Conversational Structure in Email and Face-to-face Communication

Christoph H. Loch, Joshua R. Tyler, and Rajan Lukose

Hewlett Packard Labs
Mailstop 1139
1501 Page Mill Road
Palo Alto, CA 94304

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Abstract

We examine email conversations in relation to human speech patterns. Our study makes two contributions. We offer the first (to our knowledge) quantitative model of conversation patterns. By parameterizing the model with an egalitarian bias parameter, we are able to explain a substantial part of the conversation structure both for email and face-to-face conversations. Second, we make observations that are relevant for the use of email in organizations: while email can be used as a "megaphone" to broadcast information, we find that it does not support larger interactive conversations than human speech. However, we also find that participation in email conversations is more egalitarian than in face-to-face conversations.

Key Words: email, communication, conversation size, conversational motifs, computer-mediated communication.

1 Introduction

Email communication is now ubiquitous. It is indispensable in organizations and also widespread in private relationships. Yet we do not fully understand the relationship between email and other types of communication, such as face-to-face and telephone conversations, or written documents. There is some evidence that email may complement or substitute for other media under certain circumstances (such as over long distances or for wide distribution). But we do not know much about the nature of these email conversations – are they more like oral conversations or like written memos?

Media richness theory (Daft & Lengel 1984) has suggested that email conversations pose a tradeoff between channel richness and asynchronicity. Email can restrict information transfer due to its simple text-based form (Allen & Hauptman 1990, Schmitz & Fulk 1991). However, the aynchronicity of email enables conversations even when not all participants are available at the same time, and it allows participants to reflect before answering (this is particularly relevant if participants differ in their mastery of the language used, e.g., Sosa et al. 2002).

However, there are signs that the channel capacity versus asynchronicity tradeoff does not capture all aspects that are relevant in understanding email use. First, email seems to be used for more information-intensive exchanges than media richness theory predicts (e.g., Markus 1994), and second, communicators seem to interpret email exchanges as social processes (Brodt et al. 2002) that form part of a larger set of communication types, or genres (Orlikowski and Yates 1994, Yates et al. 1999). Moreover, there is evidence that the reduced channel richness of email may actually turn into an

advantage as reduced face-to-face clues may reduce mutual intimidation (Gallupe et al. 1992, 1993): electronic brainstorming sessions (assisted anonymous idea sharing with repeated contributions via electronic media), resulted in more and higher quality ideas as well as higher satisfaction of the participants as compared to normal (face-to-face) brainstorming sessions.

The above cited work, and most existing work on e-mail, has examined how e-mail is used (see also, e.g., Constant et al. (1996), who show that e-mail allowed employees to get advice through weak ties, or Fulk (1993), who shows that attitudes to e-mail are shaped by the attitudes of the work groups if the individuals identify with the work groups). In this article, we examine the structure of the conversations rather than the circumstances in which email is used versus other media. In particular, we compare face-to-face conversations with email conversations on three dimensions: the structure of the conversational motifs (the patterns of exchange, e.g., does participation move round-robin or do two people exchange before the conversation moves to the third?), the distribution of the size of the conversation group (the number of participants in a conversation), and the number of distinct speakers as a function of the length of a conversation (the total number of distinct participants who have spoken at all since the beginning of the observation).

To make these comparisons, we gathered data on face-to-face conversations through direct observation, and on email by developing software to extract the personal email logs of volunteers (no actual email content was gathered however). We defined a quantitative model of conversations and used it in conjunction with descriptive statistics perform our comparative analysis.

We find that email conversations exhibit great similarity to natural speech in the size of the conversational "clique" and in the conversational motifs. However, email fosters more egalitarian (more equally spread) participation in the conversational group. These findings have significant implications about uses for which email is most suitable. To test these findings, we also build a random model of the structure of conversations, which is applicable both to natural speech and email.

2 Theory and Hypotheses

Rather than examining in what contexts email is preferably used, we study the conversational structure of email conversations, in particular, what we call *conversational motifs*. A motif is a specific ordering of unique speakers. Motifs have proven useful in analyzing complex networks of many kinds, from biology to the Internet (Milo et al. 2002), and here we use them as an abstraction for discussing conversation structures. For example, if speakers 1, 2, and 3 take part in a conversation, is the order of speaking 123, or 12123? We use motifs as an abstraction for discussing conversation structures, and they allow us to describe the fundamental structure underlying a conversation, irrespective of the medium. In this way, we can look for interesting or significant patterns that occur across different kinds of conversations, as well as the patterns that are unique to a specific domain or medium. From previous theory, we discover contradictory expectations of email conversations, and propose two hypotheses about their expected structure.

Much research on email communication has been based on media richness (Daft & Lengel 1984) and information processing theory (Thompson 1967, Galbraith

1973). The fundamental view is one of communication channel richness, measured as the ability to provide feedback, the capacity to provide multiple cues (such as tone of voice, facial expressions), the ability to use natural language (rather than stylized language), and personal focus. Accordingly, face-to-face is a richer medium than telephone, which is in turn richer than email and written memos. The higher the task ambiguity and interactional complexity, the more is personal contact preferred (e.g., Trevino et al. 1987, Jones et al. 1988, Schmitz & Fulk 1991). For example, Allen & Hauptman (1990) found evidence for a channel richness limit by observing that technical knowledge (which is tacit and ambiguous) was best transferred through personal contact.

