Newcomers in Self-Organising Task Groups:
When Does a Newcomer Really Contributes To a Better Performance?

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Abstract

This paper describes the consequences of turnover, especially how a work group and a newcomer mutually adapt. We tested two groups, a group in which the task allocation gives space for a newcomer to fit in and a group in which this space was not available. For both groups, we tested conditions with newcomers being specialists, contributing to a specific part of the task, newcomers being generalists, being able to contribute in a global way, and a control condition with no newcomer. We studied the development of task allocation and performance. The results indicate that both the specialists and the generalists only contributed to a better performance when the task allocation provided the space for a newcomer to fit in.

1. Introduction

Suppose you are an employee working in an office. Everybody is busy writing text, printing, copying, putting covers on large piles of paper, and sell this to customers. Everyone knows what to do, everything works out fine, like a well oiled machine, but the increasing workload causes everybody to work overtime. Therefore, your team decide that you need another employee. And so it happens. The new guy is nice, works hard and tries to help wherever he can. But after a while it seems that you have made a mistake. Although the guy helps you fixing your tasks, because of this, sometimes you suddenly end up doing tasks you do not like, are not good in, and did not do before he was installed. In fact, since the new guy started, the whole team performed worse.

This is just an example of a newcomer influencing team performance negatively. For some tasks, newcomers do not automatically positively contribute to performance. Sometimes team performance is determined by the best worker, such as mental tasks, or the worst worker, such as team sports like volleyball (e.g. Steiner, 1972). But even when workers must perform an *additive* task (the more workers, the better), where all team members contribute to the total, group performance may *decrease* when a newcomer joins the group. For instance, as the example illustrates, the newcomer may disturb the task allocation structure. Further, when a newcomer is less experienced, he might perform tasks that the other members could perform much better. Moreover, more workers performing the same task imply less chance for those workers to improve their skills concerning this task. Finally, teams perform better, when the workers are more familiar with one another (Guzzo & Dickson, 1996).

The effects of separate variables – or limited combinations - have been empirically investigated by many researchers (e.g. O'Connor, Gruenfeld & McGrath, 1993; Arrow and McGrath, 1995; Marks, Mathieu, and Zaccaro, 2001; Dineen et al., 2003). Some have studied process variables with membership change being an independent variable, but these studies either focus on conflict (O'Connor, Gruenfeld & McGrath, 1993) or learning (Carley, 1992) but do not point at task allocation processes. Moreover, it is difficult to derive empirical based conclusions on how the combination of these variables affects the performance and its underlying processes of task allocation when a newcomer enters the team. Social simulation offers a methodology to systematically explore a large number of conditions, and thus may contribute to deriving such conclusions (e.g. Gilbert and Troitzsch, 1999). In this paper, by conducting experiments in which we vary characteristics of newcomers and tasks, we explore how newcomers affects the performance of a team and how a team an a newcomer mutually adapt. We studied the effects of two types of newcomers, generalists and specialists, on two types of task groups.

The first task group is a group of which all workers have allocated the whole task in such a way that all member perform an equal part of the task. We hypothesise that this group will perform better with a

generalist. The second task group is a group of which all workers have allocated the biggest portion of the task, but leaving a small part of it, as if they are waiting on the help of a new co-worker. We hypothesise that this group will perform better with a specialist.

In the first section of the paper we focus on the theories and models we use and their formalisation, which form the basis of WORKMATE, the simulation program that we developed to study self-organising processes of task allocation. WORKMATE is used to test hypotheses concerning the relation between different types of newcomers, task allocation processes and structures, and performance. The second section describes the experimental design and the parameter settings. Next we will describe the results and we end up with conclusions and a discussion.

2. The model

WORKMATE III is a deterministic discrete event based simulation program for simulation self-organising processes of task allocation that is developed in DELPHI6. It is an elaborated version of the simulation program that we used for experiments on the emergence of job rotation (Zoethout, Jager, and Molleman, 2006), and the relation between task variety and coordination time (Zoethout Jager, and Molleman, *in press*). In this section we shortly describe the theoretical framework WORKMATE III is based on.

