Evolution of Information Accuracy in an Organization

An agent based approach

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1 Introduction

This concise report describes the initial research efforts undertaken to model information flows across trusted members of an organization. The first part presents our agent-based model approach to information flow within an organization, including model specifications and key assumptions. Then, the results of several simulation runs are analyzed. Next, some social science scenarios are suggested which could be usefully modeled using this approach. Lastly, the conclusion will indicate interesting further research possibilities.

2 The Model

In this model, we consider a pair of two counteracting forces that influence the information accuracy within an organization — according to Wixted and Ebbesen [1991], people forget things over time and this provides the channel for information accuracy to *dissipate* for each member of the organization. on the other hand, the infrastructure of an organization (e.g. *debriefing sessions* and casual encounters during *coffee breaks*) provides channels for members to remind each other of the dissipating information, thereby boosting the accuracy level. To make the recovery of information more interesting and realistic, we introduce a *trustworthiness* measure for members of the organization that denotes the extent to which they trust the accuracy of the shared information.

2.1 Model Setup

In our model, we index members of the organization to be $i \in \{1, \ldots, N\}$ and use $A_i \in [0, 1]$ to denote the level of information accuracy for member i. To denote the heterogeneity of accuracy across individuals, at $t = 0$, we assigned A_i according to a *Normal* distribution with $\mu_A = 0.75$ and $\sigma = 0.2$. To make the information accuracy land in a reasonable range, we bound A_i between 0 and 1.

Further, to capture the heterogeneity in the rate of "forgetting", we introduce the following mechanism to model the process of information dissipation:

$$A_i^{t+1} = A_i^t - A_i^t \times \gamma_i \tag{1}$$

where γ_i denotes the rate at which member i is losing information accuracy *per day*. It follows a *Normal* distribution with $\mu_\gamma = 0.03$ and $\sigma = 0.01$.

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Debriefing process Based on the implication of an organizational setting, the first mechanism to counteract the dissipation of information is through gathering all members to attend a debriefing session. Let D_f denote the gap between two debriefing sessions, then on dates during which the debriefing sessions are taking place, i.e. $t \in \{t \in \mathbb{N} \mid t \mod D_f = 0\}$, the updating in information accuracy for member i comes through two channels:

$$\Delta A_i^t = \underbrace{\frac{1}{n}\sum_{j=1}^{t} A_j \times \mathcal{L}}_{\text{group learning}} + \underbrace{(M - A_i^t \times M)}_{\text{Individual learning}} \tag{2}$$

where $\mathcal{L}$ denotes the uniform gain from population average, and M is another parameter denoting the maximal gain by a member with accuracy level 0. We have assigned $\mathcal{L} = 0.2$ and $M = 0.02$.

Trustworthiness and Coffee-breaks While *trustworthiness* may not play a role in the information sharing process at the organization level, in private face-to-face communications, it is natural to assume that an individual of low trustworthiness level shall obtain more gain in information accuracy from a member of higher trustworthiness level[1]. We use $T_i \in [0, T_{max}]$ to denote the level of trustworthiness for individual i and assign its value according to a **uniform** distribution. In our simulation, we let $T_{max} = 5$.

As members in the organization shall encounter each other on a day-to-day basis, we model such exchange of information as follows: for an arbitrary member i at time t, he/she will meet a member of the organization (j) chosen at random. Due to this random encounter,

$$\Delta A^t_{i,\text{coffee-break}} = (T_{max} + T_j - T_i) \times (A_i + A_j) \times \mathcal{L}_{coffee} \tag{3}$$

where $\mathcal{L}_{coffee}$ denotes the rate at which individuals are gaining information accuracy from "coffee-breaks". Note, our formulation is suitable for extreme cases of encountering: to give an example, for $(T_i, T_j) = (T_{max}, 0)$, member i is not learning anything from the "distrusted" member j according to equation (3). Throughout the simulation, we choose [2] $\mathcal{L}_{coffee} = \frac{M}{\mathcal{K} \times \mathcal{D}_f}$ where $\mathcal{K}$ takes an initial value of 100.

3 Analysis

In this section, several simulations are presented to analyze the sensitivity of the level of information accuracy of our 4 members to various parameters and initial values. In order to compare the different simulations, we made the *arbitrary* decision that the company is performing well in terms of communication and information sharing when its members stabilize their information accuracy around or above 0.80, while it would perform badly when its members stabilize around or below an information accuracy level of 0.20. A next decision was to set the parameter of the average forgetting curve (γ_i) so that after 100 days without any measure to increase the information accuracy level the average member would stabilize close to zero. The result is visible in Figure 1.

While fixing the parameters for the number of members in the organization ($N = 4$) and the information loss parameter (γ_i), the influence of the following parameters on information accuracy will be tested: D_f — the frequency of debriefings (without any coffee breaks); $\mathcal{L}_{coffee}$ — the coffee learning constant (without any debriefings); the effect of weekly debriefs together with coffee breaks; and lastly, μ_A — the average initial information accuracy levels of the members.

First of all, the effects of a debrief meeting every 7 days at a maximum recovery rate $M = 0.02$ is presented in Figure 2 and 3. According to the 5 simulation runs performed (of which only 2 showed here in the figures), weekly meetings are beneficial for one or two members of the organization who stabilize their accuracy level above 0.80. For the other members overall information loss still occurs and they stabilize

[1] Symmetrically, for a member of higher trustworthiness level, he shall obtain less info-accuracy from the individual with a lower trustworthiness level.

[2] As coffee-breaks is taking place *everyday* for *everyone*, in order to balance the effects of learning against the infrequent debriefing sessions, we downscale the rate of accuracy gain by the gap between two debriefings.