In this tradition, email poses a trade-off between lower channel richness and asynchronicity. The latter is advantageous because it allows a conversation to happen even though not all participants are available at the same time and because a participant can reflect before answering (this is particularly relevant if participants differ in their mastery of the language used). This advantage may outweigh the channel richness disadvantage – indeed, there is evidence that email partially displaces face-to-face and telephone conversations when the participants are physically far away from one another or have a language barrier (Sosa et al. 2002).

Higher media richness combined with synchronicity suggests that we should expect the structure of natural face-to-face speech to be different from the structure of email conversations.

On the other hand, there is evidence that the channel capacity versus asynchronicity tradeoff does not capture all aspects of email conversations. For example, Markus (1994) observed that email was used more and for more equivocal communi-

cation tasks than media richness theory would predict. She concluded that the use of communication media is shaped not only by efficiency and effectiveness, but also by social processes, such as sponsorship, socialization and social control. Brodt et al. (2002) found that email could cause information overload (failure to respond) both because of informational complexity (number of messages) and relational complexity (number of distinct social groups with whom one communicates), but only informational complexity caused stress and reduced satisfaction. This implies that speakers are comfortable with the complexity of social interactions in email as well as in human speech, which (like the results of Markus 1994) suggests a similarity between natural speech and email.

Thus, previous theory presents us with conflicting evidence on the difference between the structure of email versus natural speech conversations. A lower richness of email exchanges might suggest that they have the character of one-way information transfers more than exchanges, but the results by Markus and Brodt *et al.* suggest more similarity with face-to-face conversations. Therefore, in considering the frequency distribution of conversational motifs as a characterizing statistic, it is unclear whether we should expect the distribution of email conversation motifs to be different or similar to that of face-to-face conversation motifs.

The biologist and anthropologist Robin Dunbar has examined the size of conversational groups in primates and humans. Dunbar et al. (1995) distinguish conversational *cliques* (the people who actively participate in a conversation) from *groups* (the total number of people present, but not necessarily participating). They found that cliques averaged 2.7 members and rarely exceeded four. Group sizes (including bystanders), in contrast,

could be much larger than cliques (up to 15): typically, there are many bystanders, but only a few active participants in a conversation. Dunbar et al. conclude that a maximum clique size of 4 is an inherent property of human speech, for multiple reasons. First, ambient noise makes it harder to understand what other people say when they are further away because the clique is large, and visual contact also becomes harder. Second, the benefit of participation decreases when one's rate of speaking decreases in a larger clique: if more people share in a conversation, every single speaker has fewer opportunities to contribute his or her view.[1]

However, email conversations are not subject to these limitations: no degradation of visual or audio signals is relevant. Moreover, email asynchronicity (Sosa et al. 2002) allows several clique members to speak simultaneously, so a larger clique does not necessarily cause a decrease in any individual's participation rate. Relaxed limits on the clique size that an email conversation can support lead to our first hypothesis:

Hypothesis 1. Email conversations are subject to fewer limits on conversation clique size than face-to-face conversations, and thus, the average clique size is expected to be larger.

Finally, the reduced channel richness of email diminishes the contextual clues that are present in a face-to-face conversation. There is evidence that this contextual paucity may turn into an advantage as diminished face-to-face clues may reduce mutual intimidation (Gallupe et al. 1992, 1993): electronic brainstorming sessions (assisted anonymous

[1]Moreover, Dunbar (1997a and 1997b) provides evidence that human language might have arisen as a "bonding device," analogous to but three times more effective than primate grooming, which allowed human groups to grow to 150 (versus 50 in chimpanzees). Thus, human language may be inherently linked to a social clique size (of *active* participants) of about three or four.

idea sharing with repeated contributions via electronic media), resulted in more and higher quality ideas as well as higher satisfaction of the participants as compared to normal (face-to-face) brainstorming sessions. The authors attributed this effect to reduced "production blocking," or being talked over by someone else, and reduced "evaluation apprehension," or fear of evaluation by others because the ideas are contributed anonymously. This is consistent with Sproull and Kiesler's (1986) finding that when social context is diminished, there is an effect of status equalization and less inhibited behavior. This body of work leads to our second hypothesis.

Hypothesis 2. Email conversations are more "egalitarian" than face-to-face conversations; that is, contributions in a conversation are more equally spread among the members of the conversational clique, and the contributors become involved in the conversation more rapidly.

3 Study Design and Data Collection

3.1 Data Collection

We collected email logs from 59 people in three organizations: HP Labs and the Palo Alto Research Center (PARC) in Palo Alto, California, and INSEAD in Fontainebleau, France. The participants agreed to run a computer program that analyzed their entire email log, recording for each message the number of times it had been forwarded, when it had been forwarded, and the names of the forwarders (in encrypted form). This information allowed us to reconstruct the conversation lengths, the number of distinct

participants in any given conversation, and the conversation patterns or motifs.

All names remained anonymous and protected by our use of a one-way hash function, and no email content information was collected. These were necessary prerequisites for the subjects to be willing to allow an executable file to collect information from their email logs. In total, we collected 18,842 usable message threads, with at least two authors and conversation length greater than or equal to two. We prevented double counting by eliminating messages that represented partial snapshots of longer exchanges that were contained in other (later) messages.

In order to compare the email conversation patterns with normal human speech, we then collected similar data by observing lunch room conversations in the cafeteria of HP Labs, analogous to Dunbar et al. (1995, 1997). Since we were not studying content, but only the size of the group and the patterns of who spoke in what order, it was possible to observe a group from the neighboring table, or even two tables away, tracking who spoke (without needing to hear what was said) without being noticed. Thus, our observations did not disturb the flow of the conversations.