2.1 The multi agent system

An agent is a simple model of a human being with properties that are necessary to perform tasks. A task is considered as a set of *actions* in such a way that each action is related to a single skill (Hunt, 1976; Weick, 1979; Tschan & von Cranach, 1996). Every timestep, i.e. *round*, each agent performs one action. The individual properties of the agents are represented as a set of skills. Each skill has two variable components: expertise and motivation, that are important components that determine group performance (Wilke and Meertens, 1994; see also Steiner, 1972). Skills are passive when they are not used and become active when they are needed for the performance of a task. When activated, a threshold function determines whether the agents actually wants to perform a particular action. This function holds that only if both the expertise and the motivation are higher than their thresholds, the agent wants to perform the particular action. In this way every agent chooses a subset of actions he would like to perform. If the choices of all agents imply that there are more agents sharing the same preference as there are task-actions to perform, the agents negotiate. The negotiation process implies that the agents are trying to change the preferences of the other agents in such a way that the other agents will reach a complementary state with respect to their own (see also Zoethout, Jager, and Molleman, 2004). The influence of the agents is based on their expertise and motivation of the particular skill, which implies that the agent with the highest expertise and/or motivation is more likely to get what he wants. The process ends as soon as the number of agents with a preference of a particular action is equal to the number of available actions.

2.2 The task

Each action has to be performed a number of times, i.e. *cycles*, before the whole task is finished. In this way, a task can be represented as a matrix of actions (what) and cycles (how often). The agents may perform the task in a number of ways, for instance cycle by cycle, action by action, or something in between. The possible ways a task can be allocated are bounded by two general allocation types, *generalisation* and *specialisation*. We use the concept of *round* to describe the specific order in which a task is performed.

2.3 Expertise, motivation, and performance

When the process of task allocation is being completed, the agents start performing the task. As a result of this, the expertise may change, i.e. the agents will increase the expertise of the skills they use and forget the skills they do not use. Furthermore, the motivation may change, i.e. the agents become bored after performing a particular action for a longer time and recover from it as soon as they stop. An important characteristic of most learning curves is that they reach a maximum asymptotically (Nembhart 2000). In a sense, the same holds for motivation. Therefore, we defined learning/forgetting and boredom/recovery functions by using the same functions (for an overview, see Zoethout, Jager, and Molleman, 2006).

2.4 Performance indicators

We use two separate performance indicators to measure group performance. One that indicates the number of rounds that it takes to finish the task and one that is based on the expertise and motivation of the single agents. For instance: 2 groups of agents must perform the task consisting of 3 cycles and 3 actions. The first group consists of 3 agents, each having a total performance time of 100. This results in a group performance time of 300, whereas it takes 3 rounds to finish the task. The second group consists of 9 agents, each having a performance time of 40. This results in a group performance time of 360, whereas it takes only 1 round to finish the task. This implies that although it takes less rounds for the second group to finish the task, their performance is still worse because the first group performs its rounds a lot quicker than the second. This notion may seem a bit counterintuitive, but it is not. We have to realise that a newcomer is not only beneficial because extra hands make work lighter, but for two reasons, it may also be a disadvantage. First, a lowly skilled newcomer may take over the work of a highly skilled co-worker. Second, as more workers perform the same task, they have less chance of becoming highly skilled. Therefore, the performance indicator that we propose here is able to determine whether a newcomer actually contributes to a better performance.

2.5 Hypotheses

We study the performance and the task allocation in relation to the task and the newcomer. Task allocation depends on three sets of variables, the values of the *task* (*number of actions* and *number of cycles*), the values of the *newcomer* (*expertise and motivation, specialist* or *generalist*) and the values of the *agents* (*expertise* and *motivation).* By manipulating the values of the task, we created two conditions. In the first condition, within the system all workers have allocated the whole task. In the second condition all workers have allocated the biggest portion of the task, but leaving a small part of it, as if they were waiting on the help of a new co-worker. Further, we studied the effects of two types of newcomers, generalists and specialists. On the basis of these manipulations, we formulated the following hypotheses:

Hypothesis I: When the workers allocated the whole task, group performance will improve only when the newcomer is a generalist

