Photo Tagging Over Time: A Longitudinal Study of the Role of Attention, Network Density, and Motivations

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Abstract

Along with the growth in artifact sharing in online communities such as Flickr, YouTube, and Facebook comes the demand for adding descriptive meta information, or tags. Tags help individuals to organize and communicate the content and context of their work for themselves and for others. This longitudinal study draws on research in social psychology, network theory and online communities to explain tagging over time. Our findings suggest that tagging increases as a contributor receives attention from others in the community. Further, we find that the more a user's network neighbors are connected to each other directly, the less the focal user will tend to tag his photos. However, density interacts with attention such that those who are surrounded by a dense ego network respond more to attention than others whose ego networks are sparsely interconnected. Unexpectedly, we find no direct correlation between tagging and the individual motivations of enjoyment and commitment. While commitment is not directly associated with tagging, there is an interaction effect such that the effect of commitment on tagging is positive for users with low density ego networks and negative when a user is surrounded by a high density network. Directions for future research as well as implications for theory and practice are discussed.

Introduction

The last decade has witnessed a dramatic expansion in the use of social computing systems. Some of the Internet's most popular websites are those that allow users to continuously produce and share content as well as to meet and communicate with other individuals who have overlapping interests (Cummings, Butler, and Kraut 2002; Mislove et al. 2008; Wu, Wilkinson, and Huberman 2009). As these systems "facilitate social interaction online with rich exchange of multimedia information and the evolution of aggregate knowledge" (Parameswaran & Whinston 2007), people often choose to annotate their shared artifacts and information goods with some form of meta-information that can later help others to discover new information (Sen et al. 2006). User-contributed annotation in the form of tags (Marlow et al. 2006) can be used to describe many types of content including images, bookmarks, blogs, and videos.

Prior studies have shown that the health of online communities depends on sustained content contribution from individual members (Chiu et al. 2006; Koh et al. 2007). Understanding what motivates contributors to begin and continue tagging is critical to the long-term viability of social software systems.

Flickr (www.flickr.com) provides an example of a social computing system where users can upload artifacts—in this case photographs—and also add metadata to help contributors organize their photographs and assist other viewers in understanding what they are seeing (Ames and Naaman 2007; Nov, Naaman, and Ye 2008). Flickr has more than 3 billion uploaded photos and 35 million registered users (Harrod 2009). The system enables contributors to upload, organize, and share their digital photos (Marlow et al. 2006). In turn, others can view, comment on, and share those photos (Cha, Mislove, and Gummadi, 2009) within and beyond the immediate community. Flickr, like other social computing systems, is blurring the traditional distinctions between content sharing and social networking by allowing users to associate themselves with other users whose photos they follow (called "contacts" in Flickr). An important result of adding contacts or joining groups is that users make their photos available to others for viewing and commenting (Cha et al. 2009), and as a result are creating new avenues for giving attention to one another (Huberman, Romero, and Wu 2008).

When one user designates another as a contact in Flickr, in effect, he becomes a follower of the individual who has been designated (Cha et al. 2009). While not obliged to, most Flickr members reciprocate and create mutual friendships, or contacts (Mislove et al. 2008). By default, all users' contacts can be seen on their profile page (Cha et al. 2009), opening the possibility for a handful of friendships to broaden into a circle of mutual friends and enabling the group to become familiar with each other's work. This word-of-mouth advertising mechanism amplifies the chance for creating a cohesive ego network (Everett & Borgatti 2005) where everyone knows everyone else and information about everyone's photographs becomes common knowledge (Chwe 2001). If a user's contacts are highly interconnected with each other, or put differently, the user is the focal point of a dense (ego) network of mutual friends, then the user might not feel the need to add very

much meta-information (in the form of tags) to explain his photographs. Alternatively, if a user is surrounded by a network of mutual strangers, where the interconnections between his contacts are sparse, we suspect there is little naturally-occurring information sharing among the group, making it necessary for the user to provide more meta-information to ensure common ground among his contacts. To date, the literature is lacking on consideration of the relationship between ego network structural properties and the contribution of meta-information to online social communities.

Huberman et al. (2008) demonstrated a positive relation between the viewing of someone's videos and the subsequent production of additional content on YouTube. While this kind of attention may also play a part in stimulating the contribution of tags on sites such as Flickr, to the best of our knowledge the literature on attention has not been extended to sharing meta- information.