We tracked 61 lunch table conversations this way. Dunbar et al. (1995) did not track the conversational motifs, only the group size.[2] We compare the cumulative distribution of our lunch table group sizes to Dunbar's data in Figure 1. While Dunbar et al. (1995) distinguished conversational cliques and groups, the two coincided in our lunch table conversations – in each of our observations, all of the people at the table spoke after a sufficient amount of time (up to ten minutes, but usually two or three

[2]Dunbar et al. also made notes about the contents of the conversations, which we could not because of the confidentiality restrictions of the email study.

minutes). We believe this observation reflects that people who decide to join the same lunch table are implicitly expressing the intention to talk to one another, while Dunbar et al.'s groups were more casual and frequently broke up.

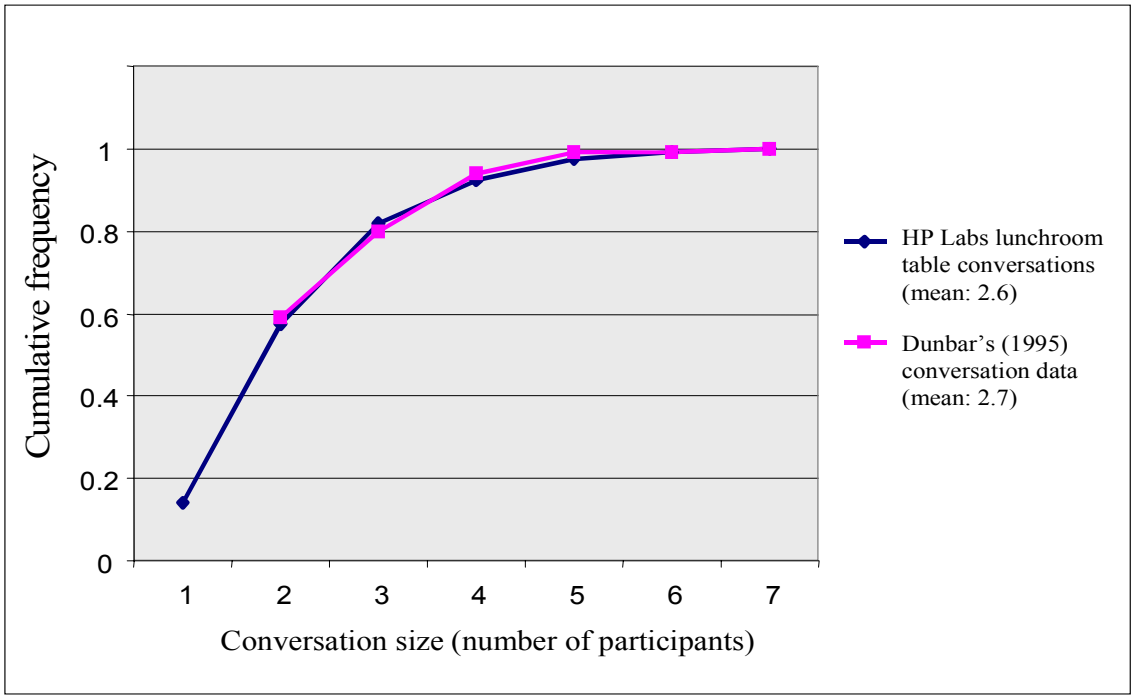

Figure 1: Conversation sizes in Dunbar et al. and at our lunch tables

Dunbar's and our clique size distributions are virtually the same, with means of 2.7 and 2.6, respectively. Few cliques larger than five were recorded (and none above seven). The consistency of our lunch table data with Dunbar *et al.* gives some assurance that the conversational cliques in HP Labs' cafeteria are not unusual or exceptional.

While the email conversation that we tracked had an identifiable beginning and end, we began and ended the lunchroom observations at random points in time.[3]

[3]We observed the tables from neighboring tables, noting down who spoke when, but not listening to or noting down any conversational content. This prevented, on the one hand, a violation of the speakers' privacy (eavesdropping), but on the other hand, it did not allow us to identify the beginning and the end of a conversation.

In order to prevent a bias, we analyzed the motifs of not only the full conversation sequences, but also of all subsequences (of length three or more). This gave us a sample of $3,591$ usable conversational sequences.

3.2 A Basic Egalitarian Random Model of a Conversation

In testing hypothesis 2, we want to measure how "egalitarian" conversations are. In order to have a rigorous theoretical measure of "equal participation", we build a stylized mathematical model of a "random" conversation in which each speaker is, at every turn, equally likely to speak up. The random model does not represent a single conversation (in which, obviously, the sequence of speakers is not random but dictated by the flow), but a composite of many conversations and many logical flows. The critical feature of the model is that it is egalitarian in participation: after every comment, every speaker is equally likely to jump in next, irrespective of the past. In the model, a conversation is represented by a (time-ordered) sequence of characters in which each character uniquely identifies a contributor. We exclude consecutive repeats of characters. That is, whatever one speaker says (without being interrupted) is counted as one entry, reflecting the fact that we do not wish to enter into a semantic analysis of participant contributions. This decision is consistent with our collection of the conversational lunch table and email data. Finally, the "egalitarian" assumption implies that each contributor in the conversation chain is selected uniformly at random from the set of possible contributors (excepting the previous contributor in the sequence, since we do not allow consecutive repeats).

