

# Measuring tie-strength in virtual social networks

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*Tie-strength has been in the focus of social science research for decades, yet the use of measurement tools or scales has been relatively scarce. The aim of this study was to fill the gap and provide a tool that is able to provide a quantitative and continuous measure of tie strength in social networks. The focus was on virtual communities because the fast expansion of Internet use and the constant growth of on-line communities provide today's researchers with an excellent opportunity for effective and speedy data collection regarding tie-strength measures in these virtual social groups. The Virtual Tie-Strength Scale (VTS-Scale) consist of 11 questions and it was developed on a sample of 56 people (3080 asymmetric ties) and tested for reliability of smaller sample of 16 (204 asymmetric ties) independent sample participation regularly on a Hungarian discussion board like forum. Reliability coefficients were reassuringly high for both samples, Cronbach alphas of 0.92 and 0.86, respectively. Data triangulation offered evidence for scale validity. In summary, the VTS-Scale and its scoring method seem to provide a valid and reliable measure of tie strength in virtual communities. Although the aim of the research was to develop a tool that measures tie-strength in virtual communities, the tool can be easily modified for off-line social groups. The VTS-Scale is also capable of distinguishing between two components of tie-strength: acquaintances and friendship. However, the content of each component needs further investigation.*

## INTRODUCTION

Social networks - real or virtual - are collections of human communities. There are several studies (e.g., Burt, 1995; Granovetter, 1973, 1982) that examined real world/off-line social groups and have influenced our thinking about social constructions. However, these empirical studies were based on limited samples insufficient for rigorous and decisive mathematical and statistical analysis. In this article, first we give an overview of computer mediated communication and virtual communities. As the notion of tie strength in social networks is in the centre of our paper, we discuss it in details. Then methodology is described, a scale measuring acquaintance and friendship in virtual communities is introduced and statistical analysis is performed. Our discussion reflects on the validity and reliability of the VTS-Scale and points to future research.

### Computer-mediated social networks

Observing and analysing on-line social networks has undeniable advantages over the face-to-face methods. Computer mediated communication (CMC) allows the researcher to overcome difficulties presented from time and distance barriers in face-to-face research (Mann and Stewart, 2000). Jones (1999), however, issues a warning not to be misled by the seductively easy access to large and textually rich data. Yet, in this research, we will use the assumptions made by Haythornthwaite (2002, p.388): “[C]haracteristics of ties hold in the mediated environments as they do in off-line environments”, and (Ibid, p. 388) “on-line exchanges are as real in terms of

their impact on the tie as are off-line exchanges”. Wellman's earlier work (2001) has also come to the conclusion that computerised networks are, indeed, social networks.

A sense of community exists in the mind of the participants. Virtual groups of people are invisible, nevertheless off-line communities, which are given meaning by their participants. In other words, a community is as its members define it for themselves. Both offline and on-line social networks can be described by 1) their participants, 2) the content, direction, strength of their relations and ties, 3) their composition, derived from the social attributes of the participants, and 4) their complexity, which indicates the number of relations in a tie (Garton, Haythornthwaite, Wellman, 1997). Traditionally, a community has been defined by shared space and common value system (see Jones, 1997). Although it is yet to be decisively proven, it is believed that virtual communities mirror those in the 'real world' in many ways: cyber communities also share values, beliefs, norms and expectations regarding the appropriate behaviour and have a sense of identity, commitments and association (Preece, 2000).

Computer Mediated Communication (CMC) has been the focus of much research in the past decade. CMC services on the Internet range from the World Wide Web (WWW), electronic mails, mailing lists, usenet newsgroups, focus groups facilities, chats, multi-user text-based role-playing environments (MUDs), multimedia environments and conferencing

message boards and Internet forums (Hine, 2000; Kollock and Smith, 2003, Mann and Stewart, 2000). These computer-supported social networks can, indeed, create a sense of community, belonging (Wellman and Gulia, 2003) and can be distinguished by their cultural aspects.

First, CMC was viewed as limited, narrow, depersonalized and self-absorbing (Kiesler et al, 1984, Kiesler et al, 1985; Rice and Love, 1987); aimed to maintain status quo (Dubrovsky et al, 1991) and sometime hostile environment (Sproull and Kiesler, 1986). Others (Jones, 1995, 1999; Kollock and Smith, 2003 and especially Rheingold, 1993) shifted attention from straight comparison of CMC and face-to-face communication to CMC as a special cultural interface with many non-traditional yet socially rich structures. In organizational setting, Walther (1995) showed that CMC users do not experience loss of intimacy, especially not when CMC is synchronous. He also suggested that depersonalization is not necessarily a function of the medium, but relates to the perceived duration of the relationship and the possibility of future communication (Walther, 1994). Hine (2000) contends that when CMC is perceived as a culture and not merely a way of communication, it has provided rich field and easily obtainable data for anthropologists, psychologists, ethnographers alike.

We focus on Internet forums for several reasons. Internet forums are ongoing CMC groups, which in general tend to develop into a specific culture with shared values, accepted behavioural norms and interpersonal relationships (Baym, 1998). Having the option to be able to see (read) communication retrospectively, researchers can map the formation and dynamics of the network from a single, large data set. Many features of social networks (different tie-strengths, personal preferences, likeness, shared interests, interpersonal likes and dislikes) can be qualitatively observed among the regular participants of this virtual community.

### **The notion of tie strength in social networks**

The notion of tie-strength is an important concept in social network analysis. Strength of a tie is a quantifiable property that characterises the link between two nodes. By definition, tie strength is a “combination of the amount of time, the emotional intensity, the intimacy (mutual confiding) and reciprocal services which characterize the tie” (Granovetter, 1973, p1361). The four indicators are thought to be linear combinations of the four elements, positive and symmetric. (Ibid, p.1361). Indicators are actual components of tie-strength (closeness, duration and frequency, breadth of topics and mutual confiding), whereas contextual contingencies (neighbourhood, affiliation, similar socio-economic status, workplace and occupation prestige) are predictors. Predictors are related to tie-strength but not components of it.