In this study we address three primary questions: (1) What effect does receiving attention from others have on the tagging behaviors of users who upload photographs? (2) Does the density of a contributor's ego network impact tagging over time? (3) How do individual motivations affect a contributor's tagging behavior, and does this effect change over varying levels of attention and density?

We add to the literature on user contribution and online communities by extending the study of the roles of attention and ego network structure to the sharing of meta-information. In addition, we build on existing research on motivations for contribution, directed at others and at the self, to develop a more complete picture of why people tag their photos.

We begin with a brief review of the relevant literature, followed by an explanation of our research model and hypotheses. We then provide an explanation of our methodology, data analysis, and results. We end with a discussion of the implications of our study.

Related Literature

As we examine the factors that drive tagging on Flickr, we focus on the effects of receiving attention from others in the community, social structures, (specifically, ego network density), and individual motivations.

Attention: Huberman, Loch, and Onculer (2004), in an experimental study based on game theoretic concepts, showed that status (awarded as applause) can serve as an objective of group participants. On the web, status can be afforded to online community participants in several ways. As an example, members may view or comment on each other's contributions to the community by rating the usefulness of a product review on Amazon (Parameswaran & Whinston 2007) or possibly by adding a "digg" to an article

on Digg (Huberman et al. 2009). Another form of attention could be adding someone as a contact or friend as on the Facebook social networking site (Burke et al. 2009) or on Twitter (Huberman et al. 2009). For Huberman, et al. (2008) and Wu et al. (2009), status is an intangible good given to others through attention. These authors found that for YouTube users, the attention received by uploaders, measured by counting the number of views per video, resulted in more video sharing. Correspondingly, they showed that a decrease in the amount of attention a contributor receives results in less content contributions, often declining asymptotically to zero. Wu et al. (2009) went further to say that for the most popular YouTube and Digg users, receiving attention from their fans results in something akin to a feedback loop so that the most prolific contributors remain so.

Ego network density: Often for enthusiasts of social networking sites, the pace of everyday life as well as time spent between competing online venues takes its toll on the availability and attention of participants, and as a result, people tend to interact only with those who matter most and who reciprocate with attention (Wang, Butler, and Joyce 2006; Huberman, Romero, and Wu 2008). Fortunately for this group, many online networking services provide features that allow their users to formally identify others as persons of interest, thus creating relationships that take on a special priority (Mislove et al. 2008). For example, the contacts feature in Flickr allows users to establish a network of relationships thereby structurally embedding them into the social fabric of the community (Nov et al. 2010).

One possible explanation for these targeted relationships is that given the limited resources of community members, they often rely on their friends and family as referrers of new friends. Indeed, Cha et al. (2009) found that much of the interaction on Flickr is localized and that users find the great majority (81-91%) of their contacts within two network hops. It also appears true that networks can quickly become dense. Mislove et al. (2008) identified a proximity bias for Flickr users to link themselves to others nearby in the network. One potential explanation for this phenomenon is that friends tell friends about interesting photos and photographers in Flickr who they have added into their contacts. In turn, this causes a type of word-of-mouth promotion and results in a dense (ego) network of mutual friends. Friends likewise practice a type of homophily—choosing to pair with people like themselves (McPherson et al. 2001; Cha et al. 2009). These homophilous ties tend to be strong ties (Granovetter, 1983), frequently requiring less communication to be maintained because friends are more likely to know each other and are more likely to know what each other knows (Chwe 2001).

Individual Motivations: We build on the works of scholars of motivation and self-determination theory (Deci & Ryan 1985) and also applied researchers of participation in online communities (Roberts et al. 2006) as well as

open-source projects (Lakhani & Wolf 2005). This paper examines the effects of enjoyment and commitment, where enjoyment is directed at the self and commitment is directed at others in the network. Enjoyment encompasses the act of having fun when participating in an activity (Deci & Ryan 1985). Commitment, on the other hand, is externally focused. It is reflected as an obligation to others in the community (Bryant, Forte, & Bruckman 2005; Lakhani & Wolf 2005). Ames and Naaman (2007) began studying the reasons that people tag their photos with a qualitative look at Flickr and Zonetag users. Their results suggested that users attach tags to their photos to organize and communicate information about their images. In a subsequent empirical investigation of Flickr contributors, Nov et al. (2010) found that enjoyment showed no correlation to tagging and that commitment (to the community) had a negative impact on tagging behaviors. Based on the previous literature (for example, Chiu et al. 2006; Hars and Ou 2002), we should reasonably expect that commitment to the Flickr community would encourage an individual to communicate more about the content of his or her photographs to other members.