This model is completely specified by the group size n. To study the model

and compare it to empirical data, one quantity of interest is the number of sequences of length h (given n) with k unique contributors. Denoting this quantity by $g_n(h,k)$, we can write the following recurrence relation:

$$g_n(k,h) = g_n(k,h-1)(k-1) + g_n(k-1,h-1)(n-k+1). \tag{1}$$

The boundary conditions for this recurrence are

$$g_n(1,1) = n. \tag{2}$$

The total number of sequences of length h given n is given by $G_n(h) = n(n-1)^{(h-1)}$. Thus, we can write the probability that a conversation of length h has k unique speakers, and thus the expected value of the number of different unique speakers, $E_n(h)$ for the conversation:

$$E_n(h) = \sum_{k=1}^{n} k \frac{g_n(k,h)}{G_n(h)}. \tag{3}$$

Although the recursion of Equation (1) is difficult to solve in closed form, a probabilistic argument leads to an exact solution for the mean defined in Equation (3). It is,

$$E_n(h) = n - (n-1)(\frac{n-2}{n-1})^{h-1}. \tag{4}$$

Equation (4) allows us to write an "expected diffusion curve" of participation in the conversation as a function of the conversation length h, given the egalitarian participation assumption. It is this expected diffusion curve (weighted over a distribution of clique sizes n), against which we benchmark the lunch table and email data.

This model of perfectly egalitarian participation is unlikely to occur in real life, where a speaker who contributes to the conversation topic now may be more likely

to make another contribution, a follow-on comment, during the next few steps of the conversational sequence (autocorrelation). However, the model serves as a useful benchmark against which our speech data and email data can be compared.

4 Results

4.1 Conversational Motifs: Structure and Speaker Patterns

In our motif notation, an integer represents a unique speaker, numbered by the order of appearance in the conversation. For example, the motif 12123 represents a conversation of five utterances from three people, person 1 speaking first, followed by person 2, person 1 again, person 2 again, and finally person 3, at which point the motif ends.

Motif Ranks in each Data Set		
motif	**email**	**lunchroom**
12	1	1
123	2	2
1213	3	3
1234	4	4
12123	5	6
121213	6	9
12134	7	5
12345	8	10
12324	9	8
1212123	10	14
12314	11	7
Spearman Rank Correlation		0.768

Figure 2: Most common conversational motifs in email and lunchroom conversations, ranked by frequency

We examine the structure of conversations by comparing which motifs occur frequently in the lunch room versus the email sequences. Figure 2 shows this comparison. The two motif frequency ranks are highly similar: of the 11 most frequent motifs in the email

sample, 10 are also among the first 11 in the lunchroom sample (only 1212123, number 10 in the email sample, places 14th in the lunchroom sample). This similarity is further evidenced by the Spearman rank correlation coefficient of 77%.

Thus, email conversations seem to be quite similar to face-to-face conversations, at least in terms of their motifs, or orderings of the speakers. Although motifs are only one aspect of conversations, this supports the notion that email conversations are social interactions similar to speech.

4.2 Conversation Size

We compare the conversational group and clique sizes of the lunch table conversations and the email conversations. The cumulative distribution of the lunch table clique size in Figure 3 is the same as in Figure 1. Two distributions are added to the Figure: the email conversation group size (counting all distinct names appearing in the "from" or "to" headers in any message in the conversation – that is, participants as well as mere recipients), and the email conversation clique size (counting all distinct names in the "from" headers in all messages – that is, only the "speakers", who authored messages).[4]

We observe in Figure 3 that the email group size is much larger than both the lunch table and email cliques, with a distribution that is shifted far to the right and has a mean of 5.1. The fact that groups are larger than cliques is consistent with Dunbar et al. (1995). Interestingly, the email cliques in Figure 3 are not larger than the natural

[4]Because of the confidentiality restrictions, we were unable to get the group size for our entire email sample. Rather, we asked a sample of six people whom we knew well to give us access to all "from" and "to" names. The group size curve is based on that separate, smaller, sample. To test the representativeness of the smaller sample, we compared the clique size distribution for this sample with the clique size distribution of the entire sample, and they were extremely close (the detailed distributions can be obtained from the authors).

