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Information Demand on Scientists' Internet Profiles

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Abstract
Many scientists nowadays choose to create profiles on the Internet and thus present themselves and their work to a worldwide audience. This study examines, how scientists use the existing online profiles when looking for information about their peers. Of particular interest are differences in behavior based on existing interpersonal ties (strong, weak, latent, and absent ties). The study analyzed data from an online survey of 123 European scientists using quantitative association measures and qualitative comparative analysis. The findings show, that the Internet can positively influence the development of social networks within the scientific community. However, the platforms available for presentation online are numerous and the peer audience heterogeneous. While Internet presence can be of advantage for scientists, it should be designed and maintain with deliberation.

Keywords: science communication, Internet profiles, online profile, scientists' self-presentation

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1 Introduction

The aim of the study was to examine the search behaviour of scientists using the Internet to look for information about their peers in relation to existing interpersonal ties. The Internet offers numerous platforms where scientists can present information about themselves and their work, e.g. personal web pages, profiles on social networking services, blogs, microblogs, profiles on resource-management systems (Ferguson, Clough, & Hosein, 2010; Hess, 2002; Herwig, Kittenberger, Nentwich, & Schmirmund, 2009; Nentwich, 2010). The content can then be accessed by a worldwide audience. Hence, the Internet appears to be a suitable platform both to support the awareness among scientists that already know each other as well as to provide information to peers who are yet unconnected. Under this assumption, the Internet could play an important role in further development of science communication; however, in order to manage their Internet presence, scientists need to be aware of the information needs of their audience. The study thus investigated whether and how the search behaviour of scientists looking for information about their peers on the Internet differed with regard to the strength of existing interpersonal ties.

The theory of social networks suggests, that individuals are connected by interpersonal ties. According to Haythornthwaite (2002, p. 386), "a tie is said to exist between communicators wherever they exchange or share resources such as goods, services, social support or information". The ties between individuals can be of different strength, reflecting the intensity of their relationship. The tie strength can be measured with regard to the contact frequency, duration of the relationship, emotional involvement, level of intimacy, and reciprocal provision of service (Granovetter, 1973; Marsden & Campbell, 1984). Individuals with strong ties communicate often and readily share resources and information. At the same time, they are more likely to have access to the same or similar resources. Individuals with weak ties have a less frequent and less intensive contact. On the other hand, they are more likely to have different resources at their disposal and can thus prove valuable when strong ties fail to provide necessary support ("strength of weak ties", Granovetter, 1973; Hansen, 1999). Latent ties are connections not created by individuals, but implicitly existent based on organization or technological structures. Latent ties can be activated and turned to weak or even strong ties if necessary (Haythornthwaite, 2002; Genoni, Merrick, & Willson, 2005). An interpersonal network belonging to an individual will be made of many ties of different strength. Forms of exchange within the types will vary according to the context: individuals with a strong friendship tie can have a high level of emotional support, while strong ties among work colleagues can be marked by an intensive sharing of information. Furthermore, the network ties are dynamic. The ties and their strength will vary according to the needs of the individual (Pickering & King, 1995; Haythornthwaite, 2002).

Based on the theory of social networks, the scientific community can be regarded as a network of scientists, who are mutually connected through interpersonal ties. The ties have different forms and strength according to the needs of the scientists. While for example scientists cooperating in research projects can share strong ties, the connection to fellow scientists publishing in related areas will be weaker. In the scientific community as an occupational group, weak and latent ties play an important role (Pickering & King, 1995). Given the nature of scientific work, scientists need to be aware of the existence and activities of others working with similar ideas. This awareness is necessary for research activities, where procedures and findings have to be positioned against the work of others. Furthermore, given the growing trend towards collaboration in research projects (e.g. Sonnenwald, 2007; Cronin, Shaw, & La Barre, 2003; Cronin, Shaw, & Barre, 2004; Leydesdorff & Wagner, 2005), scientists need to have broad networks of latent and weak ties that they can activate and strengthen as necessary.

The development of personal social networks in the scientific community is based on different levels of awareness about the existence and activities of scientific peers (Carroll, Rosson, Farooq, & Xiao, 2009). This study examined the role the Internet presence has for network management among scientists. This was done by studying the behaviour of scientists using the Internet to find information about their peers. The study focused on four research questions:

Q1: On what platforms do scientists search for information about their peers and does the selection of platforms differ with regard to the tie strength?

Q2: How do scientists arrive on the profiles of their peers and do the search ways differ with regard to the tie strength?

Q3: What information about their peers do scientists seek and does the information demand differ with regard to the tie strength?

Q4: What impact does the information search have on the interpersonal ties?

The questions were studied using 123 responses to an Internet-based survey of European scientists. The survey used an online questionnaire with multiple-choice questions, asking the respondents to recall and describe their last online search for information about another scientist. The responses were then coded and grouped to allow better analysis of search patterns and their association with tie strength. The generated data were then analysed using quantitative measures and qualitative comparative analysis (Ragin, 1987, 2008). The results show that some aspects of the search behaviour were connected to the strength of the existing ties between the searching and the sought scientists. However, while the access ways and information interests of the searching scientists varied according to existing tie strength, there was no clear trend regarding the platforms the scientists tended to view. Scientists can thus find it difficult to target their Internet profiles at a specific audience. Nevertheless, an Internet search for information in some cases led to strengthening of existing ties or to creation of new connections. The development and maintenance of online presence can thus be considered a meaningful investment in scientists' self-presentation within the scientific community.

2 Methods

The following section describes the processes of data generation and analysis. The data used in the study were generated using and online survey. The analysis combined the use of quantitative association measures with qualitative comparative analysis. The quantitative measures helped to determine the existence and strength of relationships between the tie strength and viewed platforms (Q1), access ways (Q2), sought information (Q3), and search impact (Q4). The results of the qualitative comparative analysis described combination patterns for each research question according to tie strength.

2.1 Sampling

For the purpose of the study, a scientist was defined as a person professionally engaged in research at a higher education institution. This definition covers scientists in different positions as well as in different disciplines. To obtain more consistent results, the study used a geographically focused target population. Firstly, the study was limited to scientists affiliated to academic institutions in Europe. The reason for this was to increase the comparability of the questionnaire answers. The European higher education institutions are currently a subject of an ongoing standardization effort better known as the Bologna Process. Although the conditions at the participating institutions may still vary considerably, it was assumed that the participation in the Bologna Process has created similar perception of the role of higher education and academic research. Secondly, the target population was further limited to the scientists working in countries with high level of Internet use, as the object of the study was online search behaviour of scientists. The use of Internet was operationalised as the broad band penetration per 100 inhabitants. Data from the OECD and Eurostat were used to identify countries with high levels of broadband penetration. Thirdly, the selected countries were checked with Eurostat data for the level of language skill in English and German, as these were the survey languages. As a result of this three-step focusing process, the target population was described as scientists working at academic institutions in the following countries: Austria, Belgium, Denmark, Finland, Germany, Iceland, Ireland, Luxembourg, Malta, Netherlands, Norway, Slovenia, Sweden, Switzerland, and the United Kingdom.

