.

5.2 Emotional intensity variables

In the subcategory of "friends posting or commenting on participants' Facebook content," the number of comments made by friends on participants' wall posts (the variable "comment on wall post") correlated positively ($p < 0.05$) with all five items. Friends with strong ties were found to be more likely to respond to participants' wall posts. The number of comments friends made on notes (the variable "comment on note") correlated negatively with tie strength (see Table IV), suggesting that more comments on notes were made by friends with weak relationship ties.

In the subcategory of "friends clicking 'like' on participants' Facebook content," the number of likes clicked on wall posts and videos (the variable "like on wall post and like on video") correlated positively ($p < 0.05$) with most items, but the variable "like on album and photo variables" showed negative correlation. The results showed item one has a strongest positive correlation with the number of likes clicked on comments of photos (the variable "like on comment of photo"), but a negative correlation with the "number of clicks of like on photo" variable. The variable of "like on comment of check-in" showed a strong negative correlation with item one.

The results in the subcategory of "discuss with friends using private messages" showed that when participants sent more private messages to a friend, they considered that friend to have strong ties and were likely to bring them to another SNSs ($p < 0.05$) (see Table IV).

5.3 Intimacy variables

The subcategories "relationship status in common" and "participants' number of friends" did not affect tie strength in a statistically significant manner. In the subcategory of "participants tagging friends in Facebook content," the "tag in description" and "tag in

Table III. Result of amount of time

	Strong_Regression coefficient (standardized)	Loan_Regression coefficient (standardized)	Job_Regression coefficient (standardized)	Unfriend_Regression coefficient (standardized)	Bring_Regression coefficient (standardized)
Amount of time	−0.05	−0.06	−0.16*	0.12	−0.03

Note: *Significant at $p < 0.05$

Table IV.
Result of emotional intensity

	Strong_Regression coefficient (standardized)	Loan_Regression coefficient (standardized)	Job_Regression coefficient (standardized)	Unfriend_Regression coefficient (standardized)	Bring_Regression coefficient (standardized)
Friends posting or commenting on participants' Facebook content					
Post on wall	0.06*	0.01	0.03	0.18*	0.21*
Comment on wall post	0.31*	0.26*	0.28*	0.17*	0.18*
Comment on album	−0.04	−0.04	−0.09*	−0.15*	−0.01
Comment on photo	0.06	0.10	0.12	0.11	0.22
Comment on video	0.08	0.10	0.12	−0.05	−0.01
Comment on check-in	0.08	0.02	0.04	0.10	0.09
Comment on note	−0.05*	−0.05*	−0.05*	0.01	−0.05*
Friends clicking "Like" on participants' Facebook content					
Like on wall post	0.15*	0.13*	0.15*	0.14*	0.10*
Like on album	−0.07*	−0.02	−0.11*	−0.09*	−0.08*
Like on photo	−0.27*	−0.19	−0.19	−0.23	−0.24*
Like on video	0.07*	0.07*	0.07*	0.06*	0.06*
Like on check-in	0.03	0.02	−0.01	−0.05	−0.02
Like on note	−0.02	−0.01	−0.02	−0.13	−0.11
Like on comment of wall post	−0.10*	−0.09	−0.10*	0.09	−0.02
Like on comment of album	0.02	0.14	0.09	−0.12	−0.02
Like on comment of photo	0.33*	0.11	−0.01	−0.01	0.02
Like on comment of video	−0.12	−0.06	−0.01	−0.07*	0.04
Like on comment of check-in	−0.31*	−0.36	−0.36	0.07*	0.06*
Like on comment of note	−0.09	−0.08	0.02	0.04	0.05
Discuss with friends using private messages					
Number of private messages	0.10*	0.10*	0.08	−0.02	0.08*

Note: *Significant at $p < 0.05$

photo" variables are Facebook system messages that showed the participants' interaction with their friends, which showed strong positive correlation with most items ($p < 0.05$). In addition, "check-in" variable is statistically significant with all items, and is the most potential variable of tie strength (see Table V).