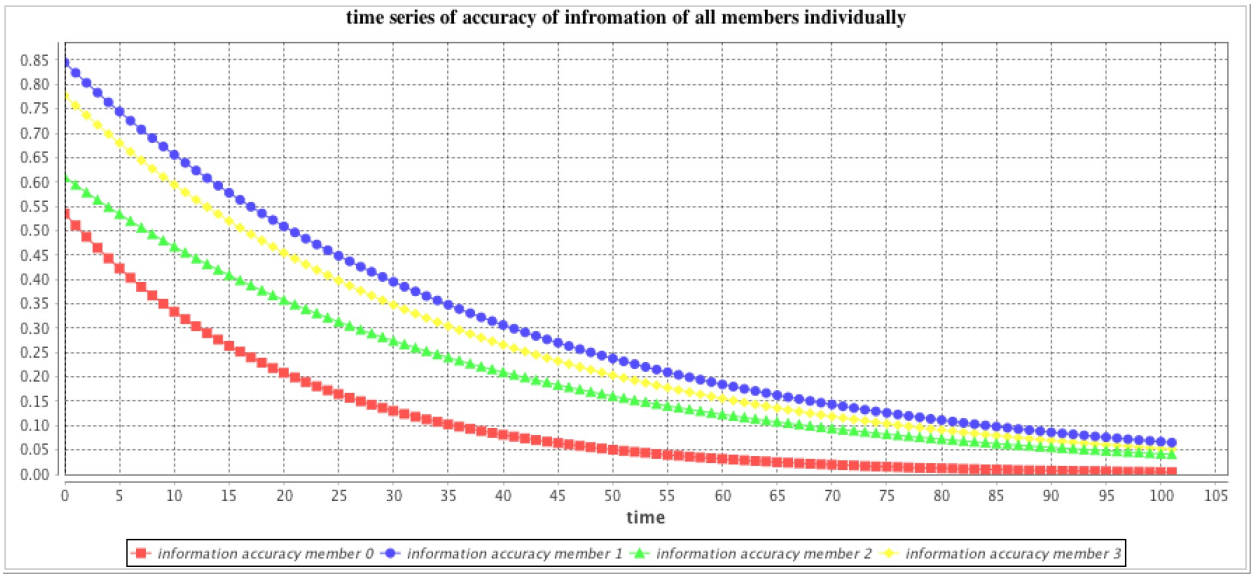

Figure 1: Information accuracy (A_i) for all 4 members dissipating to zero after 100 time steps without any information flow mechanisms

around or below an accuracy of 0.2, although it takes 200 days or more to stabilize at this lower information accuracy level compared to 100 days without any meetings.

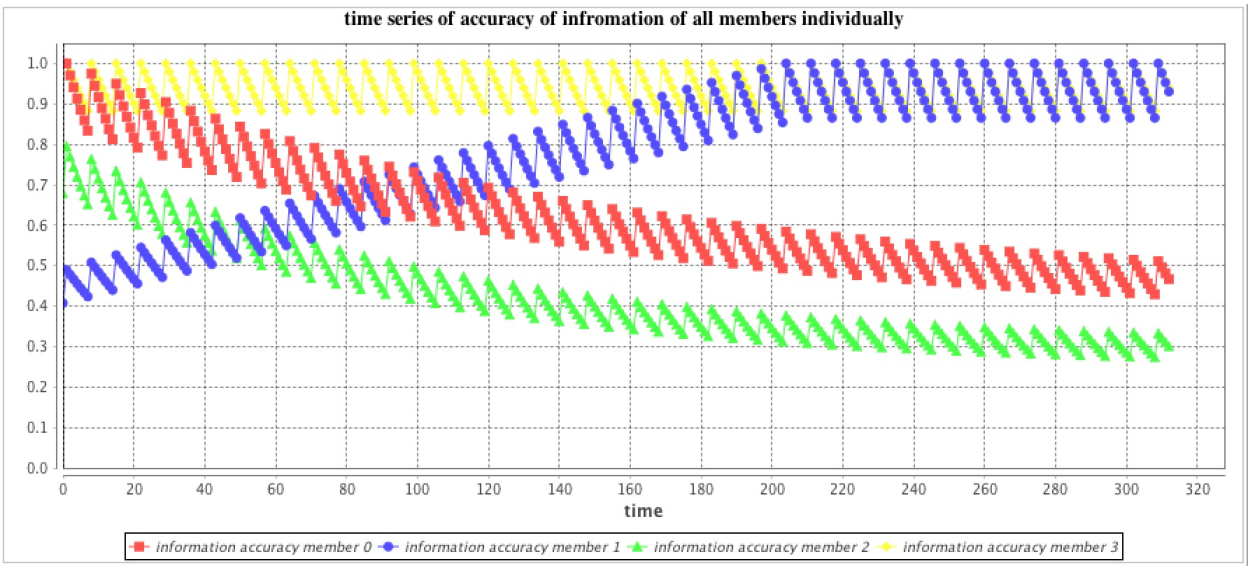

Figure 2: Information accuracy (A_i) for all 4 members with frequency of debrief meetings as $D_f = 7$, first simulation