Research Model

Flickr presents an opportunity to study how and why individuals contribute to online communities. We question what would make members of an online community expend the extra effort to add tags to their photos, after taking and then uploading them to the site. Specifically we pursue three research questions: 1.) What effect does attention from others have on future tagging behavior? 2.) Does the density of a contributor's ego network impact future tagging? 3.) How do the individual motivations of a contributor affect his or her willingness to tag their photos, for themselves and for others? Below we explain the underlying theoretical assumptions of our model.

Attention: Joyce and Kraut (2006) found that newsgroup users increased their postings when they received responses from community members. More in line with the artifact contributing nature of Flickr, Huberman et al. (2008) demonstrated that on YouTube receiving attention, given by viewing a contributor's videos, had a positive impact on future contributions. While there are several ways that a contact can give attention to another user in Flickr, we follow Lento et al. (2006) by assuming that adding comments to other people's pictures is the most mutually engaging mechanism for giving attention. We expect that receiving attention will have a positive impact on contributions to the community. Our first hypothesis is

H1 – The more attention a contributor receives from others, the more tags that he will add to his photos.

Density: Nov, Naaman, and Ye (2008; 2009) provide evidence that the more contacts an individual has, the more likely he or she is to share tags and photographs. Cha et al. (2009) showed that the majority of those Flickr contacts are found through other contacts that are generally located within one or two network nodes, and as a result of this referral process one's ego network density increases. We argue that as ego networks become denser, common knowledge increases so that everyone in the network knows much about everyone else in the network, and also, everyone knows that all other people are aware of what they each know (Chwe 2001). The implications here are that as ego networks become denser, there should be a decreasing need for communicating the content of shared photographs within the group. In Flickr, one of the primary reasons people tag their photographs is to communicate information and context to others (Ames and Naaman 2007). So then, the denser a contributor's ego network, the less need there is for him to provide others in the network with information about his pictures.

H2 – The denser a contributor's ego network, the less tags the contributor will add to his or her photos.

Individual Motivations: Nov, Naaman, and Ye (2010) found that enjoyment was uncorrelated with tagging and that commitment played a negative role in stimulating tagging behaviors, and therefore suggested a need for further research. We revisit measures for enjoyment and commitment in order to examine them in the broader context of network structure and attention. Our third and fourth hypotheses are

H3 – A higher level of enjoyment from the act of sharing photos will be reflected by increased tagging.

H4 – Increasing commitment to the community will be associated with higher levels of tagging.

Interaction Effects: After identifying the direct relationships between participation and the three independent variables (attention, ego network density, and individual motivations), we examine the interactions between ego network density and attention as well as ego network density and commitment. Over time, participants in online social networks reduce the effort that they give to the community; their initial enthusiasm fades; they become bored and disillusioned when their earlier levels of excitement become unsustainable (Brandtzaeg and Heim, 2008). However, while we posit that individuals surrounded by mutual strangers tag more than community members nested among mutual friends, we also believe that attention has a greater effect on those people surrounded by mutual friends. Our fifth hypothesis is

H5 – While, in general, users in low-density networks tag more than those in high-density networks, attention has a

stronger effect on tagging in high-density networks than in lower-density networks.

For online communities to flourish, they require "commitment and voluntary participation" from their members. Research shows that participants typically identify with either the community as a whole or with particular individuals in the community (Ren, Kraut, and Kiesler 2007). We believe the same holds true with our subjects. For individuals who are surrounded by a dense ego network (mutual friends), increasing commitment to the community has little effect on their willingness to contribute. Conversely, for individuals who are surrounded by a low-density ego network (mutual strangers), increasing attachment to the community likely results in greater sharing. Our sixth hypothesis is therefore

H6 – Ego network density moderates the effect of commitment on tagging over time, such that the effect of commitment on tagging is positive for users with low ego network density, and slightly negative for users with high ego network density.