After identifying the target population, a sample of 1008 scientists was chosen using stratified cluster sampling. In the first step, the target population was stratified according to the number of academic staff working at higher education institutions in each country using Eurostat data. This was then mirrored in the structure of the sample (see Table 1). Due to the absence of a suitable sampling frame, cluster sampling was used on the level of higher education institutions. Thus in the second step, higher education institutions were selected for each country stratum. The list of ERASMUS charter holders was used, focusing on universities, because these can be assumed to have a clear research mission. While other types of higher education institutions may also be engaged in research, an in-depth analysis would have been

Table 1: Sample structure

Country	Universities	Scientists	Proportion
Germany	44	440	43.65%
United Kingdom	19	193	19.15%
Netherlands	7	69	6.85%
Sweden	5	54	5.36%
Switzerland	5	49	4.86%
Austria	5	48	4.76%
Belgium	4	40	3.97%
Norway	3	30	2.98%
Denmark	3	27	2.68%
Finland	2	21	2.08%
Ireland	2	21	2.08%
Slovenia	1	9	0.89%
Iceland	1	4	0.40%
Malta	1	2	0.20%
Luxembourg	1	1	0.10%
Sum	103	1008	100%

necessary to separate those without or with limited research activity. Swiss universities were added to the resulting list manually, as Switzerland does dot participate in the ERASMUS exchange scheme. Then, for each country, a random sample of universities was selected according to the size of each stratum. In the third step, scientists were sampled from each selected university according to the size of each stratum. For this purpose, either an institutional staff list was used and the scientists picked using a random number generator or, in absence of such list, further clustering was used on school/faculty and department levels. The selections on all levels were done randomly, using a random number generator. The result of the sampling procedure was a list of 1008 scientists, coming from 103 universities within the selected 15 European countries.

2.2 Survey

Each of the selected 1008 scientists was sent an e-mail with a link to an online questionnaire as well as background information about the study. The questionnaire was provided in English and in German. The overall response rate was 11,21% with 113 questionnaires. There were, however, considerable differences in the response rate per country (see Table 2). Firstly, no responses were received from Iceland, Luxembourg, Malta, and Slovenia due to the limited size of the strata. Therefore, the results of the study cover only scientists from 11 European countries: Austria, Germany, Belgium, Switzerland, Denmark, Finland, Netherlands, Norway, Sweden, Ireland, and the United Kingdom. Secondly, the different response rates meant that the responses had a different composition compared to the original sample. Additionally, 23 questionnaires were filled by scientists from a university in Finland, who have not been part of the original sample. 104 of the responses from the original sample were usable, with an additional 19 from Finland.

Table 2: Post-stratification of responses

Country strata	**Stratum size**		**Responses**		**Weight**
i	H_i	H_i/N	h_i	h_i/n	w
Germany	440	0.44	51	0.43	1.03
United Kingdom	193	0.19	6	0.05	3.83
Netherlands	69	0.07	15	0.13	0.55
Sweden	54	0.05	5	0.04	1.29
Switzerland	49	0.05	8	0.07	0.73
Austria	48	0.05	8	0.07	0.71
Belgium	40	0.04	3	0.03	1.59
Norway	30	0.03	1	0.01	3.57
Denmark	27	0.03	2	0.02	1.61
Finland	21	0.02	19	0.16	0.13
Ireland	21	0.02	2	0.02	1.25
Slovenia	9	0.01	0	0.00	-
Iceland	4	0.00	0	0.00	-
Malta	2	0.00	0	0.00	-
Luxembourg	1	0.00	0	0.00	-
Other	-	-	3	-	1.00
Sum	1008	1.00	123	1.00	

As the geographical spread of the responses differed considerably (see Table 2) from the original sample, post-stratification according to geographical location was used to prevent bias. For this purpose, the sample N was divided in i strata of size H_i, where each stratum represented one geographical location ($\Sigma H_i = N$). Accordingly, the responses n were divided into corresponding strata h_i ($\Sigma h_i = n$). A weight w was then calculated for each stratum as follows:

$$w = \frac{H_i/N}{h_i/n}$$

The weight w was applied in all instances of quantitative analysis. Weighing was not used in the qualitative comparative analysis, as this method is concerned with the identification of patterns.

2.3 Questionnaire

The questionnaire was founded on the critical incident technique. The respondents were asked to recall the last time when they had used the Internet search for information about a scientists from other institution than their own. This last search was then treated as a critical incident, regardless of whether it was a typical search behaviour of the respondent and independent of the position, discipline or affiliation of the searched scientists. The following questions were based on the recall of the critical incident. The critical incident technique was chosen because it provides a more focused recall than asking questions regarding the general behaviour of the respondent. The aim of the study was not to make inferences about typical search behaviour of European scientists, but to describe possible behavioural patterns. It was thus more important to achieve a precise recall then a general overview of the respondents practices. This approach relies on the sample to provide a reasonably random selection of different searches (compare the use of this method in Tenopir, King, Edwards, & Wu, 2009).

The questionnaire collected answers about search behaviour of the respondents on three levels: (1) the scientist whose information had been looked up, (2) the scientist's online profile, and (3) the content of the profile. Based on this structure, the questionnaire contained four groups of questions (see also Appendix A):

Questions about the scientist. Questions in this group served to describe the scientist, whose information had been looked up and the relationship of the respondent to this person. The scientist was described regarding his or her discipline, position, and country of affiliation. The self-assessed relationship description served as an indicator of the ties strength.

Questions about the scientists profile. In this group the respondents were asked to recall what platforms containing information about the scientists they viewed and how had they reached them.

Information of interest. The respondents were asked to indicate what information they were interested in and whether they found it. They were also asked to describe freely what impact the found information or the lack of information had.

Information about the respondent. The respondents were finally asked to indicate their academic position, discipline and country of affiliation.

The questionnaire was developed and disseminated using the online survey tool *SurveyGizmo*. The questionnaire was designed to be very brief to increase the chances of getting a high response rate. Therefore, during the piloting the time necessary for filling it in was measured and the questionnaire adjusted to take less than 10 minutes. The brevity of the questionnaire, however, limited the number and the complexity of the items. This was particularly problematic regarding the questions serving to judge the tie strength. The strength on an interpersonal tie is a complex construct which cannot be assessed by only two items. Furthermore, the questionnaire relied solely on self-assessment of the respondents. The questions assessing the relationship of the respondent to the sought scientists can thus be considered only as indicators and not as measurements.

2.4 Analysis

The collected data were studied with qualitative comparative analysis using the program *fsQCA* as well as with quantitative analysis using *IBM SPSS* software. The free text regarding the impact of the information search was qualitatively analysed using the software package *AtlasTI*. The data were coded for quantitative analysis in the *IBM SPSS* program. The data had been partially precoded by the survey tool *SurveyGizmo*, but manual coding was also necessary. Basic descriptive statistics were derived, to provide first foundation for the analysis. To complement the qualitative comparative analysis, associations within the data were tested using the the Decady-Thomas corrected chi-squared test for multiple-response data (Thomas & Decady, 2004; Decady & Thomas, 2000), Pearson chi-squared test, and the Gamma and Cramer's V measurements.