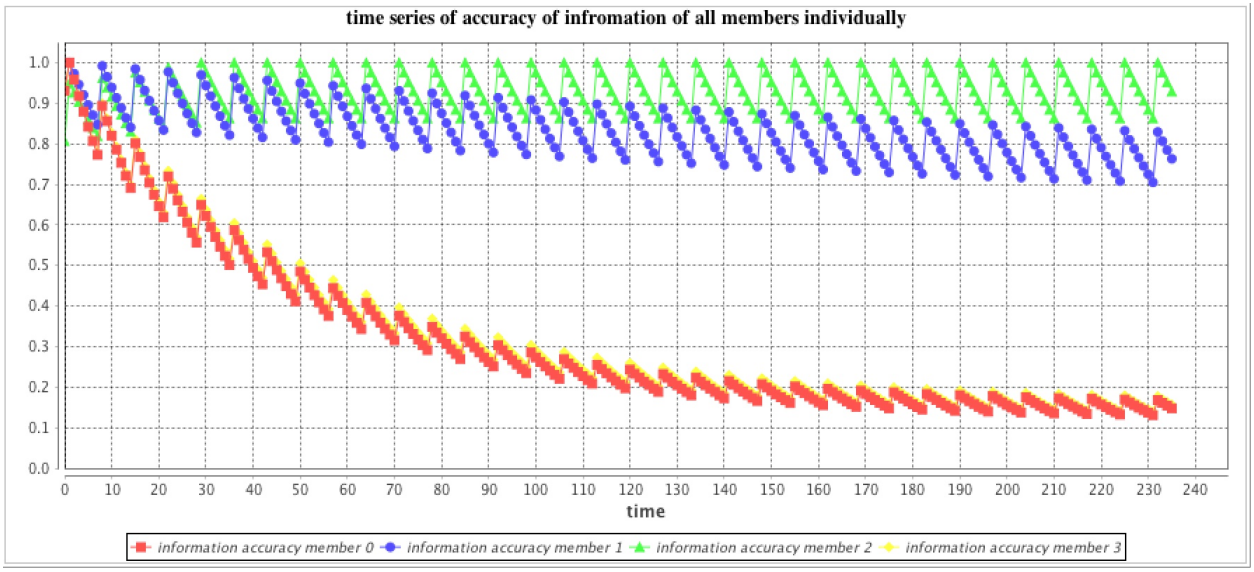

Figure 3: Information accuracy for all 4 members with debrief meetings every 7 days, second simulation

When introducing briefings every 5 days, two in 5 simulations presented one or two members stabilising at a low information accuracy level, while for briefings every 4 days all 5 of 5 simulations showed all 4 members stabilising at a high accuracy level (Figure 4).

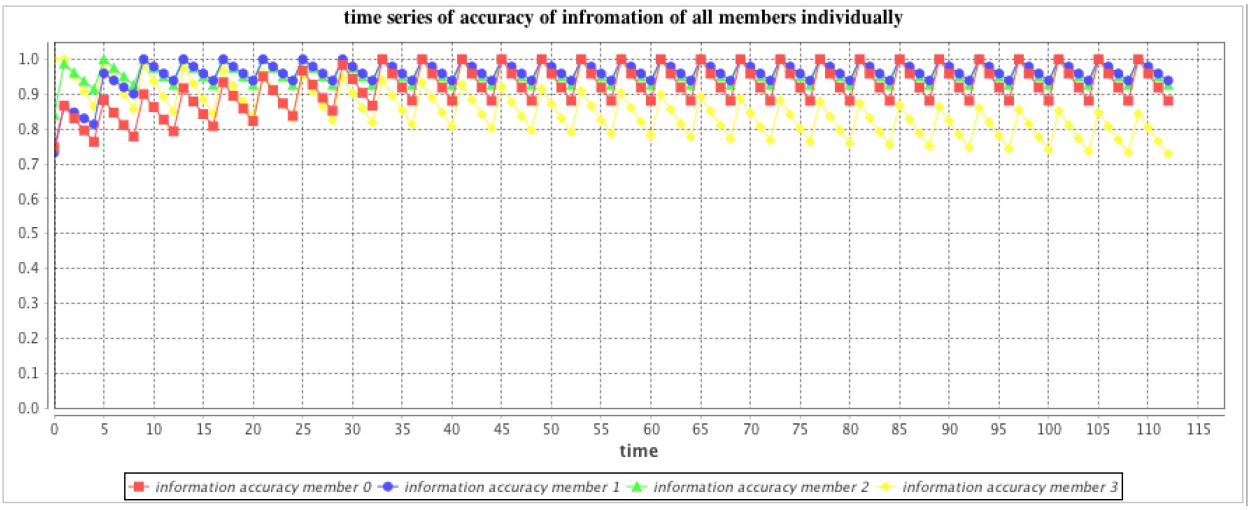

Figure 4: Information accuracy for all 4 members with debrief meetings every 4 days

For a briefing every 9 days, the information flow within the company performs badly with 3 of 4 members stabilizing below or around 20% accuracy of information for all the five simulation runs (Figure 5).

Thus for weekly debriefs, i.e. a debrief every seven days, the accuracy level of several members would still decrease at a maximum recovery rate of 0.20. Therefore, we introduce daily coffee breaks to share information between two random members of the company on a more casual occasion. First, we only test

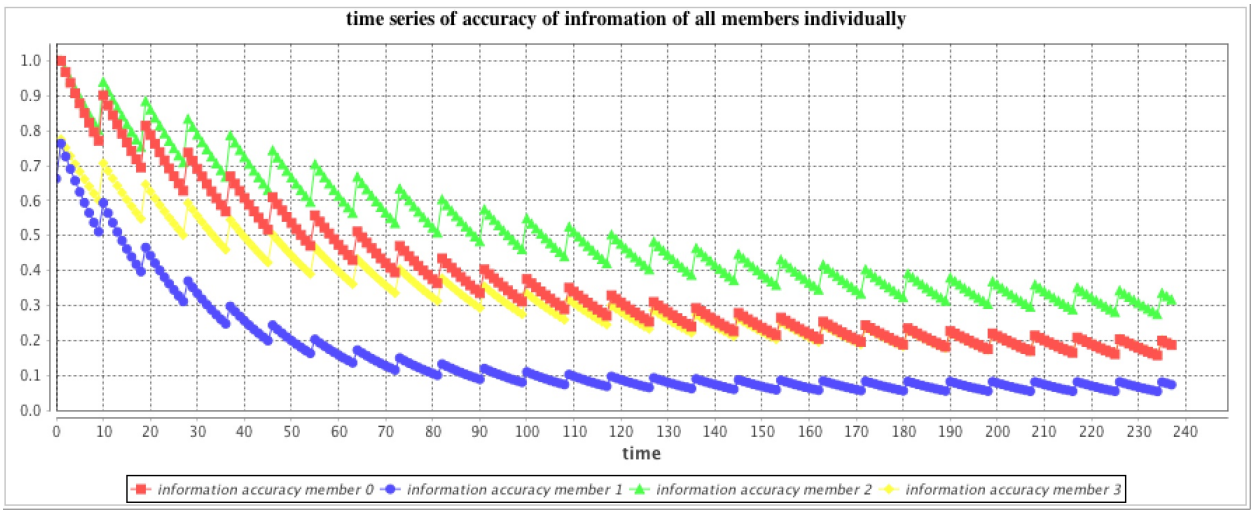

Figure 5: Information accuracy for all 4 members with debrief meetings every 9 days