The rationale behind this hypothesis is based on the notion that a generalist is better able to perform all different 'loose ends' that the workers leave. A specialist would only contribute when the group needs some specific skills. Therefore:

Hypothesis II: When the workers did not allocate the whole task, group performance will improve only when the newcomer is a specialist

Hypotheses I and II describe what happens when the newcomer matches the demands of the group. In the other situations we expect a decrease of performance:

Hypothesis III: When the workers allocated the whole task, group performance will decrease when the newcomer is a specialist

Hypothesis IV: When the workers did not allocated the whole task, group performance will decrease when the newcomer is a generalist.

3. Experimental design

3.1 Variables and design

The experiment describes the situation in which a group of 5 agents that are all specialised in a particular part of the task. Although they do have the skills to perform the other actions as well, they have a clear preference to perform certain actions. Each agent has a different pattern of preferences. All agents are free to self-organise task allocation whenever they want to, which opens the possibility of *task rotation*. Task rotation refers to the change of the preferences of the agents as a consequence of their expertise and motivational changes, which implies that they may wish to re-allocate their task.

We studied two groups, a group performing a task of 5 actions and a group performing a task of 6 actions. In the first group the agents easily develop a symmetric rotation mechanism. This mechanism holds that each agent rotates between his best and his second best skill. For instance, agent 1 rotates between action 5 and 4, agent 2 between 4 and 3, etc. With this rotation mechanism, it is hard for new members to easily fit in the

existing task allocation process. Therefore, we labelled this condition as *no fit*. In the second group, because of the extra action, the agents allocate the task in an asymmetric way. Every agent still rotates between his best and his second best skill, but now 5 agents must allocate 6 actions, which leaves some kind of 'gap'. This gap is likely to facilitate the adaptation of a new member. Therefore, this condition is labelled as *fit*.

Then the newcomer comes in. In both groups the newcomer starts at the 101st cycle. This offers the group enough time to set the rotation mechanism and specialise further, i.e. to set a steady state that resembles a group of workers existing for a longer period of time.

We tested five conditions: Two conditions in which the newcomer is a specialist, with either low or high expertise and motivation, two conditions in which the newcomer is a generalist, with either low or high expertise and motivation, and one control condition with no newcomer at all. A specialist is being defined as an agent with skills having all different values, which results in a preference for the best skills. A generalist is being defined as an agent with all skills having the same value, whereas the agent must use them consecutively. Table 1 summarises the research design:

Newcomer\Task	5 actions (no fit)	6 actions (fit)
specialist low	C1	C2
specialist high	C3	C4
generalist low	C5	C6
generalist high	C7	C8
no newcomer	C9	C10

Table 1. Design

C1,…C10 refer to condition 1, …condition 10, also in the rest of the text. We have chosen for two conditions for both the specialist and the generalist because these may indicate a range in which a newcomer actually lead to better performance. We studied the effects of these conditions on task allocation being a process variable, and performance being a dependent variable.

3.2. Agent values and parameter settings

The following parameter settings are equal for all experiments:

1. *The system consists of 5 agents + 1 newcomer*
2. *In the no fit condition, a task consists of 5 actions*
3. *In the fit condition, a task consists of 6 actions*
4. *The task consists of 200 cycles*
5. *The initial values of expertise and motivation are equal*
6. *The maxima of both motivation and expertise are set on 25*
7. *The motivation – and expertise thresholds are set on 10*
8. *The learning speed is 100*
9. *the forget speed is 3*
10. *The boredom rate is 100, the recovery rate is 100*

The parameter values are not chosen on the basis of empirical criteria, since empirical studies that indicate such parameter values are yet to be done. Instead, we simply selected a parameter space that produced behaviour that we could study: For instance, a higher forget speed would result in a group of agents that is not able to perform anymore.