Based on Granovetter's weak tie argument (1973), many important claims have been made by a range of people on a range of topics - from job seekers to job providers, social groups to formal organisations, health care systems to drug users, envi-

ronmental protection to criminology, on topics related to innovation, marketing, migration, mafia and terrorism. Examples of such research can be found in the recent literature (e.g., Albrecht & Hall, 1991; Bian, 1997; Brown & Konrad, 2001; Brown & Reigen, 1987; Burt, 1995; Carpenter et al., 2003; Crowell, 2004; Faia, 2000; Feld, 1997; Greenbaum, 1982; Hagan, 1993; Hansen, 1999; Haines & Henderson, 2002; Jenssen & Koenig, 2002; Karathanos & Pettypool, 1992; Köhler, 2004; Krackhardt, 1988; Lavigne, 1996; Lin, 1999; Lin & Dumin, 1986; Macy & Skvoretz, 1998; McGrath et al., 2003; Miller McPherson et al., 1992; Montgomery, 1992, 1994; Morselli, 2003; Rankin, 2003; Schwartz & Sprinzen, 1984; Teorell, 2003; Tindall, 2002; Valente & Vlakov, 2001; Weening, 1993; Weening & Midden, 1991; Wellman & Wortley, 1990; Wilson, 1998; Youm, 2002). However, the proportion of researchers who uses tie-strength is overwhelmingly larger than the number of empirical studies that have made an attempt to measure tie-strength (Mathews et al., 1998). Claims and theories, which rely upon the notion of tie-strength can only be tested if we are able to measure the strength of ties and able to discriminate strong ties from weak ones, independently of the original assertions (Granovetter, 1973).

In the past thirty years of social network analysis, many attempts have been made to find valid indicators and predictors of tie-strength (Walker et al., 1993). The simplest way was to assume that close friends have strong ties and acquaintances or distant friends are connected by weak ties (Erickson et al., 1978; Granovetter, 1974; Murray et al., 1981; Wilson, 1998). Additionally, multiplexity was also used as a strength indicator (Granovetter, 1973). For measuring tie-strength, frequency of contact has been proposed by Granovetter (1974) and Lin et al. (1981), used by Benassi et al. (1999); and reciprocity was suggested by Friedkin (1980). Emotional support offered and received within a tie also proved to be a plausible indicator of tie-strength (Lin et al., 1985; Wellman, 1982; Wellman & Wortley, 1990). Contextual factors such as social homogeneity (Lin et al., 1981), shared affiliation and social circles (Alba & Kadushin, 1976; Beggs & Hurlbert, 1997) were also looked at in reference to tie-strength in social networks.

Marsden and Campbell (1984) investigated two major elements, indicators and predictors of tie-strength. Of all indicators, Marsden and Campbell (1984) showed that many indicators, including frequency and time spent, are contaminated by situational factors (predictors), except one. The measure of closeness was found free of contamination.

In 1998, Mathews and colleagues repeated Marsden and Campbell's study (1984), using a 13-item scale assessing tie-strength with a college student population. Information regarding potential predictors (gender, age, relative, roommate, attending the same lectures, same hometown, overlapping affiliation and duration of relationship) were also collected. The 13 items were related to four factors, namely: intimacy, time, services and intensity. As the aim of Mathews and colleagues (1998) was to find predictors and indicators of tie-strength, they did not make an attempt to quantify strength,

nor to make distinction between strong and weak ties. Rather, the relationship between indicators and predictors were investigated and Marsden and Campbell's argument (1984) about contaminated indicators was supported. Evidence was found, however, that certain sets of indicators explain more or less of the variability of the data set (Mathews et al., 1998, p.1463) with intimacy being the strongest indicator of tie-strength.

In addition to the above measures, voluntary investment in the tie, desire for companionship and frequent "meeting" with the tie partner in various context and intimacy can also be used as an indicator of tie-strength (Blumstein and Kollock, 1988; Mitchell, 1987; Plickert et al, 2005), where obviously strong ties exhibit all of the mentioned characteristics, whereas weak ties are mostly lacking these elements. In addition to the indicators discussed, a fairly comprehensive list of potential tie-strength components in various settings is summarised in Table 1.

Based on the literature we are aware of, quantitative, continuous measure of tie-strength has not been used. Often, researchers use the notion of weak or strong ties (e.g., Feld, 1997; Friedkin, 1980, 1982; Haythornthwaite, 2002; Roch et al., 2000;) as grouping variables. In many papers, it was rather unclear how the researchers obtain information regarding the strength of interpersonal ties. Few notable exemptions are, for instance, Hansen (1999), Harkola and Greve, 1995), Mathews et al. (1998), Plickert et al. (2005), Podolny (2001), van Alstyne and Bulkley (2005) and Wellman and Frank (2001).

Even in research projects, where the authors quantified their tie-strength related variables in their data set (e.g., Mitchell, 1987; Plickert et al, 2005; Wellman & Frank, 2001), the final outcome, again, was nominal data, unsuitable for many statistical analysis, including sophisticated graph theoretical methods available for weighted graphs. Also, there are measures of tie strength which apply in case of particular networks, e.g. economic networks (Podolny, 2001), yet they do not correspond to the strength of social bonds, rather to economic interests, thus can not be applied outside their original context.

### Tie-strength measures in virtual communities

Indicators and predictors summarised in Table 1 have been extracted from data collected in off-line social groups and as such, they may or may not be valid in virtual communities. Virtual communities are created/maintained and held together by computer-mediated communication (CMC), therefore components such as help provided and received, time spent together or even communication may have different meanings.

Studies focusing on tie-strength in true virtual communities are rather sparse. Among the few, Muncer et al. (2000a, 2000b) simply defined tie as having at least one posting between two

**Table 1.** Summary of tie-strength components

Measures	Category	References
Frequency	Indicator	Benassi <i>et al.</i> , 1999; Blumstein & Kollock, 1988; Granovetter, 1974; Lin <i>et al.</i> , 1981; Marsden & Campbell, 1984; Mathews <i>et al.</i> , 1998; Mitchell, 1987, Perlman & Fehr, 1987
Intimacy/Closeness	Indicator	Blumstein & Kollock, 1988; Marsden & Campbell, 1984; Mathews <i>et al.</i> , 1998; Mitchell, 1987; Perlman & Fehr, 1987
Voluntary investment in the tie	Indicator	Blumstein & Kollock, 1988; Perlman & Fehr, 1987
Advice given/received	Indicator	Mathews <i>et al.</i> , 1998
Desire for companionship	Indicator	Blumstein & Kollock, 1988; Perlman & Fehr, 1987
Multiple social context (breadth of topics)	Indicator	Blumstein & Kollock, 1988; Granovetter, 1973; Marsden & Campbell, 1984; Perlman & Fehr, 1987
Long period of time (duration)	Indicator	Blumstein & Kollock, 1988; Granovetter, 1973; Marsden & Campbell, 1984; Perlman & Fehr, 1987
Reciprocity	Indicator	Blumstein & Kollock, 1988; Friedkin, 1980; Granovetter, 1973; Mathews <i>et al.</i> , 1998; Perlman & Fehr, 1987
Provide support/emotional intensity	Indicator	Blumstein & Kollock, 1988; Granovetter, 1973; Mitchell, 1987; Perlman & Fehr, 1987; Wellman, 1982; Wellman & Wortley, 1990
Mutual confiding (trust)	Indicator	Granovetter, 1973; Marsden & Campbell, 1984; Mathews <i>et al.</i> , 1998
Sociability/conviviality	Indicator	Mitchell, 1987

participants and used the number of postings on each strand and frequency to indicate strength. Paolillo (2001) analysed the context of the messages and used informal 'speech' (i.e., using 'u' when writing 'you') and spelling as indicator of friendship and closeness. Adamic & Adar (2003) tested similarities, homepage links and email distribution lists' membership to predict relationships and found that homepage links and mailing lists (except religious lists) are poor predictors of a relationship between two people, whilst having mutual friends seemed to foster relationship developments. Therefore, the aim of this study is to test the above predictors and perhaps identify new ones for tie strength measures that recognise the uniqueness of virtual communities.