the effects of the coffee breaks without weekly debriefs. We will investigate the effects of $\mathcal{L}_{coffee} = \frac{M}{\mathcal{K} \times \mathcal{D}_f}$. Figure 6 present the information accuracy of all members for factor $\mathcal{K} = 100$. Here, all members end up with an accuracy below 0.20 relatively quickly after more or less 120 time steps for all 5 executed runs. This means the dissipation effect is much stronger than the learning effect.

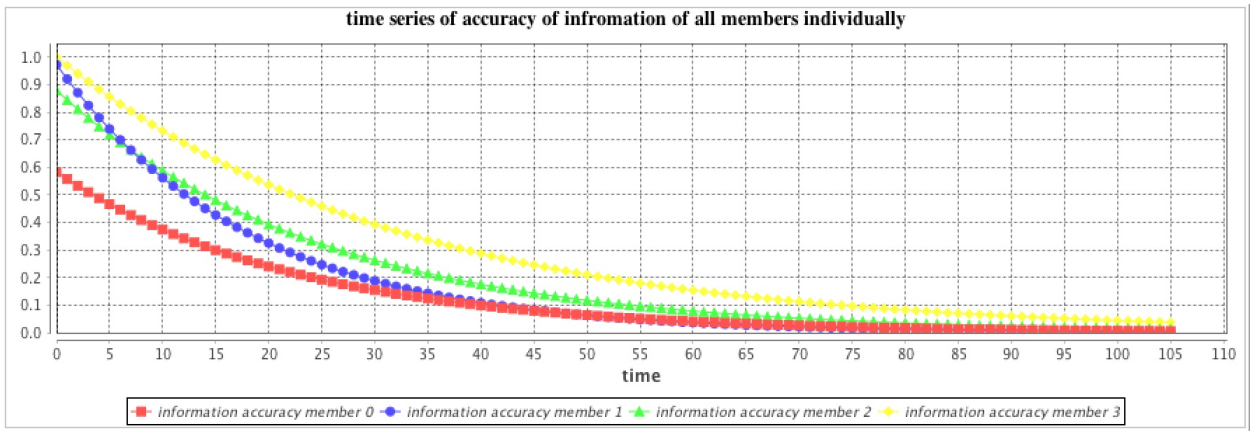

Figure 6: Information accuracy for all 4 members with daily coffee breaks with a coffee learning constant ($\mathcal{L}_{coffee}$) with $\mathcal{K} = 100$

For a lower factor as $\mathcal{K} = 1$, but thus a higher coffee learning constant, the effects are very different for each of the five simulation runs (Figure 7 to Figure 11). This means that the pairwise learning from coffee breaks does have a pronounced effect, but is very dependent on who you randomly meet at the coffee machine and what level of accuracy and trust you both have. In some cases, information dissipation turns out to be dominant, in other cases learning from coffee break talks is dominant.

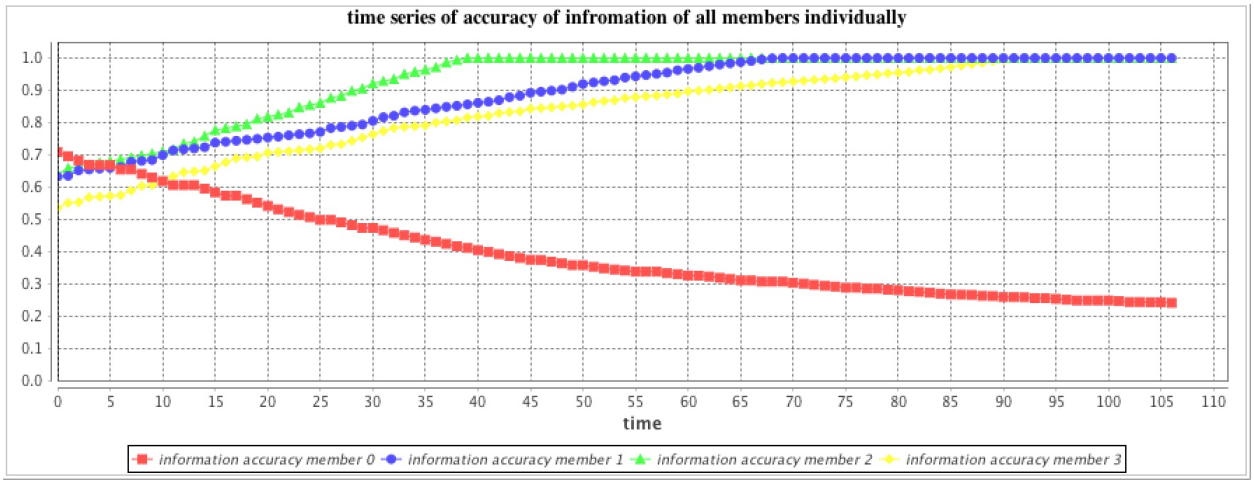

Figure 7: Information accuracy for all 4 members with daily coffee breaks with a coffee learning constant with factor 1, first simulation run