5.4 Reciprocal services variables

The results of the "reciprocal services" dimension showed that none of the variables in reciprocal services was correlated with tie strength. This is because seldom users used these reciprocal services to interact with their friends (Table VI).

5.5 Structural variables

The structural variables dimension was classified into three subcategories. Table VII shows that none of the factors in the "profile in common" subcategory was correlated with tie strength. A positive correlation ($p < 0.05$) in the "community in common" subcategory suggested that participants tended to join Facebook "privacy group," "fan pages," and "same event" of friends with strong ties. Moreover, the number of mutual friends was positively correlated with tie strength ($p < 0.05$) (see Table VII).

5.6 Social distance variables

According to the results, none of the factors in this dimension correlated with tie strength. The "profile in common" subcategory here and in the previous section showed no correlation, suggesting that the information provided in profiles does not represent the strength of relationships (Table VIII).

	Strong_ Regression coefficient (standardized)	Loan_ Regression coefficient (standardized)	Job_ Regression coefficient (standardized)	Unfriend_ Regression coefficient (standardized)	Bring_ Regression coefficient (standardized)
Relationship status in common					
Status	0.02	0.14	0.09	−0.12	−0.02
Participants' number of friends					
Number of friends	−0.01	0.05	0.08	0.04	−0.01
Participants tagging friends in Facebook content					
Tag in post	−0.02	−0.10	−0.14*	−0.02	−0.20*
Tag in description	0.23*	0.35*	0.28*	0.13	0.17
Tag in photo	0.15*	0.17*	0.17	0.10*	0.19*
Listed the same check-in					
check-in	0.33*	0.31*	0.24*	0.17*	0.21*

Note: *Significant at $p < 0.05$

Table V.
Result of intimacy

	Strong_ Regression coefficient (standardized)	Loan_ Regression coefficient (standardized)	Job_ Regression coefficient (standardized)	Unfriend_ Regression coefficient (standardized)	Bring_ Regression coefficient (standardized)
Links exchanged	0.02	0.14	0.09	−0.12	−0.02
Application in common	0.01	0.15	0.08	0.14	−0.01

Table VI.
Result of reciprocal services

	Strong_ Regression coefficient (standardized)	Loan_ Regression coefficient (standardized)	Job_ Regression coefficient (standardized)	Unfriend_ Regression coefficient (standardized)	Bring_ Regression coefficient (standardized)
Profile in common					
Interest	−0.01	−0.02	−0.04	−0.01	−0.02
Activity	−0.01	0.05	0.08	0.04	−0.01
Favorite book	−0.01	−0.01	−0.03	−0.02	−0.01
Favorite movie	0.07	0.01	0.02	0.06	0.06
Favorite music	0.08	0.04	0.03	0.06	0.04
Favorite TV	0.02	0.12	0.14	0.04	0.08
Favorite Art	0.17	0.11	0.08	0.14	0.09
Favorite Sport	0.12	0.06	0.09	0.10	0.11
Community in common					
Same network	−0.01	−0.02	−0.04	−0.01	−0.02
Public group	−0.10*	−0.10*	−0.06	0.02	−0.03
Privacy group	0.27*	0.28*	0.24*	0.21*	0.25*
fans page	0.04*	0.08*	0.05*	0.01*	−0.04
Same event	0.14*	0.18*	0.11*	0.10*	0.07*
Relation	−0.01	−0.02	−0.04	−0.01	−0.02
Friends in common					
Mutual friends	0.05*	0.08*	0.14	0.26*	−0.12*

Note: *Significant at $p < 0.05$

Table VII.
Result of structural variables

5.7 Formulation

In this study, OLS regression analysis was used to examine interaction variables and tie strength between SNSs users. S_i is the tie strength between a participant and their friend i, P_i is the variable from the tie strength dimensions, and εi is the error. The basic formula used is the following:

$$S_i = \alpha + \beta_i P_i + \varepsilon_i$$

$$P_i = P_{\text{Amount of Time}} + P_{\text{Emotional intensity}} + P_{\text{Intimacy variables}} + P_{\text{Reciprocal services variables}} + P_{\text{Structural Variables}} + P_{\text{Social Distance}}$$