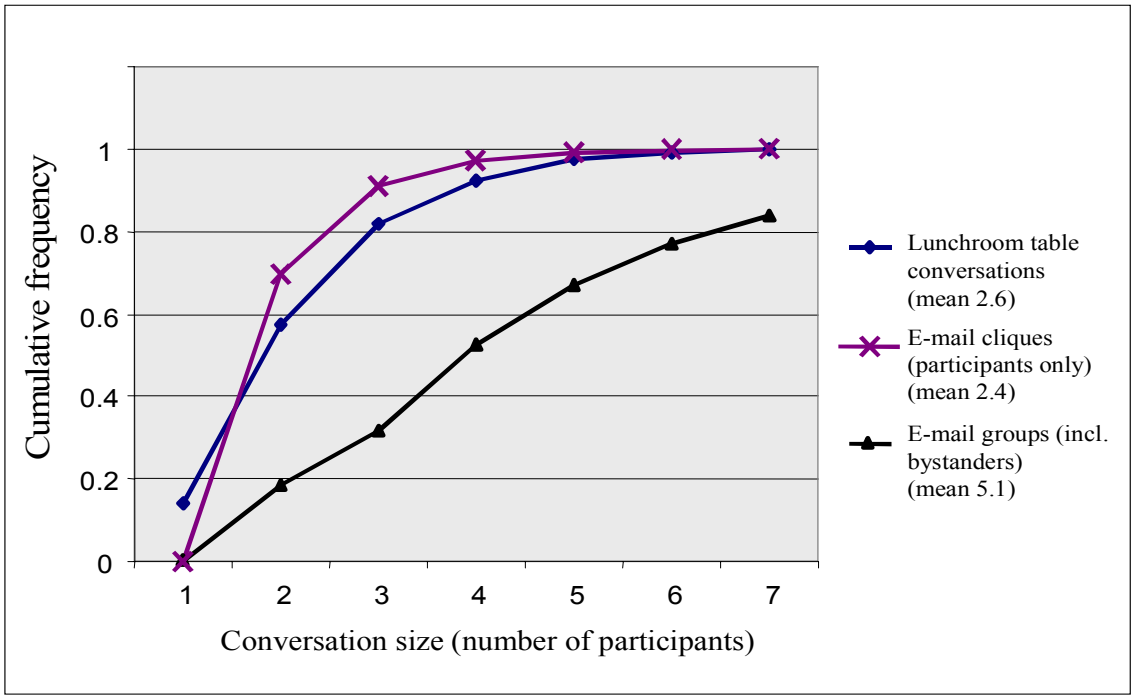

Figure 3: Cumulative distributions of conversation sizes

speech cliques – they are statistically identical in size, with a mean of 2.4 participants. Thus, Hypothesis 1 is not supported. This implies that other limitations must be at work than the ones cited for natural speech in restricting email clique size.

4.3 Egalitarianism in Email

Hypothesis 2 proposes that although email and face-to-face conversations are similar in size and in the most important motifs, there should be differences in terms of participation rates. Face-to-face conversations tend to be dominated by the initial speakers, whereas email conversations are more inclusive of additional contributors. For this reason, we say that email is more egalitarian than face-to-face conversation.

To make this suggestion quantitative, we compare both conversation sets with

our egalitarian benchmark random model. Figure 4 shows the average number of distinct participants that have spoken at all as a function of the number of turns since the beginning of the conversation.[5] The steeper the curve, the faster participation spreads through the clique – that is, the more egalitarian is the conversation (as opposed to a subset of participants monopolizing).

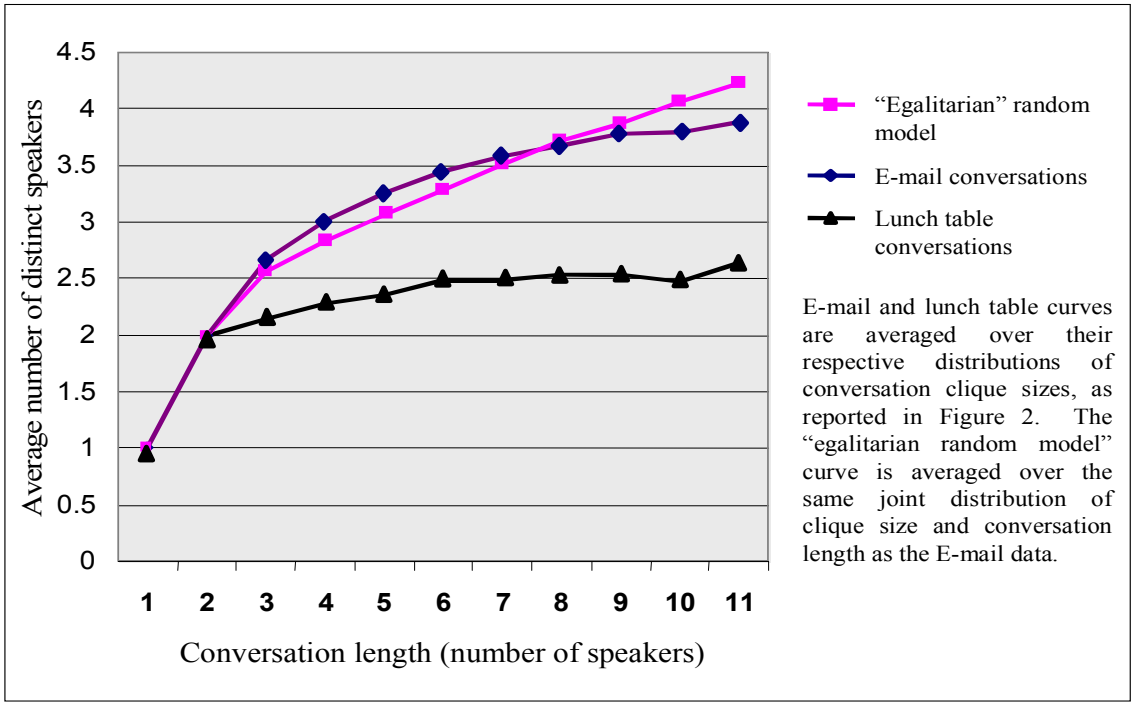

Figure 4: Spread of participation through the conversation participant group

The model benchmark curve is close to the email curve (with r-squared correlation of 0.99). In both, the number of distinct speakers grows much faster than in the lunch table conversations. This suggests that in email conversations everyone has the same chance of jumping into a conversation at any time, in contrast to the face-to-face conversations,

[5]The model curve in Figure 3 is the weighted average of curve (3) over different clique sizes n and conversation lengths h, using the weights of the email clique size distribution in Figure 2 and the associated email conversation length distribution.

which are much more clustered. Thus, hypothesis 2 is supported. What is somewhat surprising is that despite this egalitarianism, the sizes of email conversations are no different than face-to-face conversations.