### METHODS

In case of a systematic network analysis (such as in this project), preferably the entire network is surveyed. Network data relating to tie-strength was collected by survey methods with questionnaires, followed up by virtual 'focus group' discussion to verify the questionnaire results. The 12-question survey used nomination technique with non-specific aided recall. Respondents completed the questionnaires on-line.

Potential problems with reliability of network data are due to the problem of recall and informant accuracy. Killworth, Bernard and Sailer in their series of informant accuracy (Bernard et al., 1980, 1982; Killworth & Bernard, 1976, 1979; Bernard & Killworth, 1977) warned researchers to exercise great caution when interpreting survey data. They claim that people's recall of past communication patterns is far from being accurate and currently used techniques cannot help this problem. On the contrary, Freeman et al., (1987), showed that respondents are able to recall and correctly report relations in general and have a fairly accurate picture about the social relations surrounding them (Freeman et al., 1989, Freeman, 1992). The questionnaire was designed to ask general information, rather than specific actions or occurrences. Because respondents were asked to name people with whom they share friendship, good times, help, trust and confiding, there is another problem we had to face: forgetting in recall-based elicitation (Brewer, 2000). To counterbalance this problem, the full list of topic participants' nicknames was provided. Nicknames were listed in alphabetical order. Answers were recorded by clicks on nicknames.

At the beginning, invitation was sent to everyone who ever posted message on the forum, using the private message function. A reminder message was sent to those who had not completed the questionnaire after the first three weeks. Technically, the system allowed new participants' names to be added to the list as they completed the questionnaire, permitting newcomers to join the sample even after the data collection had started. In reality, there was only a few that joined the sample after the questionnaire was set and due to their relatively little involvement in the group, they had not have formed significant relationships with anyone during the time when the data was collected. The questionnaire was only available for 8 weeks. As it can be seen from Fig. 1, depicting the ratio of active versus all participants, the structure of the on-line community was stable during the data acquisition period.

Validity of the scale was established through methodological triangulation (Creswell & Miller, 2000; Denzin & Lincoln, 1998; Patton, 2002; Strauss & Corbin, 1990). Specifically, between-method triangulation was chosen based on the assumption that each method used in this research will complement, rather than compound, the other methods' strengths and weaknesses (Jick, 1979). Therefore, quantitative tie-strength data from the questionnaire was first checked against information resulted from the prolonged observation (qualitative data) and then discussed with the participants themselves. The latter one proved to be very useful for both parties and provided evidence of the validity of the quantitative data obtained via the questionnaire.

If tie-strength can be objectively quantified, any attempt to measure it should yield various strengths of ties. Correspondingly, any given person's ties to different people may vary in strength and in case of reciprocal ties; the tie-strength does not need to be equal. In order to capture the essence of social networks, classifying the ties according to their strength should allow more variability than the simple dichotomy of strength and weakness. We computed the tie-strength measuring scores as follows: awarded 1 "point" for each nomination (that is when a person received a nomination from any member of the community) and double weighted if the nomination was mutual (pairwise) to recognise reciprocity. Double weighing meant to take into account that a tie from A to B should be stronger if the same tie is confirmed by B. Therefore, 'stars' (actors with many nominations) can have strong ties only if the tie represents mutual acknowledgement. In other words, stars must nominate back those who originally gave them incoming nominations to obtain high scores. Furthermore, the literature suggests that reciprocity is one of distinctive features of strong ties (Granovetter, 1973).

Summated scores were subject to both factor analysis and hierarchical clustering. The results of factor and cluster analysis from the development sample were tested under two condi-

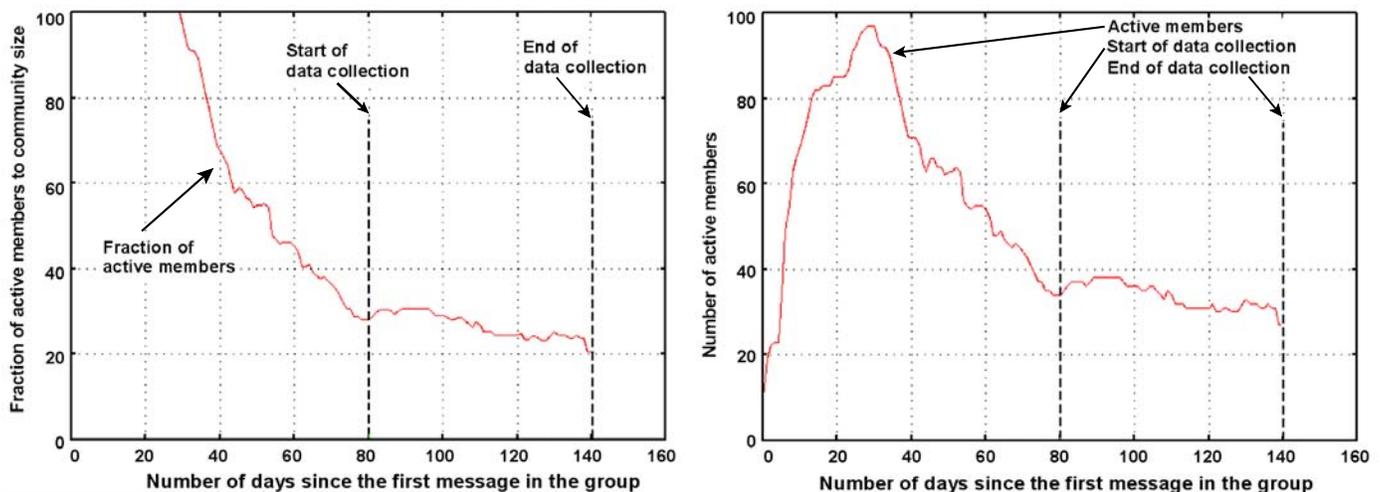


Figure 1. Stability of the discussion forum used for scale-development. On the left panel Absolute number of active participants (defined as those who sent at least one message in 30 days), left panel. Relative number of active participants (defined as the absolute number of active participants/number of all participants up to that date.), right panel. The period of data acquisition is shown with vertical lines.

tions: using data from asymmetric relationships and data with symmetric relationships only. Scale reliability was established on both data sets by Cronbach  $\alpha$  values. Factor analysis and hierarchical clustering were performed, and scale reliability coefficient was calculated using SPSS 12.1. We also used Mathematica 5 and Perl scripts to compute values of the tested predictors.