Using the results from distinct tie strength dimensions, we developed a predictive formula based on the tie strength evaluation items. The formula is as follows:

$$P_{\text{Emotional Intensity}} = P_{\text{Post}} + P_{\text{Comment}} + P_{\text{Like}} + P_{\text{Tag}} + P_{\text{Message}}$$

$$\begin{aligned}\beta_{\text{Emotional Intensity}} P_{\text{Emotional Intensity}} = {} & 0.06P_{\text{Post on wall}} + 0.31P_{\text{Comment on wall post}} \\ & - 0.05P_{\text{Comment on note}} + 0.15P_{\text{Like on wall post}} \\ & - 0.07P_{\text{Like on album}} - 0.27P_{\text{Like on photo}} \\ & + 0.07P_{\text{Like on video}} - 0.10P_{\text{Like on comment of wall post}} \\ & + 0.33P_{\text{Like on comment of photo}} \\ & - 0.31P_{\text{Like on comment of check-in}} \\ & + 0.10P_{\text{Number of message}}\end{aligned}$$

$$P_{\text{Intimacy Variable}} = P_{\text{Status}} + P_{\text{Number of friends}} + P_{\text{Tag friend}} + P_{\text{Check-in}}$$

$$\beta_{\text{Intimacy Variable}} P_{\text{Intimacy Variable}} = 0.23P_{\text{Tag in description}} + 0.15P_{\text{Tag in photo}} + 0.33P_{\text{Check-in}}$$

$$P_{\text{Structural Variables}} = P_{\text{Community}} + P_{\text{Favorite}} + P_{\text{Friends}}$$

$$\beta_{\text{Structural Variables}} P_{\text{Structural Variables}} = -0.10P_{\text{Public group}} + 0.27P_{\text{Privacy group}} + 0.04P_{\text{Fans page}} + 0.14P_{\text{Same event}}$$

$$\begin{aligned} S_i &= \alpha + \beta_i P_i + \varepsilon_i \\ &= \beta_{\text{Emotional Intensity}} P_{\text{Emotional Intensity}} + \beta_{\text{Intimacy Variable}} P_{\text{Intimacy Variable}} \\ &\quad + \beta_{\text{Structural Variables}} P_{\text{Structural Variables}} \\ &= 0.06P_{\text{Post on wall}} + 0.31P_{\text{Comment on wall post}} - 0.05P_{\text{Comment on note}} \\ &\quad + 0.15P_{\text{Like on wall post}} - 0.07P_{\text{Like on album}} - 0.27P_{\text{Like on photo}} \\ &\quad + 0.07P_{\text{Like on video}} - 0.10P_{\text{Like on comment of wall post}} + 0.33P_{\text{Like on comment of photo}} \\ &\quad - 0.31P_{\text{Like on comment of check-in}} + 0.10P_{\text{Number of message}} + 0.23P_{\text{Tag in description}} \\ &\quad + 0.15P_{\text{Tag in photo}} + 0.33P_{\text{Check-in}} - 0.10P_{\text{Public group}} + 0.27P_{\text{Privacy group}} \\ &\quad + 0.04P_{\text{Fans page}} + 0.14P_{\text{Same event}} \end{aligned}$$