The newcomer comes in after 100 rounds. In the condition of *no fit*, the initial values of the agents are chosen as follows (see Table 2a):

Skill	Agent 1	Agent 2	Agent 3	Agent 4	Agent 5
1	18	14	15	16	17
2	14	15	16	17	18
3	15	16	17	18	14
4	16	17	18	14	15
5	17	18	14	15	16

Table 2a: First condition: 1 task of 5 actions (no fit)

The values (expertise and motivation) of the agents are symmetric. This implies that the performance of every agent will be about the same, whereas the agents are being specialised in different skills. Since the number of agents matches the number of actions the task consists of, they are more likely to develop a stable rotation mechanism. The initial values of the newcomers are chosen as follows: (see Table 2b):

Skill	Agent 6 (spec. low.)	Agent 6 (spec. high)	Agent 6 (gen. low.)	Agent 6 (gen. high)
1	14	19	16	18
2	15	20	16	18
3	16	21	16	18
4	17	22	16	18
5	18	23	16	18

Table 2b: Values of the newcomers in the first condition

Spec. low refers to the new agent being a specialist with low values, *spec. high* refers to the new agent being a specialist with high values, *gen. low* refers to the new agent being a generalist with low values, *gen. high* refers to the new agent being a generalist with high values. The newcomer being the specialist with low values has the same initial values as agent 2. The newcomer being the generalist has the same initial values of all skills, both for expertise and motivation.

The values of the agents in the condition of *fit* are described in Table 2c:

Skill	Agent 1	Agent 2	Agent 3	Agent 4	Agent 5
1	19	14	15	16	17
2	14	15	16	17	18
3	15	16	17	18	19
4	16	17	18	19	14
5	17	18	19	14	15
6	18	19	14	15	16

Table 2c: Second condition: 1 task of 6 actions (fit)

Comparing the tables 2a and 2c, we see that the initial values of the agents in the second condition differ from the first condition. The highest value of the second condition is 19 instead of 18 in the first condition. This is related to the number of actions the task consists of. Because of this, the values of the newcomers also differ (see Table 2d):

Skill	Agent 6 (spec. low.)	Agent 6 (spec. high)	Agent 6 (gen. low.)	Agent 6 (gen. high)
1	18	22	16	18
2	19	23	16	18
3	14	18	16	18
4	15	19	16	18
5	16	20	16	18
6	17	21	16	18

Table 2d: Values of the newcomers in the second condition

4. Results and conclusion

In the *no fit* condition, without a newcomer it took 200 rounds to complete the task. With a newcomer entering the group at the 101st cycle, in all four conditions, it only took 184 rounds, i.e. 100 rounds without the newcomer and 84 rounds (which is about 5/6 * 100) with the newcomer. In the *fit* condition, without a newcomer it took 240 rounds to complete the task (which is 6/5 * 200). With a newcomer entering at the 101st cycle, in all four conditions, it only took 217 rounds, i.e. 100 rounds without the newcomer and 117 rounds (which is about 5/6 * 140), with the newcomer. On the basis of this, we may conclude that with a newcomer coming in, it takes less rounds to finish the task. For the actual contribution of the newcomer, the contribution that is corrected for the obvious benefit that a task is finished in less rounds, we must look at the total performance time. Figure 1a and 1b depict the total performance time in all conditions:
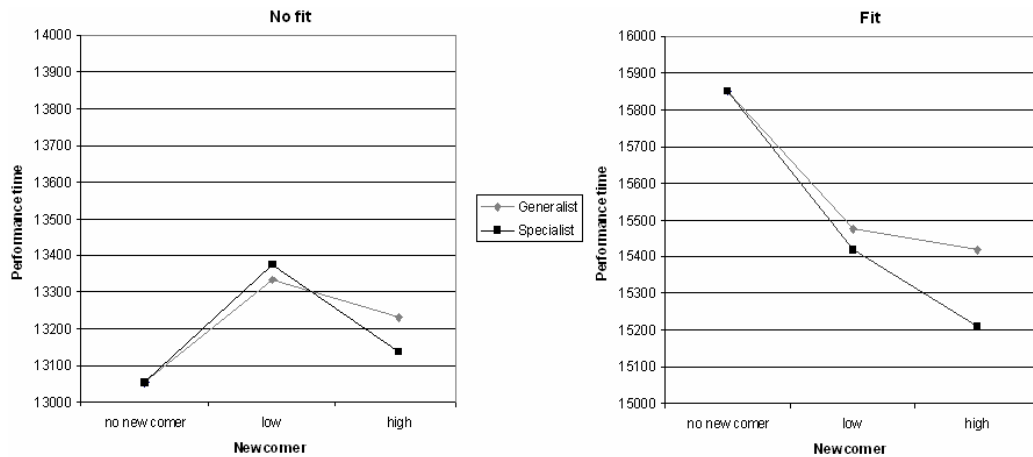
Figure 1a (left) and 1b (right): Total performance time of the groups in all conditions with specialists an generalists as newcomers