The data were also studied using qualitative comparative analysis. The qualitative comparative analysis stands between qualitative and quantitative research. Its aim is to offer a structured yet holistic method for the analysis of a limited number of cases. It is based on set theory and uses the Boolean algebra for analysis (Rihoux, 2003; Ragin, 1987, 2008; Fiss, 2007, 2011). In this case, the qualitative comparative analysis was used to identify patterns within the data with regard to the tie strength and to the platforms they viewed (Q1), the ways the have reached these platforms (Q2), and the information the respondents looked up (Q3). To carry out the qualitative comparative analysis, the data had to be calibrated. For the calibration, sets relevant to the variables of interest were identified. Then, based on the collected data, the inclusion in each set for each case was evaluated. The analysis was based on crisp-set calibration, i.e. each case was calibrated as being either included in a particular set or excluded. Four mutually exclusive sets were used to describe the strength of the tie, where each response was marked as belonging to one of these sets:

Strong-tie set. Cases were marked as belonging to this set, when the respondents had answered that they had known the scientist of interest well beforehand and when their description of the relationship indicated closeness.

Weak-tie set. Cases were marked as belonging to this set, when the respondents had answered that they had had personal contact with the scientist of interest beforehand and when their description of the relationship indicated some closeness.

Latent-tie set. Cases were marked as belonging to this set, when the respondents' answers had been aware of the scientists' existence beforehand but no close relationship existed.

Absent-tie set. Cases, where the respondents had not been not aware of the scientists' existence beforehand were marked as belonging to this set.

Furthermore, sets were defined for the platforms that the respondents viewed (one for each platform), for the possible ways of reaching the platforms (one for each way), and for information of interest (one for each type of information). These sets were not exclusive - a response could belong to more than one set. A truth-table analysis was then carried out using the *fs/QCA* software. The aim of the analysis was to find combinations of sets describing the platforms viewed in the search (Q1), the access ways (Q2), and the information of interest (Q3) as related to the defined tie-strength sets. Hence, for the analysis, the combinations of set-memberships were viewed as potential predictors of the tie-strength sets:

Q1: $TieSet = f(ViewedPlatform_1, ..., ViewedPlatform_n)$

Q2: $TieSet = f(AccessWay_1, ..., AccessWay_n)$

Q3: $TieSet = f(SoughtInformation_1, ..., SoughtInformation_n)$

The responses regarding the impact of the information search were analysed and compared across the tie sets (Q4). In the questionnaire, the respondents were asked to briefly describe the impact of the search in their own words. Of the 104 responses from the original sample and the 19 additional Finnish responses, only 85 (69.1%) respondents altogether answered this question. These were used in this step. Responses without an answer to this question have not been excluded from previous analysis as they still contained full set of information regarding the research questions Q1, Q2, Q3. The answers regarding the search impact were coded using the *AtlasTI* package. Quantitative methods were used to analyse the association between tie strength and search impact.

3 Results

This section presents the results of the analysis carried out for the tie-strength subgroups. The following sections are structured according to the research questions. Each section summarizes the results yielded both by the quantitative analysis as well as the qualitative comparative analysis. Based on the set definitions, the sample was effectively split into four subgroups according to the tie strength (see Figure 1). The 'strong-tie' group was very small, therefore the results based on the analysis of this group had limited validity. The lack of strong-tie relationships in the sample can be explain by the nature of the activity of interest: information search implies an initial lack of information. Individuals connected by strong ties would be expected to have higher awareness of each other and thus be less likely to look up each other's information online. The 'weak-tie' and especially the 'latent-tie' groups were more common. The 'absent-tie' group was smaller, again, as scientists can be expected to visit profiles of individuals of whose existence they are aware more often than to find profiles by chance.

The relationship between the tie strength, the platforms viewed (Q1), the access ways (Q2), and sought information (Q3) were studied using quantitative analysis and the qualitative comparative analysis. The quantitative analysis was based on descriptive statistics, particularly cross-tabulation and association testing using Pearson's chi-squared test and Decady-Thomas corrected chi-squared test for multiple response sets (Thomas & Decady, 2004; Decady & Thomas, 2000).

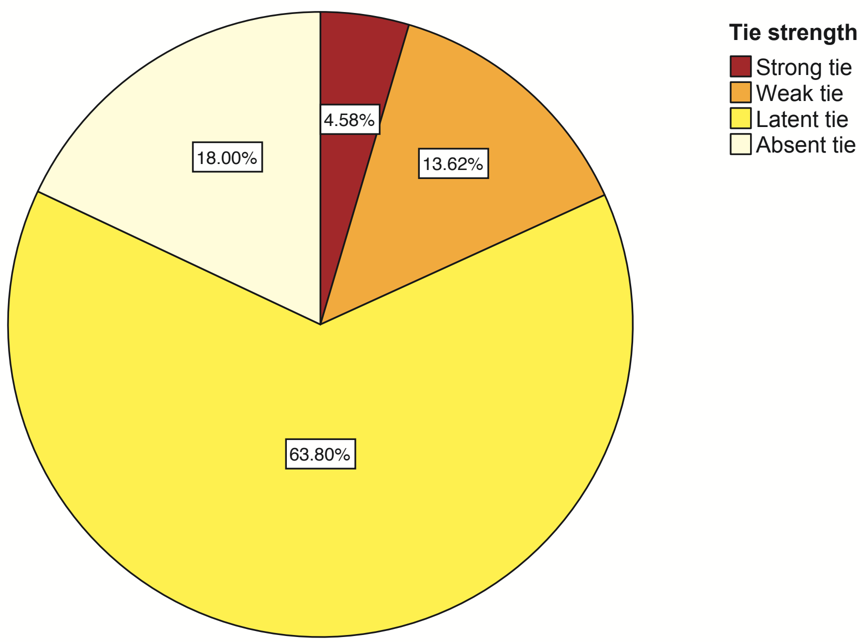

Figure 1: Sample division according to tie strength

The qualitative comparative analysis yielded tables depicting the combinations of the behaviour of interest, i.e. the platforms viewed (Q1), the access ways (Q2), and the information of interest (Q3) respectively, structured by tie strength. For the analysis, the behaviour of interest (e.g. act of viewing a platform) was translated into a membership in a set of individuals eliciting particular behaviour (e.g. viewers of a particular platform). The tables thus depict patterns as set-membership combinations. In the tables, an 'O' marks a set membership and an 'X' a non-membership.

If no symbol is assigned, the membership is ambiguous. Bold symbols mark a core feature. Core features define a combination, while periphery features (non-bold symbols) mark interchangeable combinations. The tables also give the consistency and the coverage of the combinations. Consistency is the proportion of cases with a given set-membership combination that also belong to a particular tie strength, as opposed to those with the same combination but a different tie strength (Fiss, 2011). Thus the consistency measure assesses how well the relationship between the behaviour and the tie strength has been approximated (Ragin, 2006). Coverage, on the other hand, describes how many respondents of the total number of cases with a given tie strength also display a particular set-membership combination (Ragin, 2006). Therefore, a larger number of possible combinations will automatically lead to a lower coverage per combination. Coverage can be further subdivided into raw coverage and unique coverage. Raw coverage shows the proportion of cases with a given tie strength that display a particular combination (Ragin, 2006). Unique coverage shows the coverage of a particular combination without overlaps with other possible combinations (Ragin, 2006).