Table VIII.
Result of social distance

	Strong_ Regression coefficient (standardized)	Loan_ Regression coefficient (standardized)	Job_ Regression coefficient (standardized)	Unfriend_ Regression coefficient (standardized)	Bring_ Regression coefficient (standardized)
Profile in common					
Gender	−0.01	−0.02	−0.07	−0.07	−0.06
Age	0.02	0.02	0.05	0.03	0.07
Blood type	0.03	0.02	0.01	0.05	0.04
Language	−0.02	−0.02	−0.01	−0.01	−0.01
Current location	−0.29	−0.14	−0.26	−0.49	−0.45
Hometown	−0.12	−0.06	−0.12	−0.14	−0.11
Believing	−0.02	−0.02	−0.01	−0.01	−0.01
Philosophy	0.17	0.12	0.15	0.24	0.21
Religion	−0.01	−0.02	−0.04	−0.02	−0.02
Politics view	0.11	0.08	0.07	0.05	0.07
Studied college	−0.02	−0.02	−0.01	−0.01	−0.01
Education level	−0.01	−0.01	−0.03	−0.02	−0.01
Worked company	0.05	−0.01	−0.14	0.12	−0.01

Note: *Significant at $p < 0.05$

6. Conclusions

6.1 Discussion

This study attempted to prune away spurious interaction behaviors and examine the key factors for measuring tie strength on Facebook. For this purpose, we used a program and an online questionnaire to collect an objective data set from Facebook and integrate that data set with a subjective data set containing participants' opinions on the strength of their Facebook friendships. The results provided a predictive model for quantitative and continuous measurement of tie strength. The evaluation of predictive performance distinguished between strong and weak ties with over 52 percent accuracy, and found that the variables in the dimension of emotional intensity had stronger effects than other interaction variables. This parallels Marsden and Campbell (1990) finding that emotional intensity best reflects tie strength. More specifically, the following variables contributed most in predicting tie strength (although not all variables contributed positively): "Comment on wall post," "like on photo," "like on comment of photo," "like on comment of check-in," "tag in post," "tag in description," "check-in," and "private group." Thus, definitions of tie strength dimensions proposed by previous studies (Alba and Kadushin, 1976; Granovetter, 1973; Lin *et al.*, 1981) for offline relationships cannot completely explain online relationships. The discussion below presents potential explanations for why some variables contributed positively and other negatively, and why some variables contributed more than others.

First, according to the result of emotional intensity dimension, this study revealed the effect of time spent on friendships. "Time consumption" (Li and Hung, 1997) included the time taken by a Facebook friend to understand information before responding, and the time taken to respond. Prior studies suggested that information of wall posts and videos take longer to view and understand than other posts (De Vries *et al.*, 2012; Van Der Heide *et al.*, 2012). Thus, the variables "comment on wall post," "like on wall post," and "like on video" need users take longer time to view, which is positively (and strongly) affects tie strength in all the predicting models. In contrast, "Like on comment of photo" and "Like on photo" showed opposite results. On the Facebook main page, photos are shown as pictures but comments are written in letters, which means that less effort is required for understanding photos than for reading through comments on photos. Thus, the time consumed in understanding information explains why the variable "Like on comment of photo" affects the prediction of tie strength positively, whereas the "Like on photo" variable affects the prediction negatively, which is consistent with prior study (De Vries *et al.*, 2012). In addition, this also agrees with the finding of Hsu *et al.* (2011) that Facebook users are more likely to use less time and more efficient tools for maintaining weak ties than strong ties. The negative correlations of "Like on album" variable can also be explained the same way, because album photos may be shown as pictures on the Facebook main page when albums are created or updated.

Second, the results showed that the variable "comment on wall post" has a positive effect on tie strength, but "comment on note" has a negative effect on tie strength. The results indicated that weak tie and fans mostly read note while strong tie read the posts of daily life. In addition, private messages were not found to give poster higher level of perceived intimacy with responders than public responses. This finding indicated a behavior trend distinct from that of Hsu *et al.* (2011), who suggested that users of Facebook use more intimate activities and more private controlled tools to interact with close friends. Thus, this study infers that when the level of intimacy is

higher than a threshold, as mention by Hsu *et al.* (2011), users are choose means of communication other than private messages.