4.4 Extension of the Egalitarian Model to a biased model

While the benchmark fits the curve of the participation spread in email conversations very well on average, the model is too simple to accurately describe conversations in more detail. Consider the top panel of Figure 5, which shows a scatter plot of the probability that the next speaker in the conversation is a new distinct speaker (someone who has not spoken before), plotted against the ratio of speakers to conversation length in the conversation so far (k/h, where k is the number of distinct speakers so far, and h the length of the conversation so far). The higher this ratio, the more dispersed (egalitarian) participation has been so far in the conversation.[6]

The top panel of Figure 5 makes two important observations: first, the comparison of the email versus the lunchroom data confirms again that email is more egalitarian: the fitted regression curve is much higher throughout – that is, the probability of a new distinct speaker is consistently higher. Second, the slope of the regression line suggests that the structure of a conversation is autocorrelated: if it is already egalitarian (if k/h is high), the probability of a new speaker jumping in is also high, while an already unequal conversation also has a lower probability of a new speaker coming next. In other words, a conversation tends to have a stable character over its duration.[7]

[6]The data points include sub-conversations for the lunchroom data, but not for the email data, as is discussed in Section 3.1.

[7]The data points in Figure 5 include all clique sizes n, as a more detailed analysis shows that the

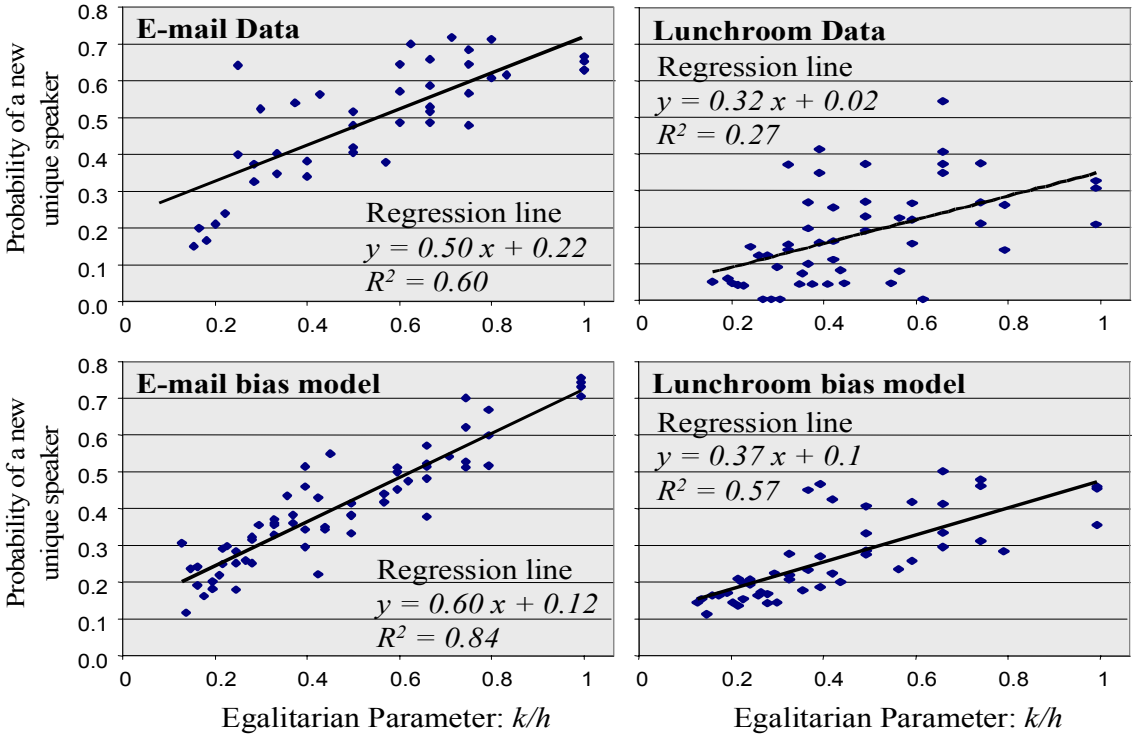

Figure 5: Autocorrelation of speakers over a conversation

The participation curve in Figure 3 is, thus, an average over conversations of different character. This is not captured by the simple egalitarian model from Section 3.2 – indeed, when we plot the analogous scatter diagram for conversations simulated according to Equation (1), the regression line is flat.[8] Thus, the basic model, while meaningful in the aggregate, is too coarse to represent the structure of individual conversations.-

We therefore extend the model with an egalitarian bias parameter $P \in [0, 1]$. P denotes the probability that the next speaker is a new distinct speaker, and $(1 - P)$ the probability that the next speaker comes from the set of clique members who have

regression curve is statistically the same for all n. It can be obtained from the authors.