3.1 Viewed platforms

Many scientists make information about their person and their work available online. They can use a variety of platforms to do so. The respondents in the survey were asked which platforms they have visited during their information search. They could choose from: (1) institutional web pages, (2) personal profile on institutional web pages, (3) private web page, (4) SNS profile (indicating the different types of SNS - professional, scientific, other; these were aggregated for the analysis), (5) blog, (6) microblog, (7) citation management, or (7) other. Respondents who have chosen 'other' described viewing a list of results after a search, a list of publications on a dedicated platform (e.g. ISI Web of Knowledge, ACM Portal), Wikipedia, and project pages. The answers were matched against the indicated tie strength. Figure 1 shows the distribution of the responses.

The respondents with different tie strength had viewed mainly institutional web pages, personal profiles on institutional sites, and with lesser preference SNS profiles. No clear patterns were discernible within the tie-strength groups. According

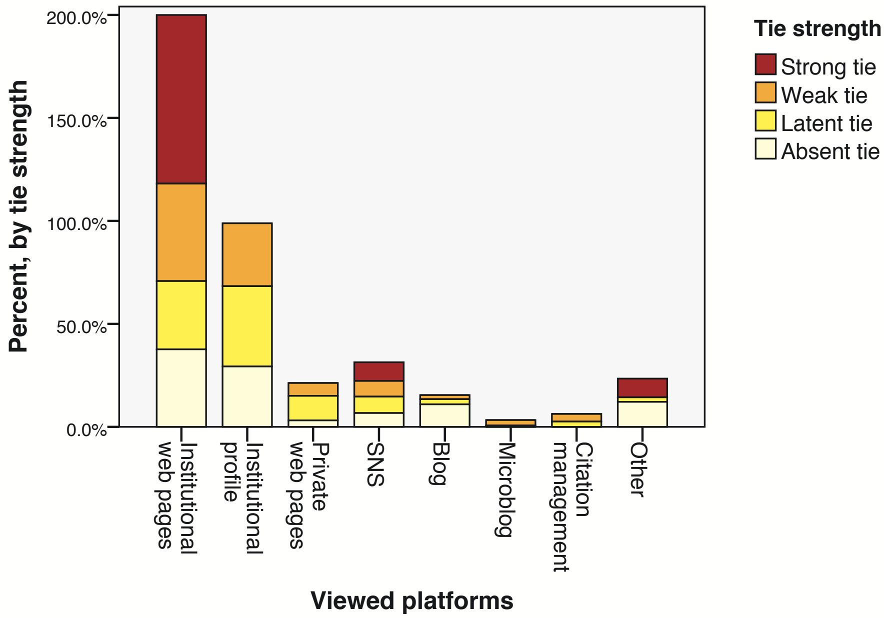

Figure 2: Viewed platforms by tie strength

to the test results (Decady-Thomas chi-squared test; chi-squared 26.88, degrees of freedom (df) 24, p-value 0.31), there was no statistically significant evidence, that an association exists between the two variables. This would imply, that scientists with different tie strength are equally likely to view the different platforms. Furthermore, when testing each viewed platform as a single dichotomous variable against the tie strength, only the viewing of a personal profile on institutional web pages and viewing other platforms had a statistically significant association to the tie strength. Interpreted as ordinal variables and using the gamma statistic, there are no significant results for the association strength. Interpreted as nominal variables, using Cramer's-V statistic, the results show a low level of association between tie strength and viewing personal profile on institutional web pages and viewing other profiles respectively (see Table 3).

The qualitative comparative analysis also provided no clear results (see Table 4). One pattern was identified for the strong-tie set, showing the combined viewing of SNS and other platforms. This pattern supports the assumption that individuals who already know each other well would use platforms that 'digitalise' these connections (e.g. SNS or resource-management platforms) and support awareness (Farooq, Ganoe, Carroll, & Giles, 2007), while they would be less likely to use profiles with more general information (institutional web pages, institutional profiles). However,

Table 3: Association measures: tie strength and viewed platforms

Viewed platforms	**Chi-squared**	**DF**	**Gamma**	**Cramer's V**
Inst. Web pages	3.38	3		
Inst. Profile	18.90***	3	-0.1	0.39***
Priv. web pages	6.13	3		
SNS	0.57	3		
Blog	4.83	3		
Microblog	2.42	3		
Cit. management	1.61	3		
Other	7.81**	3	-0.46	0.25**

*p-value $\leq$ 0.10. **p-value $\leq$ 0.05. ***p-value $\leq$ 0.01

given the very limited size of the strong-tie group, this pattern is not generalizable. Individuals with weak ties apparently combined visiting platforms with more general information ((a) institutional web pages, (b1) institutional profile, even (b2) SNS) with platforms containing particular, dynamic content ((a) microblog, (b1) blog, or (b2) citation management). This again suggests that such platforms are suitable to keep up the awareness of activities among scientists. The latent-tie patterns can be divided into thee groups: (c) focus on websites with general information, (d) viewing blogs, potentially in combination with further websites, and (e) collecting information from a range of different platforms. The absent-tie pattern combined viewing institutional profile with a blog. While consistent patterns were distinguished for each group, these are hardly clear cut (compare b1 and c, or d and the absent-tie pattern). Their coverage was also limited.

The results in Table 4 support the conclusions from the statistical testing of the cross tabulation. Although the analysis has distinguished patterns in each tie-strength group regarding the platforms viewed in the search, the combinations are not clearly cut within the tie-strength sets and of limited coverage. It can thus be concluded, that the tie-strength has little influence on the platforms viewed by scientists when searching for information about their peers.

3.2 Access Ways

When searching for information, scientists can access the platforms using different paths: they may (1) know that a profile exists and access it directly via a link or by

Table 4: Viewed-platforms combinations

	Solution													
	Strong		**Weak**					**Latent**						**Absent**
		a	b1	b2			c1			c2	d		e	
Inst. Web pages	X	**O**	X	X		O		O	X		X	X	**O**	X
Inst. Profile	X	**X**	**O**	**O**	**O**	**O**	**O**	**O**	**O**	X	X	O	**O**	O
Priv. web pages	X	X	X	X	X	X	X	X	O	**O**	X	X	O	X
SNS	O	X	X	**O**	**X**	**X**	**X**	**X**	**X**	X	X	X	**O**	X
Blog	X	X	X	**O**	**X**	**X**	**X**	**X**	**X**	X	**O**	**O**	**O**	O
Microblog	X	**O**	X	X	**X**	**X**	**X**	**X**	**X**	X	X	X		X
Cit. management	X	X	**O**	X	X	X	O	O	X	X	X	X	X	X
Other	O	X	X	X	X	X	X	X	O	X	X	O	X	X
Raw coverage	0.25	0.06	0.06	0.06	0.47	0.33	0.03	0.03	0.01	0.09	0.02	0.01	0.02	0.06
Unique coverage	0.25	0.06	0.06	0.06	0.16	0.02	0.01	0.01	0.01	0.09	0.02	0.01	0.02	0.06
Consistency	1.00	1.00	1.00	1.00	0.80	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Solution coverage	0.25		0.18						0.7					0.06
Solution consistency	1.00		1.00						0.86					0.06

typing the address into the browser; (2) be aware that a profile of the scientist of interest exists on a particular platform and look it up there; (3) search for information about a particular person using a search engine and then visit the pages that were found; (4) search for a scientist with particular qualities (e.g area of interest, country); (5) search for information on a topic and so find scientists connected to the topic; (6) follow a link; or (7) use another way. Respondents, who have selected 'other' have all used literature search on a dedicated platform (e.g. ISI Web of Knowledge, ACM Portal). Figure 3 shows, how the individuals with different tie strength accessed the profiles of their peers.