Third, according to the result of intimacy dimension, the results showed that the relationship between tie strength and predicting variables were affected by the communication tool used. For example, check-in is a tool used by Facebook users to announce their location, usually with a "status update" detailing what they are doing there (Zhao *et al.*, 2012). People listed with the same check-in information on Facebook are identified as being at the same place together and wished their relationship be socially recognized, and this positively correlated with tie strength; this is consistent with prior study (Xiang *et al.*, 2010). However, "Comment on check-in" and "Like on check-in" were not correlated with tie strength. The reason may because the places where Facebook users check-in were mostly famous places, and such information is concise and amusing and can attracts people's attention immediately (Haghirian *et al.*, 2005). Therefore, both strong and weak ties are willing to follow the check-in information, and then post their comment and click like. In addition, the negative correlation between "Like on comment of check-in" variable and tie strength indicated that even though friends with weak ties read through the content and comments, they responded mainly using the "like" button. Moreover, the "tag in description" variable strongly predicts tie strength. This finding also means the "topic" and "interactive" is the most influential on relationship.

Fourth, both variables of reciprocal services dimension have no significantly influenced on tie strength. The reason may because link and application exchanged are the behaviors with specific purpose (Cheng *et al.*, 2011), which is distinguish from the behavior of social interaction. In addition, compared to no correlation between social distance dimension and tie strength, the positive correlation between tie strength and the variables ("private group," "same event," and "mutual friends") in structural dimension illustrates a direction for dating services. The similarity in personal profile does not influence the establishment of a relationship, while the similarity in social network and mutual friends has more chance to reflect the strength of tie strength. Such result is similar to the small community, which is easier to find close friends in small group than large group (Adamic and Adar, 2003).

6.2 Theoretical and practical implications

This study has presented several unique points. First, this research starts the examination of integration of relationship between information, interpersonal relationship and social network. The development of SNSs allowed dynamic data on multiple social relationships to be collected to observe the interaction and relations (Kalampokis *et al.*, 2013). This study used real interaction data from Facebook to bridge the gap between theory and practice and demonstrate that prior studies do not provide quantitative and continuous measurements of precise tie strength. Second, our model helps to explain the meaning of interactions on SNSs and offers an efficient method to examine tie strength on SNSs. The parameters used can be applied in estimating tie strength for a pair of users in real time. Third, the variables of emotional intensity were found to contribute most to the prediction of tie strength, which agrees with views proposed in previous studies (Alba and Kadushin, 1976; Granovetter, 1973; Lin *et al.*, 1981). Fourth, time consumption and interval between interactions affected tie strength, in agreement with the finding of Hsu *et al.* (2011) that Facebook users spend more time to maintain friends with whom they have

strong ties. Fifth, the model developed for predicting tie strength model may help SNSs improve their mechanism of providing information, because connections are more influential when ties are stronger. Moreover, our finding may also help viral marketing by selecting the transmitters who send information or start a WOM discussion, because ties are more influential (Bakshy *et al.*, 2012) when they reinforce the engagement between a piece of information and its user. Finally, the method of data collection in this study may not only apply to the research in the fields of social network, but also the fields of organization management, customer relationship, performance appraisal, and information communication of holacracy. This method may also contribute to redefine the friend types, social behavior patterns, and online social network distinctions. This study can provide suggestions for SNSs programmers designing new applications, improving services and functions, and optimizing user's experience on SNSs platforms.

6.3 Limitations and directions for future studies

This research used Facebook program to collect personal profile and interaction data to integrate virtual and physical community phenomena. Due to the limits of Facebook algorithms, this study had tried to predict the whole picture of social network interaction behaviors by applicable raw data; however, only 50 percent predicting power was performed. Accordingly, future studies can improve this predictive model and reduce the bias by examining on other SNSs. Future studies also can execute a cross-comparison between SNSs to examine the social relationships. In the meantime, different study designs, different visibility of SNSs platforms, and different SNSs features could be used to reexamine this model.

References

Adamic, L.A. and Adar, E. (2003), "Friends and neighbors on the web", *Social networks*, Vol. 25 No. 3, pp. 211-230.

Alba, R.D. and Kadushin, C. (1976), "The intersection of social circles: a new measure of social proximity in networks", *Sociological Methods and Research*, Vol. 5 No. 1, pp. 77-102.