Low refers to a newcomer with low expertise and motivation and *high* refers to a newcomer with high expertise and motivation. The performance time in the figures is the sum of the performance time of every cycle. An important difference between both conditions is that the *fit* condition leads to the highest performance time of both groups because the agents in this condition had to perform a much larger task.

In general, the contribution of the newcomers to group performance is two fold: First, when their initial expertise and motivation indicate a performance time that is below the group average, the group may perform better. Second, in the last phase of task performance, the agents must re-allocate the task because some actions have been finished. Then they must work on 'loose ends', which consist mostly of actions that the agents are not very well experienced in. The contribution of the newcomer is also determined by its performance time when finishing these loose ends. When the newcomer is a *specialist*, his contribution especially concerns his initial expertise and motivation, whereas his part in performing the loose ends is quite low. The contribution of the *generalist* is just the other way around: he performs moderate or bad when he enters the group, but works a lot better on the remaining pieces. Because of this, in both the *no fit* and the *fit* condition, the performance difference between groups with a high specialist and groups with a low specialist are much larger than the differences between groups with high generalists and groups with low generalists.

The contribution of a newcomer to the loose ends only holds for the *no fit* condition, but does not apply to the *fit* condition: In the *fit* condition, the loose ends consists of the actions that the newcomer has not been finished because he started later. This implies that in the last phase of task performance, the existing members had to switch to 'help' the newcomer. This means that the performance difference between a specialist and a generalist is only determined by his initial expertise and motivation and not by his contribution to the loose ends. In the *no fit* condition, the loose ends consists of other actions than the newcomer started with. Since the newcomer performed the same action as agent 2, these actions are being finished first. Then, the newcomer must help the other group members. Because of this, the last phase of task performance that starts when the agents must re-allocate the task takes a lot more time in the *no fit* condition then in the *fit* condition. Therefore, in the *no fit* condition, a newcomer cannot improve task performance, whereas every newcomer contributes positively to the *fit* condition.

On the basis of this, the hypotheses as formulated in 2.5. are partly supported: Hypothesis I, that stated that in the no fit condition, group performance will be the highest when the newcomer is a generalist, is not supported because in this condition none of the newcomers improved group performance. Hypothesis II stated that in the fit condition, group performance will improve only when the newcomer is a specialist is not supported either because in this condition every newcomer improved group performance. Nevertheless, a specialist contributed better than a generalist. Hypothesis III that stated that a match between *no fit* and specialist would decrease group performance is accepted, because any match between *no fit* and a newcomer decreases group performance. Hypothesis IV that stated that a match between *fit* and generalist would decrease group performance is not supported because any match between *fit* and a newcomer increases group performance.

These results indicate that even in additive tasks the principle 'the more workers, the better' does not always apply. By using a performance indicator that has been corrected for the obvious benefit that more hands make lighter work, we indicated that a newcomer only contributes to a better performance when a combination of group and task structure offers the possibility to fit in. This not only yields for specialists but for generalists as well. Therefore, our study implies that group and task structure are the most important components that determine whether or not newcomers contribute successfully to a team.

On the basis of these results, we may empirically study how task allocation processes regarding the mutual adaptation of newcomers and teams are related to different kinds of tasks or personality characteristics of team members and newcomers. How is personality related to task allocation? In future research, we may enhance WORKMATE with components such as power and attraction (see also Zoethout, Jager, and Molleman, 2004). In general, this study may offer another perspective to empirical processes regarding newcomers while empirical studies may validate our model.

5. References

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