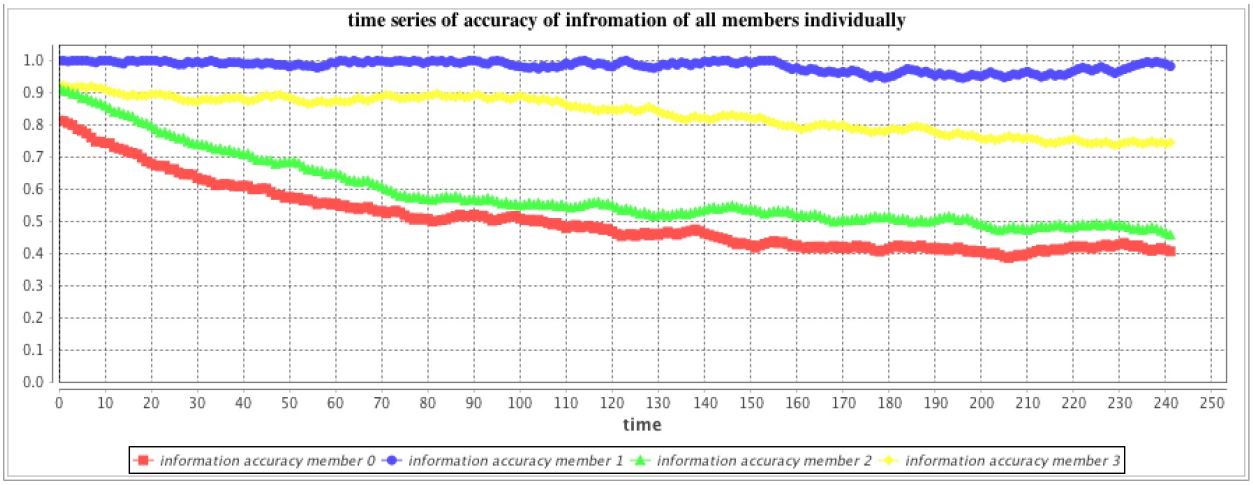

Figure 8: Information accuracy for all 4 members with daily coffee breaks with a coffee learning constant with factor 1, second simulation run

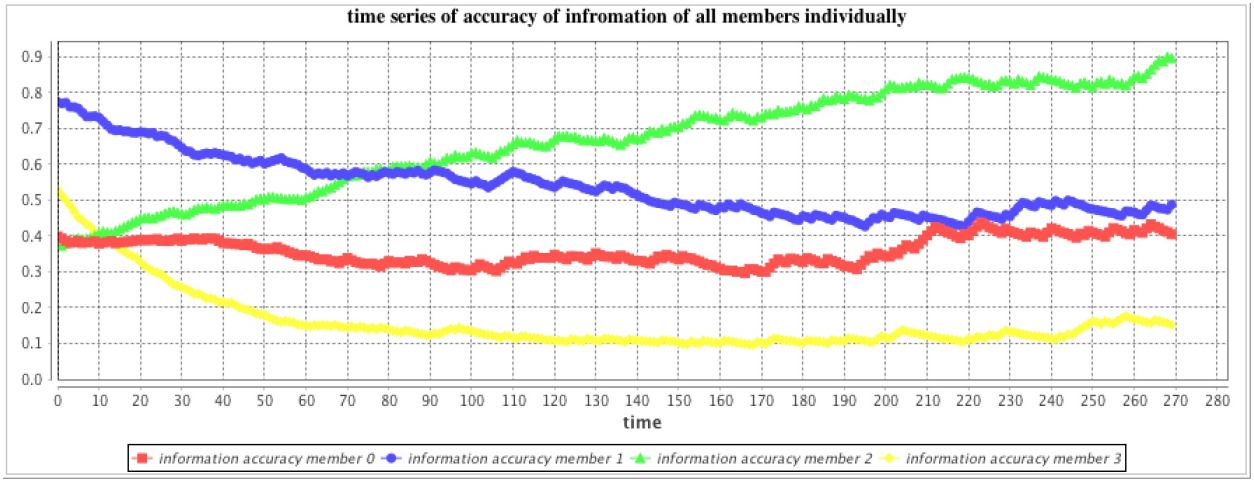

Figure 9: Information accuracy for all 4 members with daily coffee breaks with a coffee learning constant with factor 1, third simulation run

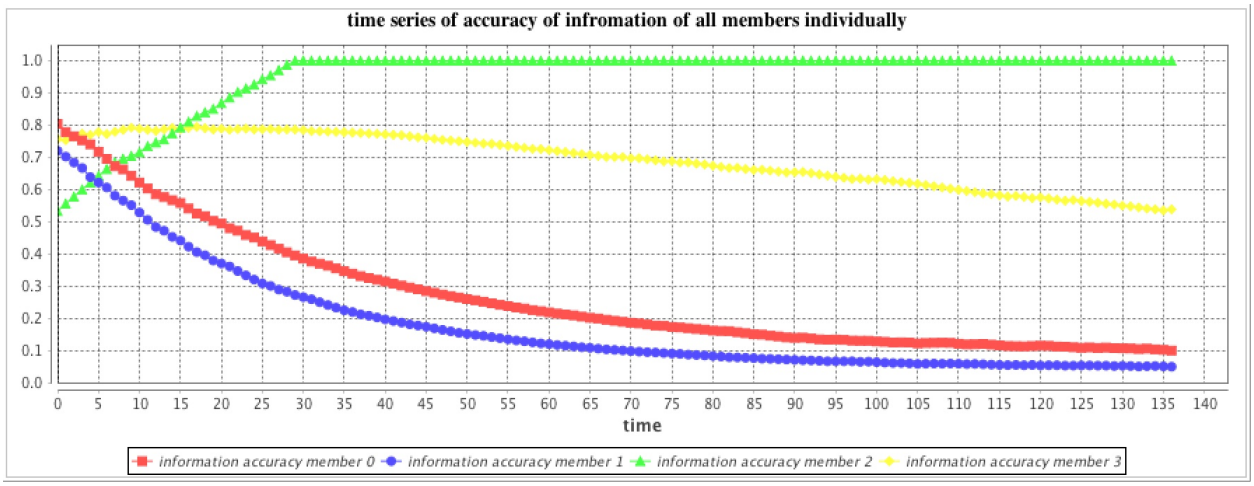

Figure 10: Information accuracy for all 4 members with daily coffee breaks with a coffee learning constant with factor 1, fourth simulation run

To be sure that coffee breaks alone can keep up or improve the information accuracy level within the company, the factor of the coffee learning constant $\mathcal{K}$ needs to lowered to 0.5. For this value, all 4 members stabilize at an information accuracy level close to 1 within the first 50 days for all 5 simulations (Figure 12).