Araujo, T. and Neijens, P. (2012), "Friend me: which factors influence top global brands participation in social network sites", *Internet Research*, Vol. 22 No. 5, pp. 626-640.

Bakshy, E., Rosenn, I., Marlow, C. and Adamic, L. (2012), "The role of social networks in information diffusion", *Proceedings of the 21st International Conference on World Wide Web, ACM*, pp. 519-528.

Baltar, F. and Brunet, I. (2012), "Social research 2.0: virtual snowball sampling method using Facebook", *Internet Research*, Vol. 22 No. 1, pp. 57-74.

Benassi, M., Greve, A. and Harkova, J. (1999), "Looking for a network organization: the case of GESTO", *Journal of Market-Focused Management*, Vol. 4 No. 3, pp. 205-229.

boyd, D.M. and Ellison, N.B. (2007), "Social network sites: definition, history, and scholarship", *Journal of Computer-Mediated Communication*, Vol. 13 No. 1, pp. 210-230.

Chen, K.-H., Shen, K.-S. and Ma, M.-Y. (2012), "The functional and usable appeal of Facebook SNS games", *Internet Research*, Vol. 22 No. 4, pp. 467-481.

Cheng, J., Romero, D.M., Meeder, B. and Kleinberg, J. (2011), "Predicting reciprocity in social networks", *Privacy, security, risk and trust (passat), 2011 ieee third international conference on social computing (socialcom), IEEE*, pp. 49-56.

Chu, S.-C. and Kim, Y. (2011), "Determinants of consumer engagement in electronic word-of-mouth (eWOM) in social networking sites", *International Journal of Advertising*, Vol. 30 No. 1, pp. 47-75.

De Vries, L., Gensler, S. and Leeflang, P.S. (2012), "Popularity of brand posts on brand fan pages: an investigation of the effects of social media marketing", *Journal of Interactive Marketing*, Vol. 26 No. 2, pp. 83-91.

Dindia, K., and Canary, D.J. (1993), "Definitions and theoretical perspectives on maintaining relationships", *Journal of Social and Personal Relationships*, Vol. 10 No. 2, pp. 163-173.

Ellison, N., Steinfield, C. and Lampe, C. (2007), "The benefits of Facebook 'friends:' social capital and college students' use of online social network sites", *Journal of Computer-Mediated Communication*, Vol. 12 No. 4, pp. 1143-1168.

Erickson, B.H., Nosanchuk, T.A., Mostacci, L. and Dalrymple, C.F. (1978), "The flow of crisis information as a probe of work relations", *Canadian Journal of Sociology*, Vol. 3 No. 1, pp. 71-87.

Gilbert, E. and Karahalios, K. (2009), "Predicting tie strength with social media", CHI 2009, Boston, MA, pp. 211-220.

Gilbert, E., Karahalios, K. and Sandvig, C. (2008), "The network in the garden: an empirical analysis of social media in rural life", *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, ACM*, pp. 1603-1612.

Granovetter, M.S. (1973), "The strength of weak ties", *The American Journal of Sociology*, Vol. 78 No. 6, pp. 1360-1380.

Granovetter, M.S. (1974), *Getting a Job: A Study of Contacts and Careers*, Harvard University Press, Cambridge, MA.

Granovetter, M.S. (1983), "The strength of weak ties: a network theory revisited", *Sociological Theory*, Vol. 1, pp. 201-233.

Haghirian, P., Madlberger, M. and Tanuskova, A. (2005), "Increasing advertising value of mobile marketing- an empirical study of antecedents", *Proceedings of the 38th Hawaii International Conference on System Sciences, IEEE*, p. 32c.

Haythornthwaite, C. (2002), "Strong, weak, and latent ties and the impact of new media", *The Information Society*, Vol. 18 No. 5, pp. 385-401.

He, Y., Zhang, C. and Ji, Y. (2012), "Principle features for tie strength estimation in micro-blog social network", *Proceedings of the 12th International Conference on Computer and Information Technology (CIT)*, IEEE, pp. 359-367.