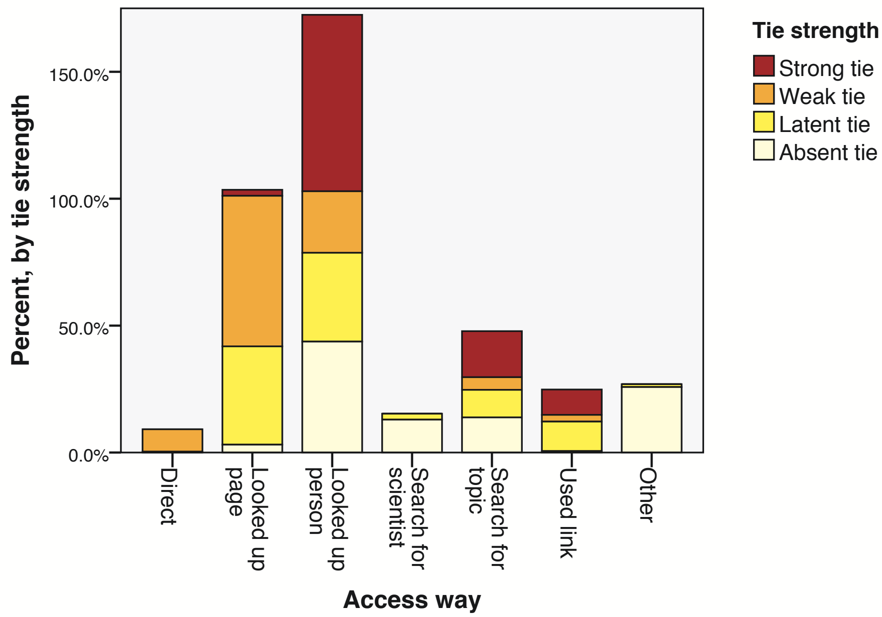

Figure 3: Access ways by tie strength

Viewing the access ways, it appears that scientists with strong and weak ties were more likely to use access ways depending on previous awareness of their peers' online profiles. The statistical test also shows an association between the strength of interpersonal tie and the access way to the person's online content. (Decady-Thomas chi-squared test; chi-squared 75.04; df 21; p-value < 0.001). Testing for association between tie strength and each access way as a dichotomous variable using the Pearson's chi-squared test shows an existing association between tie strength and use of direct link, looking up a particular page, and other access ways (literature database sites). Interpreting the access-way variables as ordinal, gamma values were calculated to determine the strength and the direction of these associations. Apparently, scientists with higher tie strength showed a tendency to look up known profile pages. Finally, individuals with lower tie strength tended to use other access ways, in this case search of literature databases. When interpreted as nominal variables, looking up known pages and other access ways displays a moderately strong association, and the use of direct links a weak association to tie strength (see Table 5).

Table 5: Association measures: tie strength and access ways

Access Ways	**Chi-squared**	**DF**	**Gamma**	**Cramer's V**
Direct	12.44***	3	0.89	0.32***
Looked up page	28.18***	3	0.51**	0.49***
Looked up person	2.91	3		
Searched for scientist	4.84	3		
Searched for topic	0.99	3		
Used link	5.34	3		
Other	22.83***	3	0.95***	0.43***

*p-value $\leq$ 0.10. **p-value $\leq$ 0.05. ***p-value $\leq$ 0.01

The qualitative comparative analysis yielded combinations of access ways in relation to the tie strength (see Table 6). No consistent results were derived for the strong-tie set due to the small size of the set. One combination was derived for the weak-tie set, consisting of the use of direct access and links. This combination agrees with the picture of weak-tie peers as having 'digitalised' their relationship e.g. through saving links to each others' profiles, though the coverage is too low to generalize. The latent-tie patters can be divided into three groups: (a) looking up known pages or scientists, using no open search, (b) looking up known scientists, potentially as a part of a topic search, and (c) less direct search relying also on links. Thus the respondents with latent ties used semi-direct searches, utilizing their awareness of the peers existence. The absent-tie set yielded just one combination, where the access was achieved by searching for a scientist with particular qualities. This access way is consistent with the fact that at the beginning of the content search, scientists with absent ties would not be aware of the existence of their peers.

According to the quantitative as well as the qualitative comparative analysis, the access way is influenced by the initial tie strength. Respondents with stronger ties were likely to use more direct access ways, while those with weaker ties used less direct ways, depending partially on unfocused searches for scientists or topics. These results support the view, that offline relationships are mirrored in the online social networks (Haythornthwaite, 2002).

Table 6: Access-way combinations

	Solution									
	Strong	**Weak**	**Absent**							**Weak**
			a		b1		b2	c		
Direct	no	O	**X**	**X**	**X**	**X**	**X**	**X**	**X**	X
Looked up page	results	X	**O**	**O**	X	O		X		X
Looked up person		X	X		**O**	**O**	**O**	X	O	X
Search for scientist		X	**X**	**X**	**X**	**X**	**X**	X	O	O
Search for topic		O	**X**	**X**	X		**O**	O	X	
Used link		X		X	**X**	**X**	**X**	**O**	**O**	X
Other		X	X	X	O	X	X	X	X	X
Raw coverage		0.06	0.36	0.51	0.01	0.19	0.05	0.01	0.02	0.24
Unique coverage		0.06	0.01	0.00	0.01	0.00	0.02	0.01	0.02	0.24
Consistency		1.00	0.79	0.81	1.00	0.89	1.00	1.00	1.00	1.00
Solution coverage		0.06				0.62				0.24
Solution consistency		1.00				0.84				1

3.3 Sought information

The online profiles of scientists can contain information of different types: (1) general information, (2) contact information, (3) curriculum vitae, (4) information about activities, (5) information about expertise, (6) list of publications, (7) a particular publication, (8) information about specific topics, or (9) other. Respondents, who have chosen 'other' further specified the sought information as further information about the scientist's institution, the scientist's photo, and further links. The answers were then viewed in relation to the tie strength (see Figure 4).