Nov et al. (2009) demonstrated that the total number of tags contributed to an artifact sharing community increases as users add more photographs. However, given the tendency of user participation to wane over time, we believe it is reasonable to assume the act of adding more photos to the system will consume part of the user's time and resources, and will result in less tags for each photograph. We therefore control for the number of photos uploaded into the system.
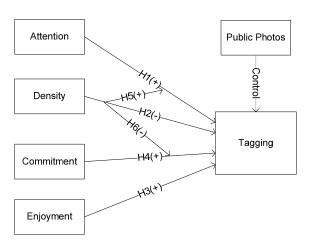

Figure 1. Research Model

Method

We draw on a combination of both user surveys and Flickr system data. As part of the independent variables, individual motivational factors (enjoyment & commitment) were measured through a web survey, while the remaining con-

structs (density, attention, and number of photos) were extracted directly through the Flickr Application Programming Interface (API). The API permits third parties to retrieve information about users, with the users' permission. In this case, permission was granted by asking users to click a link embedded in the online survey.

Motivational survey items were measured on a 7-point Likert scale. Enjoyment was adapted from Venkatesh (2000) in a study of the motivators of software users. Commitment was adapted from Wasko and Faraj (2005) in their study of motivations for contribution to electronic networks of practice. To ensure the integrity of our data, all scales were validated a second time. The remaining independent variables were collected from the Flickr system. Attention was measured by counting the number of comments that other Flickr users posted to a contributor's photos. While there are several ways to give attention to others, for example, viewing their photos or adding a particular image to one's favorites list, in this work we believe—along with Lento et al. (2006)—that the most meaningful type of attention is given by actively adding comments to someone's work. Understanding whether a contributor is surrounded by a circle of mutual friends (high-density ego network) or mutual strangers (low-density ego network) can be determined by calculating the network density of the uploader's immediate network neighborhood. A simple way to visualize a network of mutual friends and another of mutual strangers is to think about spiders and stars, respectively.
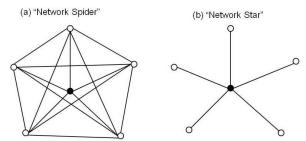

Fig. 2. Networks of Mutual Friends ("spider") & Mutual Strangers ("star")

As shown in Figure 2a, in a group of mutual friends everyone in the immediate network neighborhood is interconnected forming a spider (web) pattern where the contributor—the "ego"—is the center solid dot and other people are the hollow dots (Everett and Borgatti 2005). Community members are connected to each other through the lines. Mutual strangers, depicted in Figure 2b, are the hollow dots connected to each other only indirectly through the contributor (ego). The collection of dots and lines looks more like a star where the contributor (ego) is in the middle with all of the links to other contacts radiating outward without intersecting each other. While Flickr does allow

for one-way connections between uploaders and their contacts, we follow Cha et al. (2009) where all links are bidirectional. Given that the ego network encompasses only the immediate contacts surrounding a contributor (Everett and Borgatti 2005), ego network density is calculated as the number of links connecting the first layer of the contributor's network divided by the total number of possible links between those same people.

The dependent variable—the average number of tags added per photo within the 90-day duration of our study—is operationalized by dividing the total number of tags that a user added to his photos during the 90 days by the number of photos that the user added during the same period. It was also captured through the Flickr API.

Data Collection

A randomly chosen sample of 1807 Flickr users who had at least one public photo were invited to participate in our web-based survey. A total of 259 valid responses were received, representing a 14.3% response rate, which is typical of similar studies. To eliminate any effect of posting restrictions by the Flickr system, we included only "Pro" users, who pay a yearly fee and can upload an unlimited number of photos. Among other restrictions, non-Pro users are limited to sharing their 200 most recent photos. In addition, we limited the analysis to users with at least three months of tenure, to ensure we consider only members with established motivations and habits. In particular, we aimed to eliminate the effect of the initial excitement and very intensive posting that is associated with joining a new service.