Houghton, D.J. and Joinson, A.N. (2010), "Privacy, social network sites, and social relations", *Journal of Technology in Human Services*, Vol. 28 No. 1, pp. 74-94.

Hsu, C.-W., Wang, C.-C. and Tai, Y.-T. (2011), "The closer the relationship, the more the interaction on Facebook? Investigating the case of Taiwan users", *Cyberpsychology, Behavior, and Social Networking*, Vol. 14 Nos 7-8, pp. 473-476.

Kalampokis, E., Tambouris, E. and Tarabanis, K. (2013), "Understanding the predictive power of social media", *Internet Research*, Vol. 23 No. 5, pp. 544-559.

Kendler, K.S., Myers, J. and Prescott, C.A. (2005), "Sex differences in the relationship between social support and risk for major depression: a longitudinal study of opposite-sex twin pairs", *American Journal of Psychiatry*, Vol. 162 No. 2, pp. 250-256.

Krackhardt, D. (1992), "The strength of strong ties: the importance of philos in organizations", *Networks and organizations: Structure, form, and action*, Harvard Business School Press, Boston, MA, pp. 216-239.

Kwon, O., Kim, C.R. and Kim, G. (2013), "Factors affecting the intensity of emotional expressions in mobile communications", *Online Information Review*, Vol. 37 No. 1, pp. 114-131.

Lampe, C., Ellison, N. B. and Steinfield, C. (2008), "Changes in use and perception of Facebook", *Proceedings of the 2008 ACM conference on Computer supported cooperative work, ACM*, pp. 721-730.

Lehmann, E.L. and Romano, J.P. (2006), *Testing Statistical Hypotheses*, Springer, Science and Business Media, New York, NY.

Lewis, K., Kaufman, J., Gonzalez, M., Wimmer, A. and Christakis, N. (2008), "Tastes, ties, and time: a new social network dataset using Facebook.com", *Social networks*, Vol. 30 No. 4, pp. 330-342.

Li, W.K. and Hung, K.H. (1997), "Consumption of discretionary time: an exploratory study", *Advances in Consumer Research*, Vol. 24 No. 1, pp. 542-550.

Lin, C.P. and Bhattacherjee, A. (2008), "Elucidating individual intention to use interactive information technologies: the role of network externalities", *International Journal of Electronic Commerce*, Vol. 13 No. 1, pp. 85-108.

Lin, N., Dayton, P.W. and Greenwald, P. (1978), "Analyzing the instrumental use of relations in the context of social structure", *Sociological Methods & Research*, Vol. 7 No. 2, pp. 149-166.

Lin, N., Vaughn, J.C. and Ensel, W.M. (1981), "Social resources and occupational status attainment", *Social Forces*, Vol. 59 No. 4, pp. 1163-1181.

Marsden, P.V. (2003), "Interviewer effects in measuring network size using a single name generator", *Social Networks*, Vol. 25 No. 1, pp. 1-16.

Marsden, P.V. and Campbell, K.C. (1990), "Recruitment and selection processes: the organizational side of job searches", in Breiger, R. (Ed.), *Social Mobility and Social Structure*, Cambridge University Press, New York, NY.

Marsden, P.V. and Campbell, K.E. (1984), "Measuring tie strength", *Social Forces*, Vol. 63 No. 2, pp. 482-501.

Mathews, K.M., White, M.C., Long, R.G. and Soper, B. (1998), "Associaltion of indicators and predictors of tie strength", *Psychological Reports*, Vol. 83 No. 3, pp. 1459-1469.

Muncer, S., Burrows, R., Pleace, N., Loader, B. and Nettleton, S. (2000), "Births, deaths, sex and marriage […] but very few presents? A case study of social support in cyberspace", *Critical Public Health*, Vol. 10 No. 1, pp. 1-18.

Petroczi, A., Nepusz, T. and Bazsó, F. (2007), "Measuring tie-strength in virtual social networks", *Connections*, Vol. 27 No. 2, pp. 39-52.