## DATA COLLECTION

Although there are many ways to define virtual community (e.g., Hine, 2000; Jones, 1995, 1999; Paccagnella, 1997; Preece, 2000; Rheingold, 1993), for the purpose of this research, virtual communities were defined by using Jones's (1997) four criteria: minimum level of interaction (1) among the variety of communicators (2) via a common public place (3) where most of the CMC occurs and a minimum level of regular membership (4). The selected two groups conform to the above criteria.

Data was collected via an on-line questionnaire in which participants were asked about their relationships to other members in the community. Following the recommendation of Ferligoj and Hlebec (1999), tie-strength was measured with several questions tapping into two distinct levels of relationship (acquaintances and friendship, see Table 4) and summated scores were calculated. The importance of reciprocity was recognised by adjusted weighting of the score in which mutual recognition occurred. The notion of weighting ties has been already used in Podolny (2001) in relation to inter-organisational economic ties, but to our knowledge, not in personal social networks.

To begin, a single topic was selected with 14,907 postings at the time when our data collection ended. The topic has grown out from a discussion on similar childhood memories and later turned into a virtual meeting place for people (mostly middle-aged women with family responsibilities and full time jobs). One of the researchers has been a member of the selected topic since the beginning. The researcher's involvement can be described as complete participation (Spradley, 1980). The researcher virtually 'lived' among the group members for over six months: made appearance every day on the forum, listened to their stories and shared own stories with them, provided encouragement, advice or help as needed and gratefully accepted the reciprocated favours, whilst every effort was made to remain an active yet objective and observant participant. Following the recommendations of Sharf (1999) regarding participant observation on the Internet, the investigator's true identity was revealed prior to data collection (i.e., after the first 3 months period). The decision about when to start collecting data was based on participant observation. Network structure stabilised after the first 1500 – 2000 postings, or approximately 3 weeks (Nepusz et al., 2005).

The personal, prolonged involvement of the researcher was twofold. First, the aim was to develop a sense for the virtual life and particularly for this virtual community. The secondary

intention was to establish rapport with and gain trust among the discussion forum members. Fifty-six members of the active 83 participated in this study. As Jones (1999) pointed out, it is seductively tempting to plunge into the vast amount and easily accessible data internet chat forums and discussion boards provide and harvest it for research purpose – without a real understanding of its meaning. In fact, understanding virtual communities is not any easier than to understand face-to-face human interactions. Living among those we wish to understand is a proven method in ethnography and virtual ethnography should not be any different in this respect.

The second set of data was collected from the same web-portal asking volunteers from another long-lived topic to complete the questionnaire. There was no overlap between the two sample groups. Although the topic was smaller (postings at the time of data collection remained under 3000), it had many regular members visiting the topic often to ask and provide help and encouragement relating to their post graduate studies. Members of this topic are all mature students (females, often with full time jobs and/or family responsibilities) of the same distance-learning programme. Sixteen of the total 86 agreed to participate in our study. (The lower positive response rate shows that establishing rapport among participants is just as essential in virtual groups as in their face-to-face counterparts.)

**Table 2.** The questionnaire (questions as they appear here are translated from Hungarian)

	Question	Measure
1	Which participants of the forum do you like?	Positive relationship
2	Which participants of the forum you do not like?	Negative relationship
3	Which participants do you trust (for example they know your real name, email address, password to your introduction sheet)?	Trust
4	Which participants have trusted you (have seen their introduction sheet, known their real name and email address)?	Trust
5	Which are the forum participants who have asked your help or asked a favour?	Support
6	Which are the forum participants, from whom you asked a favour or you asked their help?	Support
7	Who are the forum participants from which you feel you could ask a favour?	Support
8	Who are the forum participants with whom you have private correspondence?	Intimacy
9	Which of the forum participants do you consider to be your virtual friend?	Companionship
10	Who are the forum participants, with which you discussed topics other than the forum's topic?	Multiplexity
11	With whom of the forum participants, would you like to have a discussion about topics other than the forum's topic?	Multiplexity
12	Which ones of the forum participants would you like to meet in person?	Companionship/closeness

**STATISTICAL ANALYSIS OF THE QUESTIONNAIRE DATA**

Although Granovetter (1973) assumed that all ties are symmetric, our data suggest otherwise (see Table 3). In asymmetric relations, strength of tie  $A \rightarrow B$  is not equal to strength of tie  $B \rightarrow A$ . In other words, an asymmetric relationship acknowledges that a relationship between two nodes is not necessarily mutual. Based on Granovetter's work (1973) it can be assumed that strong relationships should contain mutual elements, whilst weak ties can be asymmetric relationships. If we adhere to mutuality of relationships where every indicator of tie-strength must be reciprocal to be acknowledged, tie-strengths are organised in symmetric matrices, where strength of  $A \rightarrow B$  is the same as strength of  $B \rightarrow A$ , thus it can be noted as strength of  $A \rightarrow B$ . The measurement tool (questionnaire) was examined under both conditions.

We considered a pair to be symmetric when mutual nomination was received on the same question(s). For the purpose of comparison we display the symmetric and asymmetric pairs (Table 3). One should note the difference in symmetric and asymmetric nominations. As Table 3 shows, some aspects of a tie are more sensitive to symmetry constraint than others. Notably question 2, which is the only negative question (dislike) does not have symmetry at all. Questions related to trust (Q3 and 4) and expressed feeling of friendship (Q9) seem to be prone to symmetry, whereas questions regarding individual likes, interest and desire (Q1, 10, 11 and 12) are greatly unidirectional, which results significantly larger number of asymmetric pairs than symmetric pairs. The discrepancy between the total number of ties and the sum of ties is due to the large number of non-nominations.

Principal component analysis was performed to identify common factors among the 11 questions. Q2 was not used in the final analysis, as it was the only negative question and as such,

showed distinct difference from the acquaintance and friendship factors. The Kaiser-Meyer-Olkin sampling adequacy index was excellent (0.939) when using asymmetric matrix and very good (0.822) when using the more restrictive, symmetric dataset. Factor loadings are shown in Table 4. Factors with eigenvalues greater than 1 were considered. To allow components to be related, Promax rotation was used. Factor analysis identified two factors

that were, indeed, significantly correlated (Spearman's  $r = 0.5$ ). The first factor relates to issues of "liking" someone: shared interest, degree of intimacy and trust, desire to meet in person. The second factor consists of serious "friendship" questions: acknowledgement of the friendship and reciprocal help. Combining the two components of a tie (acquaintances and friendship), scores received on each element were added together. Thus the maximum score for the combined tie-strength was 22, (11 questions, all double weighted), the minimum was zero.