An analysis of the data reveals a diverse sample set. Respondents' average age was 38.7 (median = 38, SD = 12.3), of whom, 40.2% were female. The average number of public photos they added during the 90day study was 517.7 (median = 240, SD = 1760.8), and the average number of tags added was 69.1 (median = 14, SD = 500.1). See Table 1 for more details.

Construct	Mean	Std. Dev.
Commitment (to Flickr community)	5.66	1.17
Enjoyment	5.10	1.30
Comments by others (per photo)	.248	1.58
Density	.227	.298

Table 1. Descriptive Statistics

Instrument Validity and Reliability

While items in the survey had been validated in previous research, we validated them again in this study. To confirm the reliability of items measuring individual motivations, we used a principle component analysis (PCA) with a Varimax rotation. The PCA produced two constructs corres-

ponding directly to enjoyment and commitment. Overall each item had a factor loading higher than 0.6 and less than 0.4 on cross-loadings. To confirm convergent and discriminant validity, we calculated the average variance extracted (AVE) for each component. To verify convergence, the AVE must exceed 0.5, while to meet the discriminant requirement the square root of the AVE must exceed the correlation with other constructs. Enjoyment and commitment satisfied both requirements. In addition, all constructs had alpha values greater than 0.7.

Summary of Findings

We tested the hypotheses with a linear regression analysis. All independent variables were centered to the mean. As is often the case with studies of social computing systems, we used the log transformation due to skewness in the system-derived data. The overall model was statistically significant and explained 29.4% of the variance. See Table 2.

Independent Variables	β	t	P
(Constant)		2.965	.003
Attention: log(Comments/Photo)	.419	5.877	.000
Density: log(Density)	.187	3.071	.002
Commitment	.087	1.473	.142
Enjoyment Posting	.005	.082	.934
Public Photos added: log(Change Public Photos)	.154	2.875	.004
DensityXAttention: log(DensityXComments)	.106	1.702	.090
DensityXCommittment: log(DensityXCommittment)	.166	3.085	.002
R^2	.313		
Adjusted R^2	.294		
F	16.501 (df 7, $p < .001$)		

Table 2. Regression Results (coefficients are standardized)

Interaction Effects

Figure 3(a) shows, as expected, that low-density ego networks are characterized by higher levels of tagging; yet, users in high-density ego networks tend to tag more as a result of receiving attention. One plausible explanation is that in high-density ego networks, characterized as a group of mutual friends, there is more word-of-mouth promotion among the friends than what can be expected between the mutual strangers in low-density ego networks. This free and effective type of advertising essentially produces more commenting and hence more tagging. Huberman, Romero,

and Wu (2009) provide evidence that this process continues over the long-term for artifact sharing. We say more about this in the Discussion.

Figure 3(b) demonstrates that increasing levels of commitment produce more tagging in low-density ego networks. This might be explained by considering the type of relationships that people regard as most important. For example, consider the people above who are members of a low-density network (mutual strangers). They are not members of a tight knit clique. The attachments that sustain their participation might very well be to the Flickr community instead of a set of particular individuals. On the other hand, for people who belong to a high-density ego network (mutual friends), their commitment to those friendships may matter more to them than their relationship to the community-at-large. Hence when the commitment construct is framed in terms of the Flickr community as in Table 1, for people in dense ego networks commitment is not related to higher levels of tagging, and for people in sparsely interconnected ego networks commitment is important. Overall, H1, H2, H5, and H6 are supported. H3 and H4 are rejected.
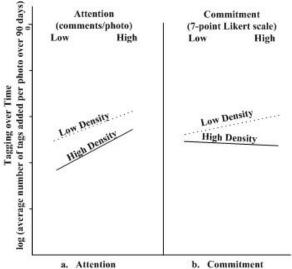

Figure 3. Interaction effects between (a) density and attention & (b) density and commitment

Discussion and Conclusions

As social computing environments continue to blur their purpose and functionality, traditional information-artifact sharing communities are morphing into various forms of social networks. Through a multiplicity of pathways for connecting and interacting, members are networking and communicating more than ever before; still, evidence shows that constituents quickly become bored and stop participating in the community's activities. Therefore, community designers and researchers alike can benefit from a better understanding of the factors that enhance and moderate user participation over time. To support that effort, we considered how attention from the community, ego network structure, and individual motivations affect community participation.