Pollet, T.V., Roberts, S.G.B. and Dunbar, R.I.M. (2011), "Use of social network sites and instant messaging does not lead to increased offline social network size, or to emotionally closer relationships with offline network members", *Cyberpsychology, Behavior, and Social Networking*, Vol. 14 No. 4, pp. 253-258.

Robers, S.B.G. and Dunbar, R.I.M. (2011), "The costs of family and friends: an 18-months longitudinal study of relationship maintenance and decay", *Evolution and Human Behavior*, Vol. 32 No. 3, pp. 186-197.

Scott, J. (1990), *Social Network Analysis*, Sage Publication, Thousand Oaks, CA.

Shao, G. (2009), "Understanding the appeal of user-generated media: a uses and gratification perspective", *Internet Research*, Vol. 19 No. 1, pp. 7-25.

Shi, X., Adamic, L.A. and Strauss, M.J. (2007), "Networks of strong ties", *Physica A: Statistical Mechanics and its Applications*, Vol. 378 No. 1, pp. 33-47.

Steffes, E.M. and Burgee, L.E. (2009), "Social ties and online word of mouth", *Internet Research*, Vol. 19 No. 1, pp. 42-59.

Taylor, S.E., Sherman, D.K., Kim, H.S., Jarcho, J., Takagi, K. and Dunagan, M.S. (2004), "Culture and social support: who seeks it and why", *Journal of Personality and Social Psychology*, Vol. 87 No. 3, pp. 354-362.

Tong, S.T., Van Der Heide, B., Langwell, L. and Walther, J.B. (2008), "Too much of a good thing? The relationship between number of friends and interpersonal impressions on Facebook", *Journal of Computer – Mediated Communication*, Vol. 13 No. 3, pp. 531-549.

Van Der Heide, B., D'Angelo, J.D. and Schumaker, E.M. (2012), "The effects of verbal versus photographic self-presentation on impression formation in Facebook", *Journal of Communication*, Vol. 62 No. 1, pp. 98-116.

van Noort, G., Antheunis, M.L. and van Reijmersdal, E.A. (2012), "Social connections and the persuasiveness of viral campaigns in social network sites: persuasive intent as the underlying mechanism", *Journal of Marketing Communication*, Vol. 18 No. 1, pp. 39-53.

Wellman, B. and Wortley, S. (1990), "Different strokes from different folks: community ties and social support", *The American Journal of Sociology*, Vol. 96 No. 3, pp. 558-588.

Xiang, R., Neville, J., and Rogati, M. (2010), "Modeling relationship strength in online social networks", *Proceedings of the 19th International Conference on World Wide Web, ACM*, pp. 981-990.

Xu, K., Guo, X., Li, J., Lau, R.Y.K. and Liao, S.Y. (2012), "Discovering target groups in social networking sites: an effective method for maximizing joint influential power", *Electronic Commerce Research and Applications*, Vol. 11 No. 4, pp. 318-334.

Zhao, L., Lu, Y. and Gupta, S. (2012), "Disclosure intention of location-related information in location-based social network services", *International Journal of Electronic Commerce*, Vol. 16 No. 4, pp. 53-89.

Further reading

Friedkin, N. (1980), "A test of structural features of Granovetter's strength of weak ties theory", *Social Networks*, Vol. 2 No. 4, pp. 411-442.

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1. Douglas Castilho, Pedro O.S. Vaz de Melo, Fabrício Benevenuto. 2017. The strength of the work ties. *Information Sciences* **375**, 155-170. [CrossRef]
2. LimWeng Marc Weng Marc Lim School of Business, Monash University Malaysia, Bandar Sunway, Malaysia and Faculty of Business and Design, Swinburne University of Technology, Kuching, Malaysia . 2016. Social media in medical and health care: opportunities and challenges. *Marketing Intelligence & Planning* **34**:7, 964-976. [Abstract] [Full Text] [PDF]