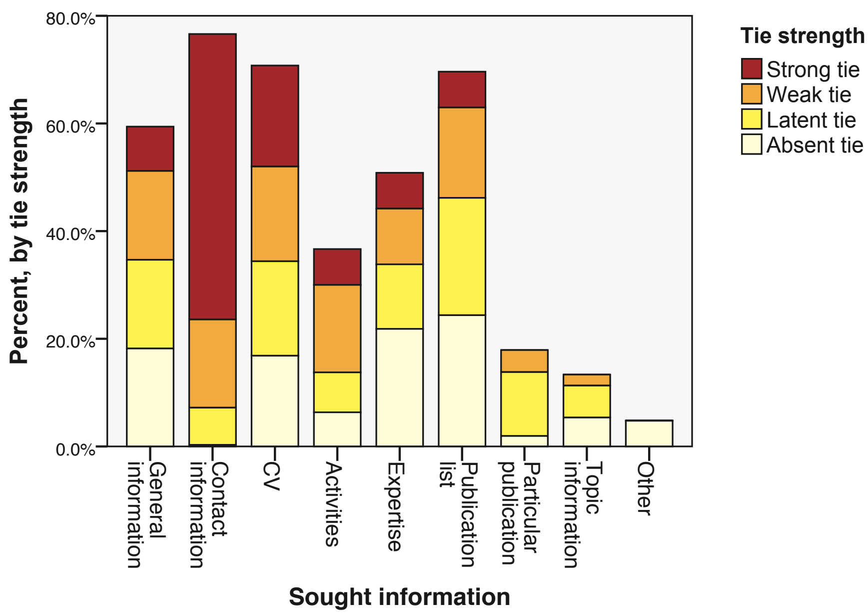

Figure 4: Sought information by tie strength

Patterns within the distribution of sought information and tie strength are only partially visible. A large portion of the strong-tie set has sought for contact information. Weak- and latent-tie respondents apparently sought for a variety of information, while respondents with absent tie tended to search for general information about their peers, their achievements (CV), expertise, and publications. Contact information appeared to have been of interest mainly to respondents with stronger ties. Decady-Thomas adapted chi-squared test showed a significant association between the multiple-response set of sought information and tie strength (chi-squared 78.94; df 27; p-value < 0.000). Association tests between tie strength and types of sought information as dichotomous variables revealed significant association between tie strength and contact information, information about activities, particular publication as well as a publication list, and other sought information respectively. Interpreting tie-strength and each sought information type as ordinal variables, it appears that respondents with higher tie strength were more likely to look for contact information. Higher-tie individuals also showed a slight tendency to look for information related to their peers activities. Viewing the variables as nominal measures, there further appear to be weak associations between tie strength and viewing of publication list, viewing particular publications, and viewing other information respectively (see Table 7).

Table 7: Association measures: tie strength and sought information

Sought information	**Chi-squared**	**DF**	**Gamma**	**Cramer's V**
General information	3.67	3		
Contact information	22.31***	3	0.82***	0.43***
CV	3.31	3		
Activities	7.8*	3	0.37**	0.25*
Expertise	1.57	3		
Publication list	7.36*	3	-0.11	0.25*
Particular publication	13.30***	3	0.06	0.32***
Topic information	3.21	3		
Other	9.15**	3	-1.00	0.27**

*p-value $\leq$ 0.10. **p-value $\leq$ 0.05. ***p-value $\leq$ 0.01

The result of the qualitative comparative analysis were combinations of information sought by the respondents (see Tables 8 and 9). No consistent results were derived for the strong-tie set due to the small size of the set. The weak-tie combinations could be subdivided into three patterns: (a) search for information about achievements and activities supported by further information, (b) viewing publication list supplemented by personal information, and (c) viewing topic information in connection with further information about the scientists person and work. The latent-tie set yielded 23 combinations that can be divided into 4 pattern groups: (d) search for information about the scientists' person and their work with different focus (e.g. on general information, CV, activities etc.), (e) focus on publication list with potential interest in further information about the scientist, (f) search for a single publication potentially also viewing the whole publication list and further information, and (g) interest in a particular topic potentially leading to viewing further information about the scientists and their publications. The absent-tie set yielded three patterns: (h) search for general information, (i) focus on the scientists' work (expertise, activities, publications), and (j) viewing personal information as a part of a topic search.

Table 8: Sought-information combinations

	Solution														
	Strong	Weak					Latent								
		a		b		c	d1	d2	d3		d4	e			
General info.	no	O	X	X	O	X	X	X	**O**	**O**	**O**	O	X	X	X
Contact info.	res.	O	X	X	O	X	X		X		**O**	X	O	X	X
CV		**O**	**O**	X	O	X	X	**O**	**O**	**O**		O	X		O
Activities		**O**	**O**	X	X	**O**	**O**	X	X	X	X		O	X	O
Expertise			X	X	X	**O**	X	O		X	X	X	O	X	O
Publication list			X	**O**	**O**	**O**	X	X		X	X	**O**	**O**	**O**	**O**
Part. publication		X	X	X	X	**O**	X	X	X		X	X	X	X	
Topic info.		X	X	X	X	**O**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Other		X	X	X	X	X		X	X	X	X	X	X	X	X
Raw coverage		0.13	0.06	0.06	0.06	0.06	0.02	0.02	0.15	0.05	0.03	0.08	0.01	0.12	0.02
Unique cover.		0.13	0.06	0.06	0.06	0.06	0.02	0.02	0.08	0.02	0.02	0.02	0.01	0.12	0.02
Consistency		1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	1.00	1.00	1.00	1.00	0.80	1.00
Sol. coverage				0.38							0.72				
Sol. consistency				1.00							0.95				

Table 9: Sought-information combinations (continued)

	Solution																
	Latent (continued)														**Absent**		
	f1			f2				g1			g2				h	i	j
General info.	X	X	X	O	X	O		X	O	X	O	O	X	X	O	X	O
Contact info.	X	X	O	X	O	O	X	X	X	O	X	O	X	X	**X**	**X**	**X**
CV	X	X	X		O	X	X	X	O	X	O	O		O	X	X	O
Activities		O	X	X	X		X	X	O	O	X	O	X	X	X	**O**	**O**
Expertise	X	X	O	X	X	X	O	**O**	**O**	**O**	O	X	X	X	X	**O**	**O**
Publication list		X	O	O	O	O	X	X	X	O	O	O	O	X	O	O	
Part. publicat.	**O**	**O**	**O**	**O**	**O**	**O**	**O**	X	X	O	**O**	**O**	**O**	**O**	**X**	**X**	**X**
Topic info.	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**O**	**O**	**O**	**O**	**O**	**O**	**O**	X	X	**O**
Other	X	X	X	X	X	X	X	X	X	X	X	X	X		O	O	X
Raw coverage	0.05	0.02	0.01	0.03	0.01	0.02	0.03	0.02	0.01	0.01	0.01	0.01	0.03	0.02	0.06	0.06	0.06
Unique cover.	0.03	0.01	0.01	0.03	0.01	0.02	0.03	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.06	0.06	0.06
Consistency	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sol. cov.							0.72									0.18	
Sol. consist.							0.95									1.00	

The analysis shows differences in the information sought by the respondents depending on the tie strength. Strong-tie and weak-tie respondents were more interested in contact information of their peers. This would agree with the assumption that they were already aware of more general information. The weak-tie group was generally concerned with collecting information that would help them to get a broader picture about the scientist of interest (achievements, activities, expertise, and publications), also with potentially more interest in contact data. The latent-tie and absent-tie group sought for more specific information, either concerning the scientist or resources he or she produced. These groups we also likely to find the information in connection to a topic search.