[8]While this seems intuitive, it is not a trivial conclusion because the probability of a new speaker depends on the relative size of the set of previous speakers and the set of clique members that have not yet spoken.

already spoken before in the conversation. Then the recursion (1) becomes

$$g_n(k,h) = (1-P)g_n(k,h-1)(k-1) + Pg_n(k-1,h-1)(n-k+1). \qquad (5)$$

There is a subtle difference in the cognitive process assumed in the biased model (5) in comparison with the basic model. In the basic model, every clique member is equally likely to be the next speaker, which makes the event of a new speaker less likely as more and more clique members have spoken. In the biased model, the clique behaves as if it *first* decided whether a new speaker should now raise his voice or not, and *then* picked with equal likelihood someone in the respective subset. Thus, the probability of a new speaker does not depend on how many clique members have already spoken.[9]

The upper scatter plots in Figure 5 suggest that the parameter P would be stable throughout a single conversation, but different conversations would have different vales of P. Thus, we simulated the biased model, using the empirical distribution of k/h as an estimator of P: k/h expresses the number of new speakers as a ratio of the number of conversation contributions, and thus, an estimate of P. The lower left panel of Figure 5 shows the result for the P distribution found in the email data, and the lower right panel of Figure 5 shows the simulation with the empirical P distribution corresponding to the lunch table conversations.

We see that the model fits the qualitative structure of the data well: both simulated plots have upward sloping regression lines, which roughly match the slope and intercept of the corresponding empirical regression lines. The email simulation

[9]The alternative model, which would have the likelihood of speaking equally boosted or reduced for all potential new speakers (and the opposite for the people who have spoken already), and the clique picking a new speaker according to those new probabilities, is refuted by the data: in this model, the same scatter diagram shown in Figure 5 would have to have a down-sloping regression curve as k/h increases.

line is above the lunchroom simulation line throughout (expressing the more egalitarian nature). The simulated scatter plots are less dispersed (have a higher explained variance) than the empirical plots, which should be the case because the models do not contain additional (omitted) influences that are present in the empirical data. Thus, Figure 5 offers strong support that the extended biased model does capture an important aspect of the structure of the lunchroom and email conversations. Moreover, the fact that the same model, only differently parameterized with respect to egalitarianism, can capture both email and face-to-face conversations, further demonstrates that email conversations are very similar to face-to-face conversations (although the channel is less rich).

Motif Ranks in each Data Set

motif	email	lunchroom	simple model	bias model (email)	bias model (lunchroom)
12	1	1	1	1	1
123	2	2	2	2	2
1213	3	3	3	3	3
1234	4	4	6	4	5
12123	5	6	4	5	4
121213	6	9	5	6	6
12134	7	5	8	7	7
12345	8	10	12	8	14
12324	9	8	10	11	10
1212123	10	14	7	9	9
12314	11	7	9	10	8

Spearman Rank Correlation of Email Data

Correlated with:	email	lunchroom	simple model	bias model (email)	bias model (lunchroom)
Spearman value	n/a	0.768	0.832	0.973	0.777

Figure 6: The rank-ordering of conversation motifs in the email observations, and the three models (simple egalitarian model and the biased model for email and lunchroom distributions). We also include the Spearman rank correlation coefficient for the email rank data with the rank data from the other three sources.

Yet another way to test the fit of the biased model is to again compare the frequency ranks of the motifs. Figure 6 is an expansion of Figure 2 to include the rank ordering of

motifs for the proposed models, as well as Spearman rank correlation coefficient values between the email and all others. At the bottom of the figure, we see that the email data is most strongly correlated with our biased model using the empirical email distribution of P, and is a nearly identical match. This lends further support for the usefulness of the bias parameter in Equation (5) as an improvement over the simple egalitarian model.

Still, the extended biased model is not detailed enough to be able to fully capture the spread of participation averaged over many conversations. Figure 7 shows the average participation for the biased model (parameterized for email and lunchroom data), as in Figure 3. While the two models compare the right way (the email curve spreads faster), their fit with the data is not satisfactory (they do not differ enough). The simple egalitarian model happens to be the best fit to the aggregated email data.