The 11 questions were subject to cluster analysis. Hierarchical clustering using squared Euclidean distance and Ward methods produced two clusters that are almost perfectly aligned with the two factors (for comparison, see Table 4). In our case hierarchical clustering separates the questions in the positive quadrant of a two dimensional space. The coordinate axes are labelled with factor names. Graphical representation of the cluster formation is displayed in Fig. 2 and Fig. 3.

Although the VTS-Scale was investigated under both conditions (symmetric and asymmetric pairs), the great discrepancy between the number of ties must be noted. Granovetter (1973) and many who followed his footsteps assumed the pairs to be symmetric. The assumption may hold to a certain degree when ties only take dichotomous values: exist or does not exist; positive or negative; and perhaps weak or strong. When one attempts to measure the strength of the tie and represents this strength by a value (that is, the measurement is taken on at least an interval scale), it is unlikely that two people feelings toward each other are exactly the same. Realistically, such scenario only happens on two extreme ends of the scale: on the lowest end, where the value of tie strength is zero (two people do not have

Table 3. Frequency of nominations obtained in the survey

Question	Frequencies	
	Symmetric	Asymmetric
	175 pairs	3080 pairs
1	137	230
2	0	26
3	61	79
4	65	76
5	15	65
6	12	37
7	51	100
8	56	90
9	30	54
10	70	164
11	65	268
12	69	199

Table 4. Summary of the factor loadings under the two conditions.

Questions	Asymmetric ( $N_{pairs} = 3080$ )			Symmetric ( $N_{pairs} = 175$ )		
	Factor loadings <sup>a</sup>		Cluster	Factor loadings <sup>a</sup>		Cluster
	PC 1	PC 2		PC 1	PC 2	
1	<b>.801</b> <sup>b</sup>	.444	1	.186	.183	1
2	-	-	-	-	-	-
3	<b>.837</b>	.698	1	<b>.790</b>	.450	1
4	<b>.849</b>	.703	1	<b>.802</b>	.477	1
5	.523	<b>.844</b>	2	.262	<b>.832</b>	2
6	.463	<b>.866</b>	2	.319	<b>.799</b>	2
7	<b>.824</b>	.591	1	<b>.757</b>	.329	1
8	<b>.817</b>	.654	1	<b>.686</b>	.498	1
9	.724	<b>.790</b>	2	.666	<b>.720</b>	2
10	<b>.749</b>	.548	1	.306	<b>.569</b>	1
11	<b>.766</b>	.384	1	<b>.574</b>	.167	1
12	<b>.831</b>	.483	1	<b>.633</b>	.164	1
Cronbach $\alpha$	0.9209	.7864		.7645	.7662	

<sup>a</sup> Promax rotation

<sup>b</sup> Numbers in bold indicate factor loadings on the first factor

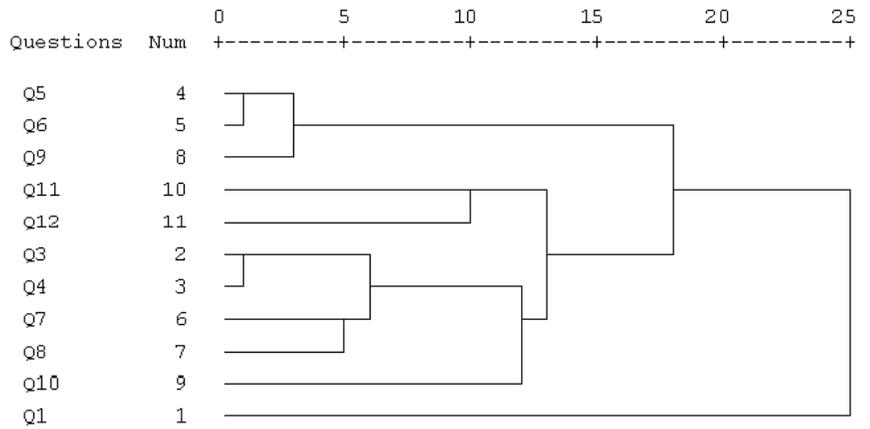
any relationship) and maybe on the highest end, where two people benefits from very strong bond between them. In our data, there were 2323 pairs with tie-strength value of zero (75.4% of all pairs) and only 4 pairs (0.1%) with the maximum score of 22. Distribution of the tie- strength values is shown in Fig. 4.

As it can be seen from the dendrogram (Fig. 2 and Fig. 3), questions 5, 6 and 9 are clearly separated from the remaining questions. This small cluster is identical to the component named friendship, whereas the remaining questions form the other, acquaintances component. The results suggest that tie strength may consists of distinguishable elements, thus the VTS-Scale may further be divided into subscales.

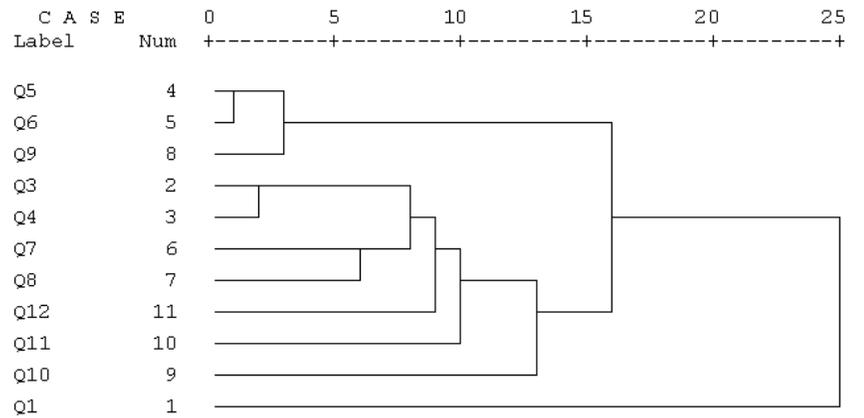
**DISCUSSION**

Based on the 56 participants who completed the survey, we created a table consisting of 3080 edges possible in principle among the respondents. The ties were grouped as follows: scores in the range 0-3 meant no or weak tie (2756 ties, 89.5%), ties with scores in the range 4-16 were named as medium strong (274, 8.9%), and ties with scores 17-22 were considered strong (50, 1.6%). These ratios seem to contradict the assumption that in virtual communities, the number of strong ties should be higher because it is easier to develop and manage strong ties in situations where face-to-face interactions is not required whilst asynchronous interaction and giving parallel attention is possible.