The most logical following step is to look at combined effects of debriefs and coffee breaks. The results for combining the parameter values which gave undecided results for information flow performance separately, i.e. weekly debriefings ($D_f = 7$) and coffee breaks with $\mathcal{K} = 1$, are presented in Figure 13. Here, the two information mechanisms work together to ensure information accuracy levels above 0.80 for all 4 members after 100 days in all 5 simulation runs.

Lastly, we execute a test if the success of these specific two communication measures, i.e. weekly debriefs and coffee breaks with a coffee learning factor $\mathcal{K} = 1$, persist if the average initial accuracy levels of the organization's members (μ_A) are lowered from 0.75 to 0.50 and 0.25. At an average initial accuracy of 0.50,

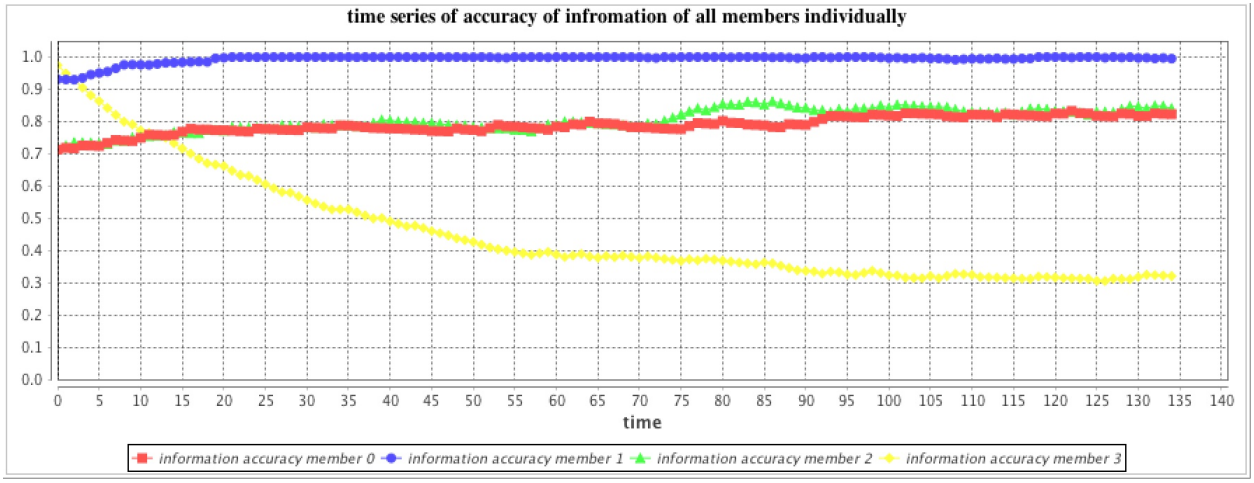

Figure 11: Information accuracy for all 4 members with daily coffee breaks with a coffee learning constant with factor 1, fifth simulation run

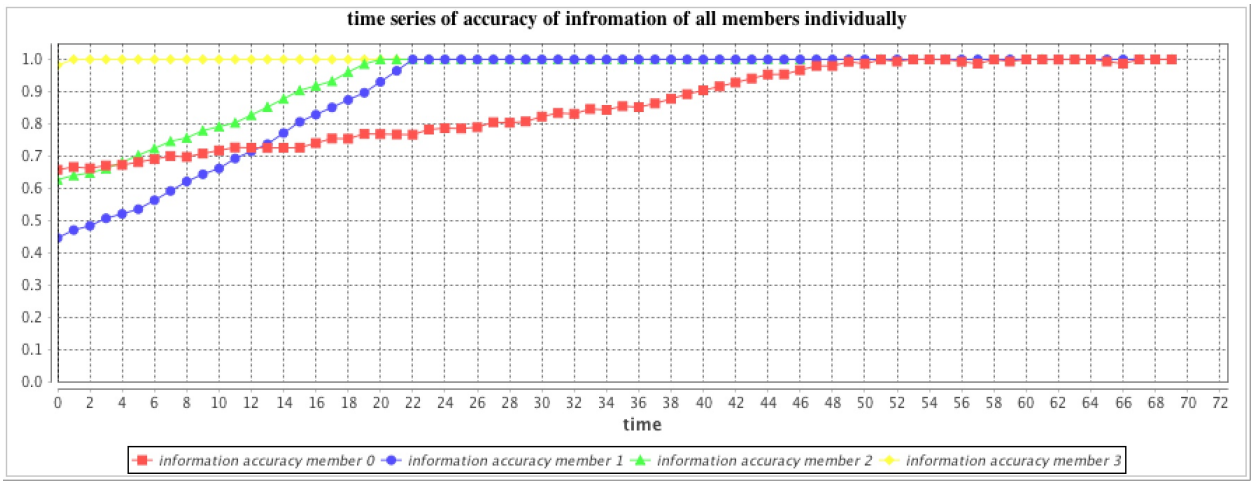

Figure 12: Information accuracy for all 4 members with daily coffee breaks with a coffee learning constant with factor 0.5, fifth simulation run

the information accuracy of all members still grows and stabilizes at high levels above 0.80, although in 2 of the 5 simulation runs, one member only stabilized around 0.70 accuracy after more or less 150 days (Figure 14 and Figure 15). An average initial accuracy of 0.25 gives roughly the same result as for 0.50. However, it takes a couple of weeks longer to reach the same high level of information accuracy (Figure 16 and Figure 17).