3.4 Impact

The respondents were asked to assess the result of their search. Firstly, they were questioned whether they had found the information they looked for. Secondly, they were asked to briefly describe the impact of their search. The open question about the search effect was answered by 85 (69.1%) respondents. The answers were categorized into eight groups: (1) no impact, (2) better knowledge about the scientist of interest, (3) initiation of personal contact to the scientist, (4) acquisition of resources necessary for own work (e.g. publications, information, ideas), (5) contact with the scientist to acquire further resources, (6) unspecific impact description indicating that the search was generally useful, and (7) need for further search. Figure 5 shows the distribution of the answer groups. There was a significant correlation between whether the respondents have found the information they have sought and whether they described the impact (Pearson's chi-squared 10.01, df 2, p-value 0.006). If the respondents found information, they were slightly more likely to describe the impact of their search (gamma 0.39, p-value 0.036). It can thus be assumed, that many respondents who had not answered the effect question needed (7) further search. There was further correlation between the non-response and the assigned tie strength (Pearson's chi-squared 8.56, df 3, p-value 0.04). Respondents with weaker ties were slightly less likely to respond. However, at the same there was a correlation between finding information and tie-strength (Pearson's chi-squared 11.54, df 6, p-value 0.07; gamma -0.17, p-value 0.31).

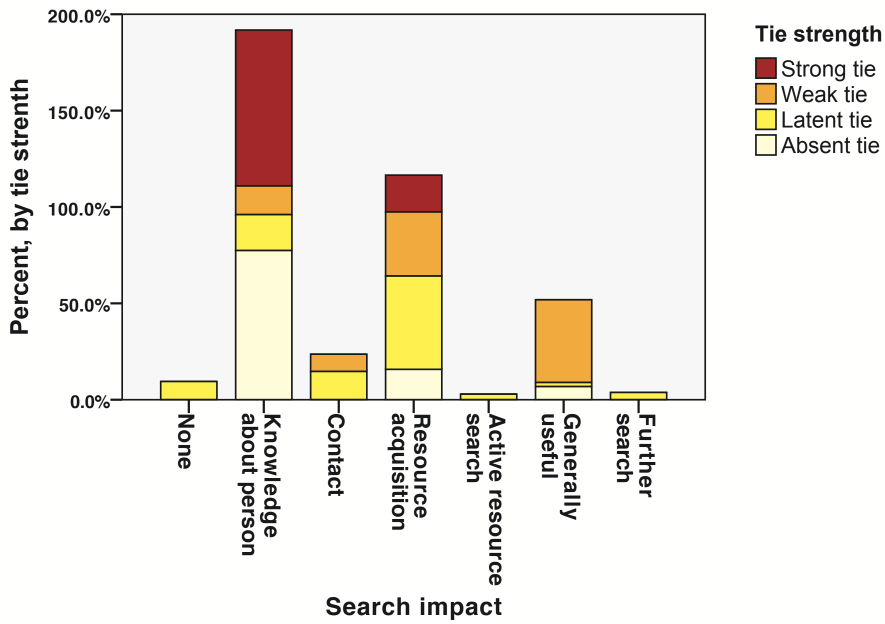

Figure 5: Search impact by tie strength

Quantitative analysis revealed a weak association between the search impact and the tie strength (Pearson's chi-squared 46.78, df 18, p-value < 0.001; Cramer's V 0.431, p-value < 0.001). Figure 2 shows what impact the information search had on individuals with different tie strength. Apparently, scientists with latent ties were more likely to use the search for resource acquisition, though they would also seek to contact the scientist in question as a result of the search. Absent-tie scientists were looking to increase their knowledge of their peers and were less likely to acquire resources through their search. Weak tie scientists tended to describe the search as generally useful.

The scientist's search for information about their peers had a multitude of possible impacts. The impacts appear to be connected to the scientists' tie strength. Of interest are impacts that can potentially serve to increase the tie strength the scientists had to their sought peers. From the absent-tie set, 13 (59.22%) respondents gained knowledge about their peers. Given that these were previously virtually unknown to them, the search has contributed to changing and absent tie into a latent one. Similarly, of the latent-tie set, 10 (15.58%) respondents said that they had some personal contact as a result of their search, thus potentially creating a weak tie to their peers. An analogous potential for changing weak ties into strong ties through personal contact was described by 1 (6.25%) respondent.

4 Discussion

The results of the study show a moderate association between tie strength and the behaviour of scientists. Different levels of association were described regarding the viewed platforms (Q1), access ways (Q2), sought information (Q3), and impact (Q4). As discussed below, the findings show, that the Internet can positively influence the development of social networks within the scientific community.

Only a small number of scientists in the sample were described as having strong ties with the peers whose information they sought. This absence suggests, that scientists are less likely to search for information about their peers online, if they are connected with strong ties. Given that individuals with strong ties are expected to know each other well and be in frequent contact, it can be assumed, that content of public Internet profiles would be of limited information value. Most scientists in the sample were assigned to the latent-tie set. Given the nature of the scientific community (geographically disjunct, awareness and reputation based on scientific publishing)(Pickering & King, 1995), it would be expected, that many scientists are aware of each others existence, without ever having been in personal contact. The proportion of the latent-tie set in the sample suggests, that the Internet is suitable for collecting further information about peers from the scientific community. It also confirms, that creating online profiles can be a suitable way of self-presentation within the scientific community.

The existing tie strength had little influence on the platforms viewed by the scientists in their search. Though some patterns have been identified, these were not clear cut among the tie-strength sets. While this finding may appear trivial, it can be an important realization for scientists managing their online profiles. It shows that various forms of presentation are likely to have a mixed audience: a blog might be used by a weak-tie colleague to maintain awareness as well as by a fully unknown scientists looking for topic information; an institutional profile can serve to provide contact data and lead to a tie activation as well as to collect general information to get a first impression of the scientists. The variety within the audience thus appears to justify the need for multiple profiles on different platforms to reach different groups of peers within the scientific community.

Clearer distinctions among the tie-strength sets were visible with regard to the ways used by the scientists to access their peers profiles. Here, scientists with stronger existing ties (strong ties, weak ties) tended to use more direct access ways, like using saved addresses or looking up known profiles. Scientists with latent ties used less direct access, like searching for known peers and looking up further pages, though they might also find peers' profiles while searching for information on particular topics. Scientists with absent ties showed a tendency to search for scientists with particular qualities. This behaviour supports the assumption, that the relationships 'digitalised' in the virtual environment mirror existing offline networks (compare the assumptions in Haythornthwaite, 2002). Additionally, as the participation of the absent-tie set, shows, the online presence may be suitable for creating relationships beyond the offline networks.