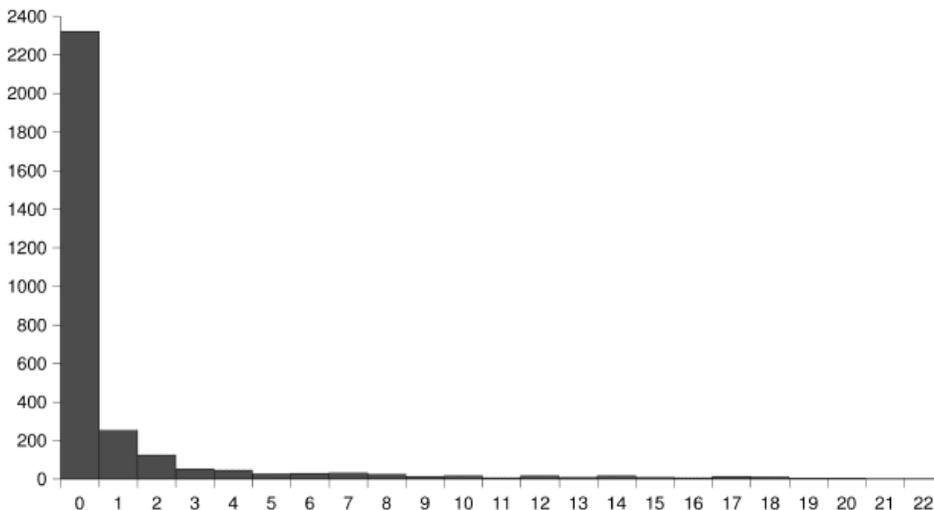
The cut-off point of 17 was selected because score 17 is above the upper quartile. Thus, one may obtain at most 16 points for the recognitions of acquaintance and 6 points for friendship. In



**Figure 2** Result hierarchical clustering of VTS-Scale questions (symmetric pairs)



**Figure 3** Result hierarchical clustering of VTS-Scale questions (symmetric pairs)



**Figure 4** Distribution of tie-strength values in the asymmetric pairs

reality, it seems that there is no precise distinction between medium weak and medium strong relationships. Although there is no doubt that such relationships exist, we assume that either they are transitional and usually indicate a (possibly unsuccessful) attempt to form a strong relationship, or they are the indicators of a one-sided relationship (cases when someone nominating a 'star' of the community). Hence we did not subdivide the medium strong group further. The dynamics of these medium strong ties is, indeed, very interesting and probably imperative in network formation; therefore the issue will be further investigated in future research.

Granovetter (1973) assumed that ties between friends and acquaintances are likely to differ in strength. In short, friends are connected with strong ties, whereas acquaintances are

connected by weak ties. Correspondingly, in our data, tie-strength appears to be comprised of two components: degrees of acquaintance (interests, liking, private communication) ranging from knowing each other to casual friendship and close friendship with mutual acknowledgement of the position, multiplexity and reciprocal support (help, advice, assistance, emotional support). This result corroborates Tausing and Michello's (1988) findings that people prefer to seek support via their strong ties, regardless of the nature of the problem.

From the measurement viewpoint, every strong tie should include a weak tie as well (i.e., friendship builds upon acquaintan-

5 that the probability to have at least 13 points from a maximum of 16 for those who obtained the maximum score of the friendship (6) was 66.67%. On the contrary, the probability of having the maximum 6 points for those who scored 13 on the acquaintance-scale is only 24.24%. Thus we can conclude that strong friendship must contain the elements of acquaintance, but in most cases strong acquaintance does not mean friendship.

The condition of a strong relationship was having at least 1 point from the friendship component (Q5, 6 and 9). Thus, strong relationship is defined as points between 17 and 22. As

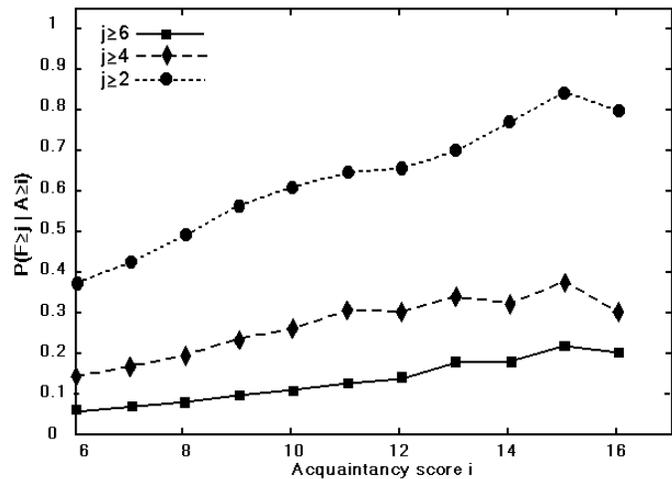
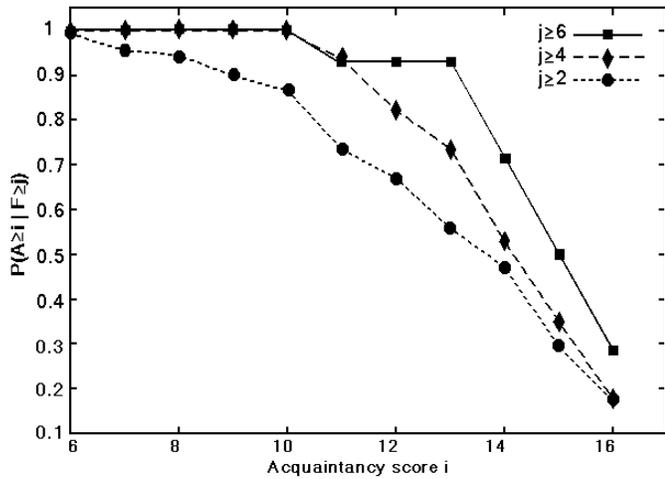
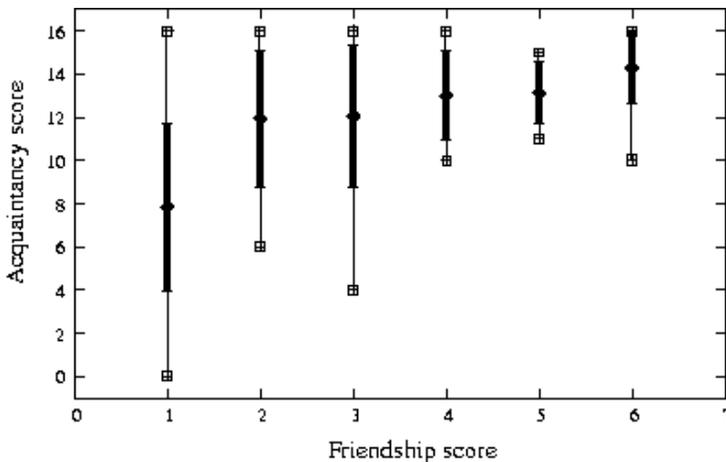


Figure 5. Conditional probability of acquaintance score given the friendship score, left panel, conditional probability of friendship score given the acquaintance score right panel.

tances). In other words, it is not possible for someone to have a strong tie (reciprocal confiding, mutual acknowledgement as friends) without claiming a weak tie with that particular person. Yet, not all relationships reach the level of friendship – some may stay as acquaintances over time, whereas others may fade out eventually. Conditional probabilities (Fig. 5) suggest that acquaintance is part of friendship. It can be read from Fig.