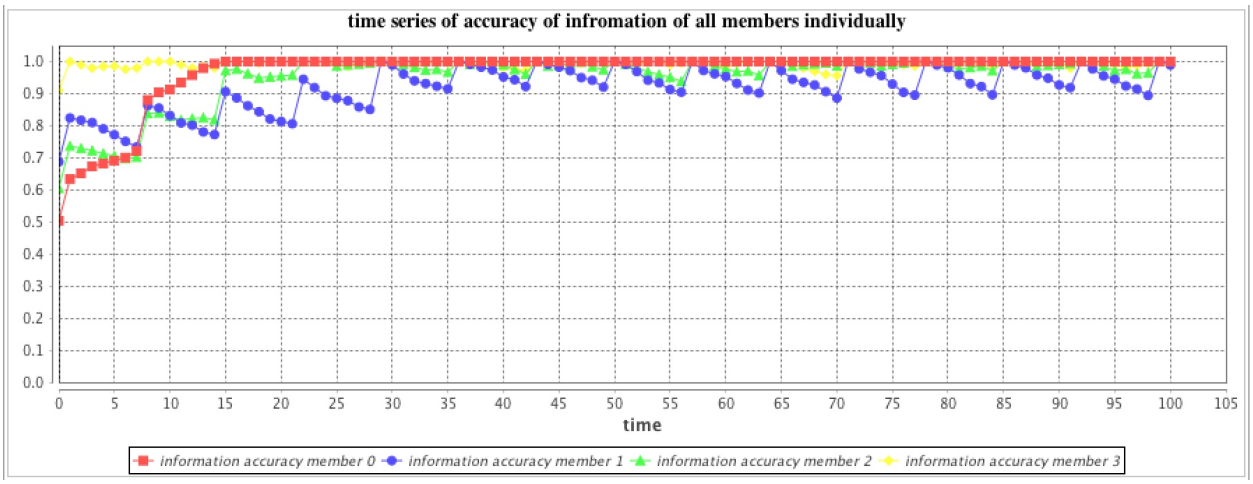

Figure 13: Information accuracy for all 4 members with weekly debriefs and daily coffee breaks with a coffee learning constant with factor 1, fifth simulation run

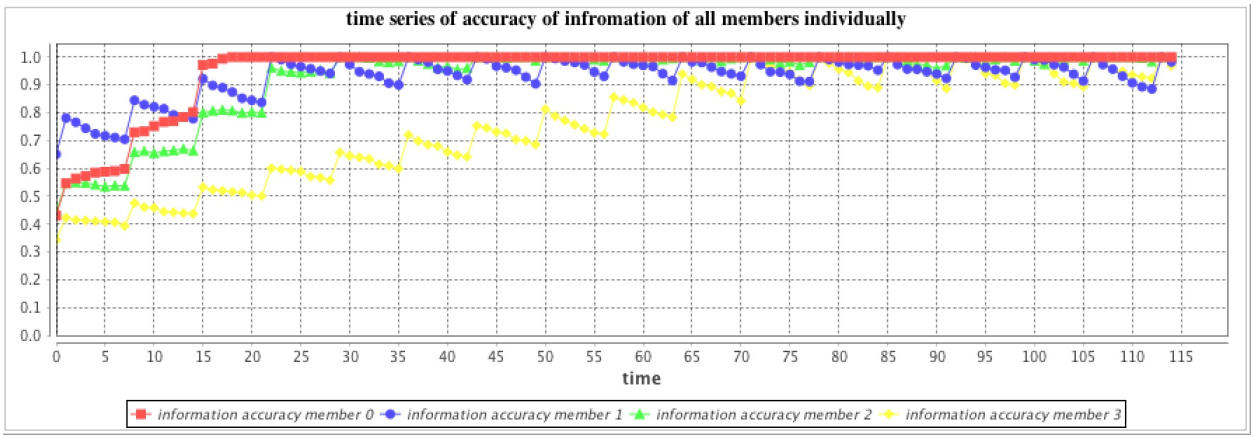

Figure 14: Information accuracy for all 4 members with weekly debriefs and daily coffee breaks with a coffee learning constant with factor 1, initial average information accuracy level at 0.50, first simulation run

Discussion of applicable social science scenarios This modeling approach of the evolution of information accuracy can be applied in all different organization types since we did not specify what type of information is shared or what the goal of the organization might be. Examples could be a company, government departments, civil society movements, local organizations, cooperatives, university departments... For now, this model relates more to organizations with a flat organizational structure since we randomly distribute initial levels of information and every member had the possibility to learn from all the other members.

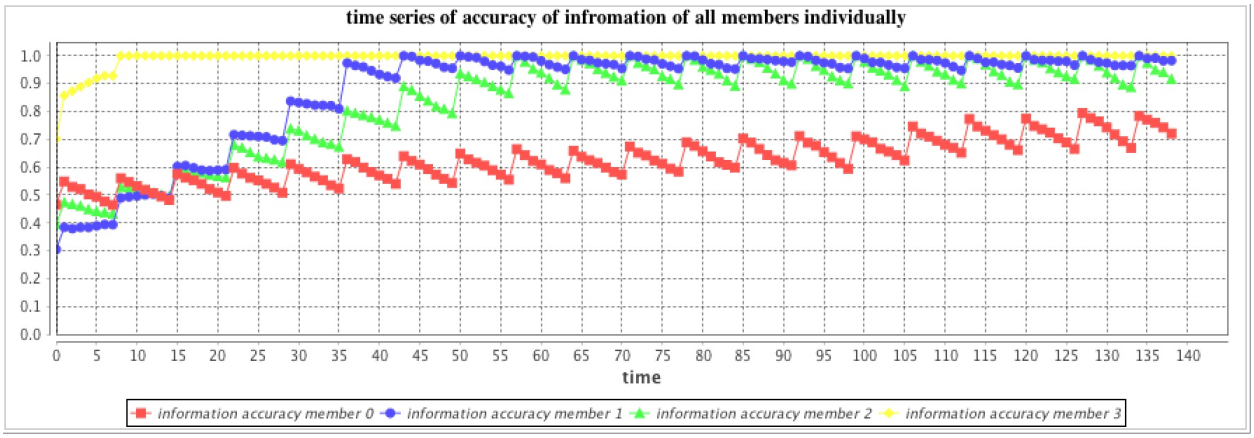

Figure 15: Information accuracy for all 4 members with weekly debriefs and daily coffee breaks with a coffee learning constant with factor 1, initial average information accuracy level at 0.50, second simulation run