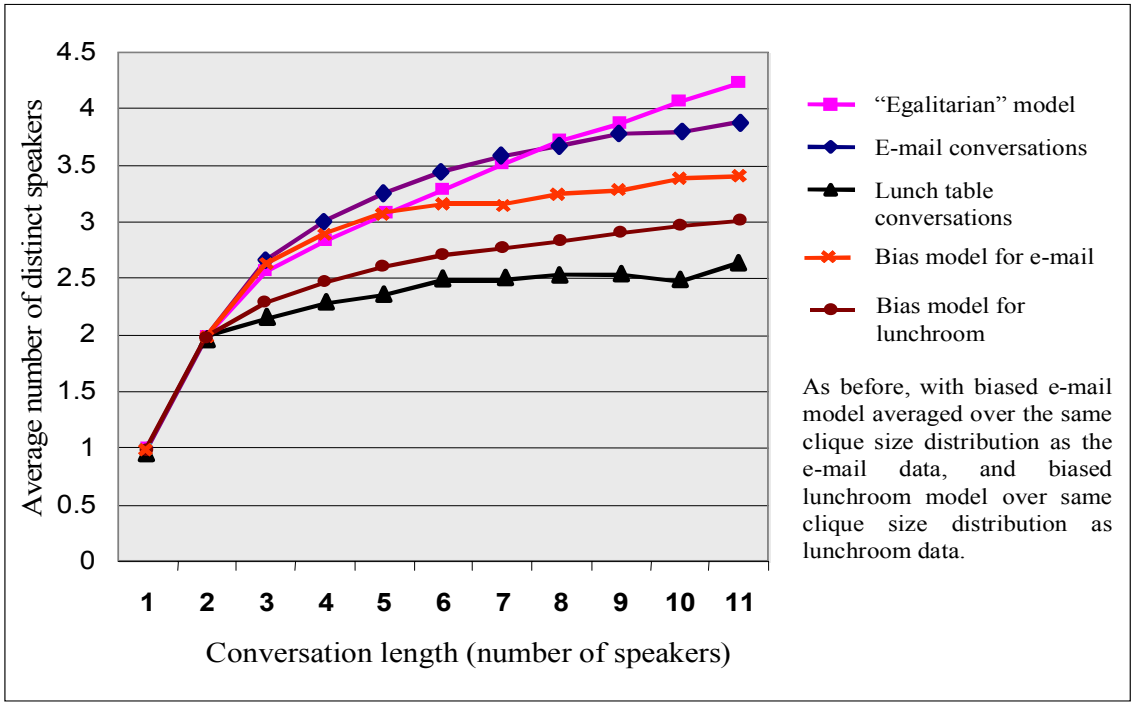

Figure 7: Spread of participation in data versus biased model

5 Discussion

Our results have shown that (a) email conversations are similar to natural speech conversations in the frequencies of conversational motifs and in the strikingly similar cliques sizes, and (b) participation in an email conversation is more egalitarian than speech. These findings suggest several significant implications.

First, the low email conversation clique size implies that the reasons for limited clique size cited in Dunbar et al. (1995) are not the only ones at work. Certainly the acoustic and visual limits are not present in email, and the lower frequency of speaking (in asynchronous email, one does not have to wait for the other participant to finish before making another comment) is also less salient. Other limitations must be at work. It is at this point still speculative what these other limitations are – a biologically rooted preference for conversation sizes of three may be present, as Dunbar suggests, but the additional limits might also be social conventions, or the computational complexity of keeping track of more than three speakers' contributions to the thread of the conversation. More work is needed to arrive at an explanation, but our results suggest that the known physical constraints are insufficient as a complete explanation.

The low email clique size suggests a limit in its communication function – email provides a "megaphone" as if the organization were concentrated in one open space, but it does not easily lend itself to fostering larger interactive communications than speech. The participants may be spread out, but the number of participants that typically interact is three or four, just like in human speech. This has important implications for the use of email in organizations: the "megaphone" may serve (in the

form of mass mailings) to broadcast information. However, it may be unrealistic to hope that large teams are able to keep an ongoing interactive communication going via email, simply because email is not subject to the physical restrictions of hearing and simultaneous presence. Our findings suggest that communication in large teams will fall apart into multiple separate conversations, just as if the physical limits were still present. Email does not seem to be the solution to the breakdown of communication in large groups. Dunbar's (1997) and our findings, consistent with Markus (1994), suggest that social bonding through intense interaction and relationship building may be necessary to ensure a sufficient flow of communication (and even then, the communication will not take the form of one gigantic cohesive conversation clique).

Our second major finding suggests that email conversations seem more egalitarian in participation than face-to-face conversations. At this point, we can only speculate about the reason – it may be that the lack of contextual richness eliminates status inequality (e.g., body posture, tone and loudness of voice, facial expressions, see Sproull and Kiesler 1986, Loch et al. 2001), or that the missing visual clues reduce the feeling of the participants of being judged by the others (as was found in anonymous electronic exchanges by Gallupe et al. 1992). That is, the lower channel richness has the benefit of also reducing inequalities. More work is required on this finding.

Again, this has important managerial implications – rather than hoping to support larger group sizes, a manager may choose to use email, rather than face-to-face meetings, in unstructured problem solving situations, when all the expertise present in the group needs to be used and everyone should be encouraged to speak up (see Soll & Larrick 2003). Thus, email may have a subtle benefit in situations in which

established intuition would suggest that an information-rich communication channel is most important.

6 Conclusion

While most research on email communication to date has approached the topic from the viewpoint of media richness theory, we have examined email conversations in relation to human speech patterns (Dunbar et al. 1995). Our study makes two contributions: one, we offer the first, to our knowledge, model of speech patterns. By parameterizing the model with an egalitarian bias parameter, we are able to explain part of the speech structure both for email conversations and for face-to-face conversations. Two, we make observations that are relevant for the use of email in organizations: while email can be used as a "megaphone" to broadcast information, we find that it does not support larger interactive conversations than human speech. However, we also find that participation in email conversations is more egalitarian than in face-to-face conversations.

One limitation of this study lies in the fact that we have examined only the structure of conversations, but not the content, out of privacy considerations. There is an inherent tradeoff when it comes to research using private personal data – our decision not to use this sensitive information enabled us to collect data from a larger and more diverse set of subjects. Examining the content of email messages would be instructive in further understanding how closely email is related to normal speech: Dunbar (1997a, 1997b) showed that people devote two-thirds of their conversations to social topics relating to their personal lives, and he argued that this is a fundamental aspect of human language.

Although email might be expected to be more formal (due to the context and the fact that the conversational parties might be further removed from each other), it would be interesting to see to what extent this social character of speech carries over to email.

A second limitation of our study lies in the fact that we could not distinguish the physical distance among the conversational parties and could not, therefore, examine the effect that distance might have on conversation structure or size. Proximity is an important factor in communication (see, for example, Allen 1985 and Kraut et al. 2002) and merits further consideration.

Further examination of these two questions may contribute to a better understanding not only of the use of email in organizations, but also to fundamental characteristics of human speech.

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