Fig. 6 shows, increasing strength of friendship not only results in increased statistical means of acquaintances, but also produces smaller range and reduced variability.



Two thirds (20) of all the strong ties were reciprocal (i.e. reciprocal tie with the same strength), 10 were non-reciprocal; whilst for the medium strong ties we found 96 non-reciprocated ties and 89 reciprocal connections. Judging from the content of Table 3 (question 9), developing friendship tie may not be any easier in virtual life as claimed by, for instance, Haythornthwaite et al. (1995), Kollok and Smith (2003) or Wellman and Gulia (2003). Even if developing and maintaining friendship ties via CMC is easier, it does not necessarily mean that people will have more ties when they are on-line, let alone stronger on-line than off-line ties. This finding supports Holme et al.'s (2004) recent discoveries regarding characteristics of on-line communities. Between all possible pairs of the 56 respondents in our data set, only 1.6% had strong friendship ties and an additional 8.9% developed into acquaintances. The remaining 89.5% of all ties were practically non-existent. However, this is in concordance with our preliminary expectations. The total number of possible pairs is just a theoretical limit and one cannot reasonably expect that all participants in a community form ties with each other. This shows that virtual communities, in this sense, are similar to their off-line counterparts. As we consider only a chosen few people as our friends or acquaintances from the vast amount we meet each day on the streets

Figure 6. Summary of acquaintance scores given the friendship score. For a given friendship score displayed are: the mean, standard deviation around the mean, minimal and maximal acquaintance scores.

or in clubs and parties, we also carefully choose from the ones we cross path in cyberspace.

In terms of numbers of strong, medium-strong or weak ties a person has in this particular community, we found that the average numbers of strong, medium and weak ties were 1.75 ( $\pm 3.15$ ), 9.66 ( $\pm 9.53$ ) and 103.65 ( $\pm 5.83$ ), respectively. The total number of all possible ties related to a given participant is 110 (sum of 55 outgoing and 55 incoming edges). The adjacency matrix of the forum participants was sparse: of all the 17030 possible edges 1147 were present (6.74%). The adjacency matrix of the subnetwork comprised of those forum participants was also sparse, out of all 3080 possible edges 582 were present (18.90%).

Marsden and Campbell (1984) found closeness to be the best indicator of tie-strength (time spent together and duration being good but contaminated indicators), whereas in Mathews et al. (1998), intimacy appeared to be the most important factor explaining variability in tie-strength, followed by time, reciprocal services and intensity. In our survey, questions related to explicitly stated friendship and mutual help seemed to make the distinction between weak and strong ties. Although the three measures cannot be directly compared, it can be said that if mutual acknowledgment of the friendship is measured as the ratio of reciprocated ties, it is most pronounced in the strongest tie group.

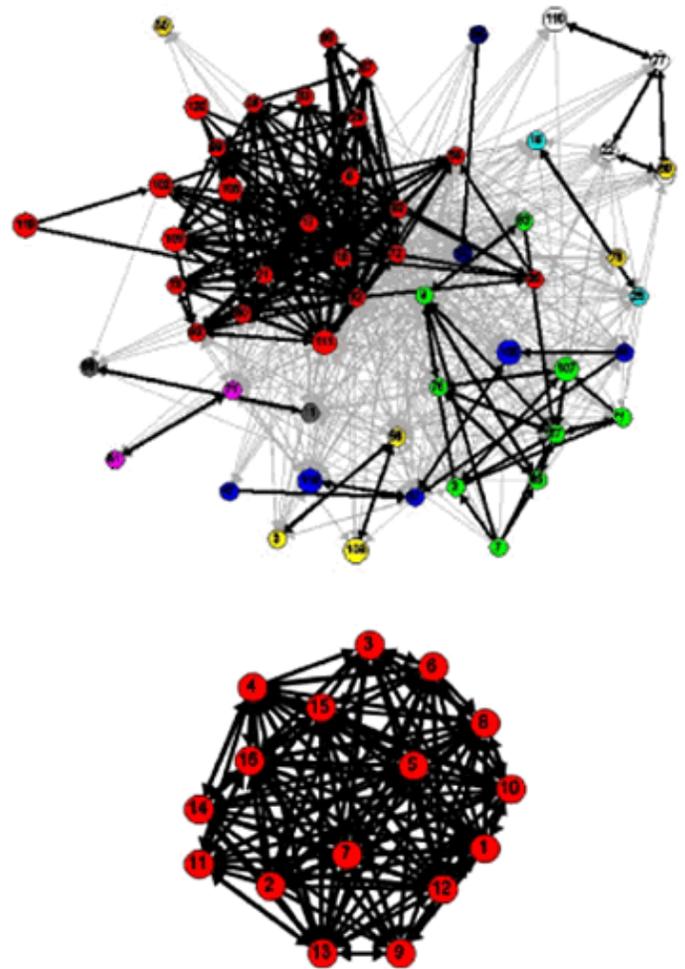
## VALIDITY AND RELIABILITY

Values of the tie-strength measures using the developmental sample ( $N = 56$ ) were used to create graphs showing (Fig. 7) people's relationships within the group. Discrepancy in numbers is due to the way data was collected. As we used aided recall, respondents were provided with the complete list of forum participants (116), not only those who completed the questionnaire.

Community structure was explored using the Markov Clustering method (van Dongen, 2000a,b). This method discovers clusters by simulating a large amount of random walks on the directed edges of the graph. The main concept is based on the observation that random walks initiated from densely connected clusters tend to remain in the same cluster. We used the original implementation of the author, available as a separate software package under Debian Linux (<http://micans.org/mcl/>).

Freeman (1992) and his colleagues (1989) showed that people have a fairly accurate picture of their immediate social world and their mental images about their group's structure are closely corresponding with observed interactions. The mental process of creating a social map of this particular on-line group was further assisted by the fact that – due to the nature of the discussion forums – large part of the interaction among group members is visible to all. Therefore it is easier for individuals to correctly judge other people's relationships. Discussion with group members supported the results presented in a graph thus

provided evidence for validity of our measures. In general, participants agreed with their network position, yet in some cases their perception about the amount of their strong ties was slightly overestimated. As stated in the method section, one of the authors was an active member of this on-line group (number 8 on Fig. 7). As the third point of the between-method triangulation, results were checked against the active participant researchers' field notes and personal perceptions of the group structure as well. In summary, network structure displayed in Fig. 7 'made sense', meaning what is on the graph is congruent with the researcher's personal impression of the group as a whole and it's members' place within it.



**Figure 7.** Top: Network structure revealed by Markov clustering based on tie-strength measures (Development sample,  $N_{\text{pairs}} = 3080$ ). Clusters are coded with colours. Bottom: Network structure based on tie-strength measures (Test sample,  $N_{\text{pairs}} = 240$ ).