The tie-strength sets also showed some differences regarding the information they sought. Scientists with strong or weak ties were more likely to look for contact information, while those with latent or absent ties were interested more general information about their peers. Apparently, all scientists were likely to look for publications, either as a list or for particular ones. The clear interest in publications stresses the important role that scientific publishing plays in establishing reputation and awareness within the scientific community (Heimeriks & Vasileiadou, 2008; David, 2004). The distinction between the sought information among the tie-strength sets coupled with the lack of clear patterns regarding viewed platforms predicts difficulties in managing scientists' Internet presence. Scientists may have difficulties in defining the audience of their profiles and thus strategically selecting the content presented on the different platforms.

The impact of searches for information about peers affirms, that the Internet as a presentation platform can serve not only to support existing social networks in the community, but also to develop them. While weak tie scientists have described different impacts, most often regarding the search as 'useful'. These scientists thus apparently used the Internet search for general awareness cultivation. Scientist with weak ties apparently sought mostly resources (e.g. information, publications). Scientists with absent ties, however, tended to build knowledge about their peers as a result of their search. Hence, they created latent ties to their peers. The impacts described by the scientists in general show, that a search for information about peers can results in strengthening existing ties or creating new ones. Creating a presentation in the Internet can therefore be considered as a meaningful investment in the self-presentation within the scientific community.

5 Conclusions

The aim of the study was to examine the search behaviour of scientists looking for information about their peers and the influence of existing social ties on this behaviour. Of interest were the platforms viewed by scientists during the search (Q1), the ways the scientists chose to access these platforms (Q2), the information that the scientists looked for (Q3), and the impact of the information search of the scientists work (Q4). The data for the study were collected using a survey of a clustered random sample of European scientists, with a resulting sample size of 123. The data were then analysed using quantitative association measures and qualitative comparative analysis. The results show an existing, though moderate association between the strength of social ties and scientists' peer search.

According to the results, creating an online presence can be useful for scientists. it can serve to promote their self-presentation within the scientific community and thus potentially develop their social networks. The scientists' online presence can be used to 'digitalise' existing offline networks, based on traditional forms of networking, like scientific publishing or personal contact during qualification. At the same time, online self-presentation can serve to strengthen social ties with peers or even create new connections. However, the study also points to the difficulties in managing such online presence, particularly with regard to strategic audience orientation. According to the findings it is difficult to predict who will visit which Internet profiles. As peers with different strength of existing social ties showed interest in different information, it can be problematic to decide what content to provide on which profiles. Furthermore, scientists must also take care to provide direct as well as indirect access ways in order to make their profiles available to a variety of peers. In conclusion, the design and maintenance of an online presence can be meaningful tool for scientists' networking in the scientific community. However, given the numerous platforms available online for self-presentation as well as the heterogeneity of potential audience, scientists should design and maintain their Internet presence with deliberation.

There are two limitations regarding the generalizability of the study findings: the sample size and the measurement of tie strength. The findings of the study are based on a sample of 123 scientists from 11 European countries. The sample for the survey has been selected using cluster sampling based on geographical locations of affiliated institutions. The responses were later weighted to resemble the structure of the original sample. Despite these strategies, the sample size is too small to allow simple generalization to all scientists in the considered countries. At the same time, the results represent valid trends which exist in the search behaviour of scientists. These trends are also in agreement with assumptions and findings of existing research. As such, the results from this study can be applied by researchers and practitioners beyond the scope of the studied sample. Furthermore, to keep the questionnaire brief only two items were used to assess the construct of tie strength. As such, these cannot be described as true measurements, but only as indicators. A more elaborate way of assessing the tie strength could lead to better distinction among the sets and clearer cut results, thus giving a more definite shape to the trends outlined by this study.

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A Questionnaire

Explanation and instructions

Many scientists nowadays provide information about themselves or create content on the Internet. They can use different platforms, for example have a personal page on the website of their institution, have a profile on a social networking platform like Xing, LinkedIn, Academia.edu or Facebook, write a blog, have microblog (e.g. Twitter), use an aggregator platform (e.g. FriendFeed) and more. In order to fill in this questionnaire, please think about the last time you have used the Internet to view a profile (e.g. website, profile on a platform) or content (e.g. a blog, microblog) of a scientist from a different institution than your own.

This might have been a typical or an atypical encounter with information about or by a scientist in the Internet for you. You may have seen one or more pages about or by the scientist. The scientist may have been of any academic position from a doctoral student to a professor. The scientist may have come from any academic discipline (your own or a different one) and may have been affiliated to any institution worldwide other than your own. Please keep this incident in mind when filling in the questionnaire.

The scientist

1. What was the scientist's academic discipline?

    - Agricultural sciences
    - Architecture, urban and regional planning
    - Arts and Design
    - Business studies and management sciences
    - Cultural studies
    - Education, teacher training
    - Engineering, technology
    - Geography, geology
    - Humanities
    - Informatics

- Languages
- Law
- Mathematics
- Medical sciences
- Natural sciences
- Social sciences
- Veterinary medicine

2. What was the scientist's academic position?

- Doctoral student
- PostDoc
- Lecturer
- Researcher
- Professor

3. In what country did the scientist then work?
(alphabetised list of countries worldwide provided)

4. Did you know the scientist prior to viewing his or her information or content?

- Yes, I knew the scientist personally and well.
- Yes, we have had some personal contact before.
- I have met or seen the scientist briefly before (e.g. at a conference).
- I knew the scientist's name, but hardly more (e.g. from reading a publication or from others).
- No, I did not know and have not heard of the scientist at all before.

5. What term would you choose to describe the scientist?

- A student
- A young scientist
- A colleague
- A fellow scientist
- An expert
- Other:

Information search

6. What kind of pages related to the scientist or created by him or her did you view?

- Website of the scientist's institution
- Personal profile on the institutional pages
- Private website
- Personal profile on a professional social networking platform (e.g. Xing, LinkedIn)
- Personal profile on a scientific social networking platform (e.g. ResearchGate, Academia.edu)
- Personal profile on other social networking platform (e.g. Facebook, MySpace)
- Blog
- Microblog (e.g. Twitter, Identi.ca)
- Aggregator (e.g. FriendFeed, ScienceFeed)
- Profile on a citation management platform (e.g. Mendeley, CiteULike, Zotero)
- Other:

7. How did you reach the scientist's page(s) or content?

- I knew the page(s) and went there directly (e.g. via a bookmark, by typing in the URL, using a contact list).
- I knew that the page(s) existed and looked them up (e.g. through Google-search, platform search).
- I searched for some information about this scientist.
- I searched for scientists with particular properties (e.g. expertise, areas of interests).
- I followed a link.
- I searched for information on a specific topic.
- Other:

Information of interest

8. What information was of interest for you?

- General information about the scientist

- Contact information of the scientist
- The scientist's curriculum vitae and academic achievements
- Information about activities in which the scientist participated
- The scientist's areas of expertise
- The scientist's academic publications
- A particular publication by the scientist
- Information on a specific topic
- Other:

9. Did you find the information you were looking for?

- Yes, I found all the information I needed.
- I found some of the information I needed.
- No, I did not find the information I needed.

10. What was the impact of the information search? Please describe briefly, how the information you have found (or the lack of the information you needed) effected you or your work.

Demographic data

11. What is your academic discipline? (equivalent to question 1)

12. What is your academic position? (equivalent to question 2)

13. In what country do you work? (equivalent to question 3)

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