In this longitudinal study, we contribute to the literature on online communities by:

(1) Extending the body of knowledge on attention beyond its effects on artifact contributions, and consider how attention drives meta-information sharing.

(2) Relating the concept of ego network to meta-data sharing in online social computing systems.

(3) Developing a research model that exposes the interrelations between attention, ego network structure, and individual motivations in a longitudinal study, based on data from multiple independent sources.

The data demonstrates that receiving attention from the Flickr community is highly correlated with the average number of tags that a contributor adds to his photographs. We also find that increased density in one's ego network is negatively associated with tagging. Surprisingly, both commitment and enjoyment are uncorrelated with the contribution of tags. By connecting attention and density with individual motivations, we paint a more complete picture of the factors that drive tagging over time.

Our findings provide details on the interactions between attention and ego network density, and between commitment and ego network density. As expected, we were able to show that high-density ego networks (mutual friends, shown previously as a spider pattern) share less information about the content and context of their photos than do low-density ego networks (mutual strangers, shown earlier as a star pattern). However, we also demonstrated that the attention received by someone in a network of mutual friends has a greater impact on tagging than it might for someone surrounded by a group of isolated individuals. It is possible that this increased sharing is due to word-of-mouth promotion between friends. For example, if someone in a network of mutual friends likes a photograph or photographer, one might reasonably believe he would tell his friends. Given the homophilous tendencies of mutual friends, we expect that both will share the same tastes, and as a result both will like the artist's work. We speculate that a preference for the photographer's work will result in more attention to the photographer, who will in turn, increase the amount of tags he adds to his photographs. An alternative explanation might have to do with the "quality versus quantity" of attention. If the attention one receives comes from a group of people who are mutually interconnected, that is a network of mutual friends (the spider pattern), that attention may be more valuable; hence, receiving it provokes more communication about the photographs, i.e. tagging.

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We also address the interaction effects between ego network density and commitment. Our data confirmed that for individuals surrounded by lower density ego networks (mutual strangers, represented previously with a star typology), increasing commitment to the Flickr community resulted in more tagging. Conversely, we found that for individuals surrounded by denser ego networks (mutual friends, represented as a spider shaped configuration), higher levels of commitment did not seem to have much of an effect. As a way of explaining these phenomena, we employ the theories of common bond and common identity (Ren, Kraut, and Kiesler 2007). People are generally tied to online communities through one of two types of affiliations, namely attachment to the community as a whole (common identity) or attachment to particular individuals in the community (common bond). Reasonably, one might assume that people who are surrounded by mutual strangers are sustained more by the satisfaction they receive from being part of the larger Flickr world than they do from attachments to particular individuals. Therefore when our survey items for commitment asked participants about their "commitment to the Flickr community," people surrounded by mutual strangers (lower density networks) responded positively. Conversely, people surrounded by mutual friends are likely to be motivated to act more by the small group surrounding them. Consequently, commitment as framed in this study had little influence on meta-information sharing for networks of mutual friends.

The study's limitations offer directions for future research: By studying tagging on Flickr, we examine meta-information sharing in one kind of social computing environment; other types of communities that depend on annotating their artifacts include videos (e.g. YouTube) and blogs (e.g. Technorati). A study of these other communities would enhance the generalizability of our findings. Future investigations should also develop quantitative measures for all the possible channels that provide contributors with attention. These pathways might include 'views', 'favorites', 'recent posts', 'favorites of friends', and 'most viewed photographs'. Similarly, we do not know enough about the details of who is giving attention to contributors. It would be informative to tie tagging rates to categories of attention-givers so that we can determine if attention from particular kinds of people evokes greater response.

Community managers would benefit from a deeper understanding of the types of comments that promote communication among friends and the types that create a lull in the exchange. Fayard and DeSanctis (2005) provide an analytic device from their work in online forums that uses language games to examine the evolution of online discussion. Their work might well serve as a model for collecting and analyzing the comments that contributors receive.

Our results demonstrated that sharing meta-information tends to decrease as a contributor's contacts become increasingly interconnected. It would be interesting to extend the network growth models of Mislove et al. (2008) and others to predict when a contributor's network will become critically dense and sharing will stop. This information should help to identify critical junctures where network managers can recommend new contacts or take other actions to ensure that a contributor continues participating in the system.

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