In the network shown in Fig 7., on the left panel, black, bold lines represent ties within a cluster, whereas grey lines shows relationship between clusters. Nodes with the same colours belong to the same cluster. The nodes coloured yellow are one-member clusters. The 'hard core' of this particular on-line group is the one in red. This is not only the largest cluster within the

network, but also the most strongly connected. They meet and communicate regularly over the internet, some of them also met in person. Isolated pairs with strong tie between them are typically people know each other from another topic. They tend not to connect strongly to the main group.

VTS-Scale's reliability first was estimated for the developmental sample (N = 56) by calculating reliability coefficients (Table 4). Cronbach  $\alpha$ s using asymmetric and symmetric matrices for the 11 questions together were 0.92 and 0.81, respectively. Reliability coefficients were also calculated for the test sample (N = 16), where Cronbach  $\alpha$  for the 11-question scale had an excellent value of 0.86.

Subscale reliability was reassuring for the acquaintance-factor ( $\alpha = 0.85$ ) but alarmingly low ( $\alpha = 0.52$ ) for the friendship network. One plausible explanation for the low value may be found in the content (Question 5, 6 and 9). Question 5 and 6 are related to asking and providing help, which are indicators of a close relationship in a friendship network (developmental sample) but does not quite carry the same weight in a group, where the main reason of the group's existence is to provide help to each other (test sample). For the same reason, the relationships in the second group tend to be more functional. Personal feelings (likes and dislikes) are less relevant. Yet, people in the later group indicated in their answers that in general, they do like each other. The relative number of nominations for the first question was much higher than the same in the first sample.

As expected, the test sample shows great cohesion among members, Fig. 7, right panel. All 16 members form one cluster. Fig. 8 shows that the distribution of tie-strength scores is somewhat different and the mean score is higher for the test sample than for the development sample. This is due to the fact, that the test group was smaller, and respondents happened to know each other much better than in the original group, as reflected in the relative number of non nominations (12% for the test

sample and 75% for development sample). Our findings (cf. Fig. 6, right) are in concordance with our view about the mutual supportive nature of the second group. The VTS-Scale seemed to be reliable and valid measurement tool for tie strength in virtual communities. Due to the obvious difference between the two groups, component of tie-strength require further investigation. It is recommended to use the VTS-Scale as a one-dimensional measure and sum scores from Q1 to Q12 (not using Q2). Factor loadings of a one factor solution is better than acceptable (Table 5), ranging between the good 0.52 and excellent 0.87. High Cronbach  $\alpha$  values ( $> 0.85$ ) provided further reassurance about the VTS-Scale.

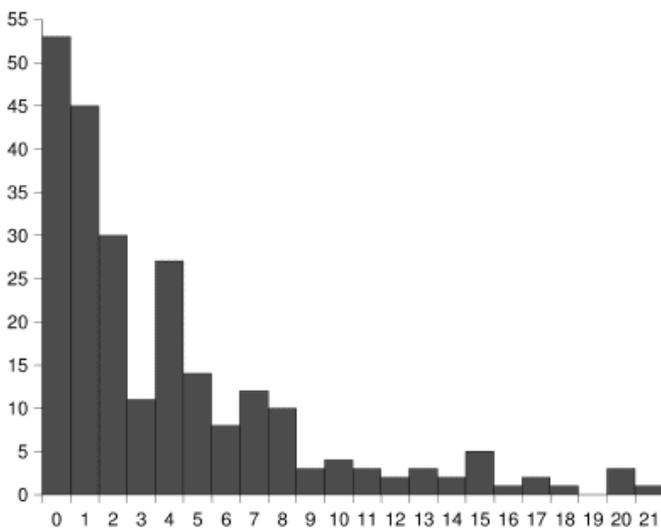
**Table 5.** Summary of the factor loadings in two independent samples.

Questions	Factor loadings	
	N <sub>pairs</sub> = 3080	N <sub>pairs</sub> = 240
1	.751	.630
2	-	-
3	.859	.842
4	.870	.775
5	.668	.574
6	.629	.556
7	.815	.522
8	.830	.827
9	.803	.675
10	.756	.655
11	.706	.573
12	.786	.698
Cronbach $\alpha$	0.924	0.859

**CONCLUSION**

Based on our result, we can safely conclude that indicators in virtual groups are similar to those in off-line networks. Trust, mutual confiding, multiplexity and shared interests is equally important in both types of social groups. The unique aspect of virtual communities is related to help asked and provided; and the desire to meet in person.

Help is easily available on the net. Posting a message on a list serve, an electronic board or initiating a new topic in a discussion forum environment pleading for help is sufficient to solicit advice, help or even emotional support. A person who is in need of advice can rely upon previous personal experiences that somebody will be out there to respond. As no relationship is required between the person who seeks help and a person who is willing to provide it, such network formation can only be described as an association network. Reciprocity has a different meaning in such networks as help or advice may very well be provided by a third (fourth, fifth, etc.) person or group within a broad timeframe. It is not expected to help the particular person who helped us when we needed, but to provide help or support to those who needs it within that particular virtual culture



**Figure 8.** Distribution of tie-strength values in the test sample.

(Wellman and Gulia, 2003). Therefore, receiving virtual support is not the equivalent to receiving personal support or help through a friendship tie. As a beggar on the street cannot claim to have a large friendship network based on the fact that a hundred people donated their change, support offered to complete strangers cannot be compared to support asked for- and received, or offered between two friends. To use help as indicator, one must step beyond what is normally offered on the net: either mutual reciprocity or help asked and provided beyond what can be normally expected on the net is required to make distinction between strong and weak ties based on help.

Developing the virtual friendship into a traditional relationship seems to be an important step. Even the most devoted members of virtual communities protect their personal life. People give strong value on their true identity (not as much to share personal information and photos, but to actually meet face-to-face) and their time. To make a commitment, moreover, to desire a personal meeting indicates that two (or more) people in this situation are probably strongly connected.

In summary, the VTS-Scale appears to be a valid and reliable measurement of tie strength, perhaps both in virtual and off-line groups. However, the difference between the two samples highlighted the importance of contextual contingencies. Differences in situations must be taken into account and reflected in the phrasing of the questions. The VTS-Scale is a useful tool for researchers who wish to use tie strength as dependent, rather than independent variable as it provides continuous measures of tie-strength instead on the previously used binary classification. The use of tie strength as an outcome variable, if measured on nominal or ratio scale, is limited to non-parametric techniques.

In addition, studying details of social structure may benefit from weighting network edges on a continuous scale, as in that case a large apparatus of statistical techniques may be meaningfully applied. In case of simply grouping edges into strong and weak ones much less can be said about the social structure as a whole. Future research should aim to explore the friendship and acquaintances components further, both in on-line and off-line communities.

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