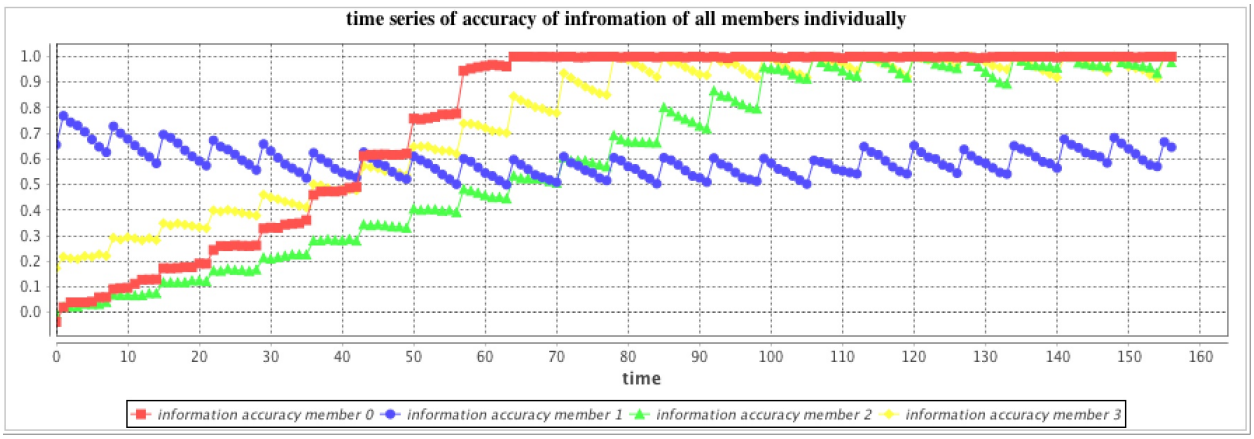

Figure 16: Information accuracy for all 4 members with weekly debriefs and daily coffee breaks with a coffee learning constant with factor 1, initial average information accuracy level at 0.25, first simulation run

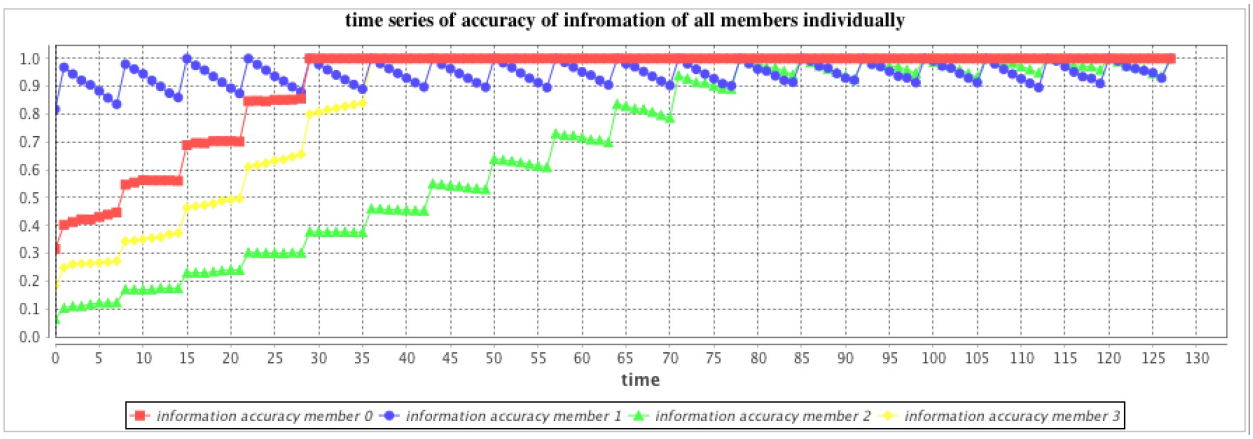

Figure 17: Information accuracy for all 4 members with weekly debriefs and daily coffee breaks with a coffee learning constant with factor 1, initial average information accuracy level at 0.25, second simulation run

4 Conclusion

In general, this all means that, assuming information is forgotten by members of an organization over an average of 100 days, different communication and learning mechanisms are available for contouring this information loss. The two tested mechanisms, i.e. briefing meetings with all members and more casual coffee talks in random pairs, can completely counter the dissipation loss and give high information accuracy levels depending on the chosen parameters. For intermediary parameters values, which would not give certainty for high levels of accuracy for all members when applying the communication mechanism separately, the combined effects of debriefs and coffee breaks can still achieve high performance of information flow and learning within the organization. Lastly, the initial level of information accuracy of the members does not play a role in whether high accuracy can be reached.

There are many different future research possibilities to take with this model. First of all, it would be good to automate the runs over at least 100 times and analyze the average results, since many parameters and initial values are assigned a random number or a number selected from a certain distribution. Further, more fundamental changes to the model structure could be to include quantity of information next to quality or accuracy of information and to endogenize the building of trust instead of assigning fixed initial trust values. Smaller changes to the model, or interesting scenarios to test, would be the possibility of spreading misinformation, hierarchical structures influencing the direction of information flows and distribution of partners in the coffee talks, the inclusion of individual choices to avoid briefings and coffee breaks, the possibility of management strategies in the decision of briefing frequency, the introduction of new employees with low level of information accuracy who need to be trained, and lastly, more robust tests of the influence of the number of people within the organization on the evolution of information accuracy.

References

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