A Multi Party Negotiation Game for Improving Crisis Management Decision Making and Conflict Resolving

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A Multi Party Negotiation Game for Improving Crisis Management Decision Making and Conflict Resolving

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Preface

This thesis is the result of my Master of Science research project at the Delft University of Technology, The Netherlands. The project has been carried out at the faculty of Electrical Engineering, Mathematics and Computer Science (EEMCS) for the department of Mediamatics. The topic of this thesis is the design and implementation of a training game intended for improving the crisis management decision making process.

I would like to thank my supervisor Birna van Riemsdijk for her guidance and support during this project. I also thank Zhiyong Wang for his help during various phases of this project including assisting with the various experiments that were performed, as well as Catholijn Jonker, Mark van Gurp and Willem van Santen for their advice at various points of my project.

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Contents

1 Introduction

In crisis management situations, people from different backgrounds have to work together to find a optimal way to handle the crisis. An example is when fire breaks out on a large scale in a rural environment. In this case the fire department, police department, medical personnel and the policy makers of that area have to work together to solve the crisis. However these people also have their own goals to tend to, which often are given higher preference than the global goal of solving the crisis. This can result in suboptimum solutions, due to each player sticking to their own ideas. Therefore some way needs to be found to teach them to work together, by showing that this is actually beneficial for the global goal.

To facilitate this we created a training game in which players have to reach a global goal while each of them also has an individual goal. The game was created in the Blocks World For Teams (BW4T) environment, in which players have to collect and return colored blocks in a specific order. These blocks can be situated in the rooms that are in the environment. Prior to the game the players need to negotiate about how to approach the task among other topics. When an outcome in this negotiation has been reached the actual mission is enacted by agents who have knowledge of the goals and the outcome. After the simulation is finished, which can be either by completing the mission or by not being able to complete the mission anymore, the players can learn the effects of their negotiation and will be debriefed on how to improve their teamwork after which they play another round of our game. In this second round a change in behaviour should become apparent.

This report discusses the design and implementation of this game as well as the results that came out of the experiment we ran. First of all we discuss existing literature in Section 2. After this we will present the design of our game in Section 3. Then we will explain how we implemented various parts of our game in Section 4. After this we will explain the final experiment as well as discuss the results of this experiment in Section 5. Finally we will end with a conclusion in Section 6 and suggestions for future research in Section 7.

2 Literature Survey

In this section previous research on similar subjects will be given and discussed. First of all as we discuss the crisis management domain in Section 2.1, as our developed game is targeted for this domain. Second previously made serious games that also incorporate aspects of teamwork and negotiation in various ways will be discussed in Section 2.2, so that they can be compared to our game later on. Third some existing literature on teamwork, including negotiation, will be discussed in Section 2.3, which is useful for designing the agents of our game.

2.1 Crisis Management

As the game we created is intended to be used to train crisis management experts we need to know what crisis management entails and what problems arise during the management of a crisis. First of all we need to define what a crisis is. There is however no single set of criteria by which a crisis can be defined. Rosenthal [33] mentions that a crisis is a threat to the basic infrastructures or the fundamental values and norms of a social system. Pauchant et al. [31] define different disruptions to a system or one of its subsystems. They define an incident as a disruption of a subsystem with the potential to affect the total system. An accident is defined as affecting the system as a whole but not affecting the social identity of this system. Finally they define a crisis, similarly to Rosenthal, as affecting or having the potential to affect the total system while also threatening its social identity. Other effects of crises are that they threaten higher priority goals, restrict response times and force surprise on decision makers [18], as well as having a high level of uncertainty [33].

Therefore the field of crisis management tries to find a way to optimally deal with crises. There are two models which are often used by western government agencies, these are MPRR (mitigation, prevention, response, recovery) and PPRR (prevention, preparation, response, recovery), these models are used to describe the process of crisis management, but are not applicable for creating a crisis management system that can be used to help solve a crisis [21, 17].

In the Netherlands a crisis management organization consists of multiple teams which are also multi-disciplinary. The organization is determined using the GRIP-system which is based on the severity of the crisis [38]. This system has five layers which are the following:

- 0: This is used when the operational services are carrying out their usual activities.
- 1: This is used when there is a smaller incident where only the source location is involved.
- 2: This is used when there is an additional area of effect in addition to the source location.
- 3: This is used when the wellbeing of a large group of civilians is in danger.

- 4: This is used when the incident affects an area which crosses municipal borders.

These layers determine which levels are contained in the organization, which are the field level, the tactical level, the operational level and the policy level. The field level consists of actors who are operating at the scene of the incident, which are the firemen, policemen and medical support personnel. These actors will follow decisions made by the higher levels, but also are the closest to the crisis and will therefore be affected the most by changes to the situation. The tactical level coordinates the tasks done at the scene of the incident, and will continuously observe the situation. It acts on decisions made by the operational level and also gives the operational level the information they need. The operational level acts on decisions made by the policy level, which contains policy makers and mayors, and in turn also gives the policy level the information they need, which they gather from the tactical level. Finally the policy level concerns itself with legal matters as well as the high-level organizational matters. Their decisions are given to the tactical level who will make a more detailed plan of action based on these decisions.

Crises are usually managed using a network-centric approach [38]. This approach has evolved from Network Centric Warface (NCW) which was used by the military [2]. The main goal of NCW was to share information between all parties, with the motivation being that having a superior information position gives you an advantage over your opponent. By adapting this to crisis management the Network Centric Operations (NCO) system was conceived. NCO allows information to be shared horizontally as well as vertically throughout the organization dealing with the crisis, and also allows information to be shared amongst multiple units. The network-centric approach contains a single commander in chief who controls all the actors in the network. For this approach to work correctly all actors should have the most up to date information, which means that all information should be shared amongst all actors to which the information is relevant. Also each of the actors should have common goals which they all are striving to achieve.

However as mentioned earlier, at least in the Netherlands, a crisis management organization consists of multiple teams that contain multiple disciplines. An evaluation of crises has shown that the previously mentioned criteria for a working network-centric approach are usually not met [36]. These teams usually consist of members who do not share the same goals, instead having their own goals that they want to achieve. Also the information systems are not used optimally as well as the information not being accessible.

Therefore van Santen et al. [36] claim that the crisis management decision making process should be seen as a multi-party multi-issue negotiation, as each of the parties in one of the decision-making teams has their own interests and preferences. So in order to make a decision each party has to make some compromises, the final decision is based on the attitude, negotiation strategy and negotiation skills of each party. A collaborative negotiation strategy should be used to reach a decision. The authors also mention that the team will perform better if each team member takes the preferences of other team members into

account. However at the start of the process each team member will not have this knowledge or will not be trained sufficiently to be able to gain this knowledge and will negotiate competitively, meaning that they will prioritize their own preferences. These people should be trained before the decision making process so that they can negotiate using a collaborative mindset instead of a competitive mindset.

2.2 Related games

First of all we found several closely related games that incorporate teamwork to some extent, we will summarize each game in this section.

2.2.1 SimParc

The SimParc project [5] focuses on participatory park management. The goal of the game is to make players understand conflicts and make them able to negotiate about them. The game takes place in a park council, that consists of various stakeholders like the community or the tourism operator. The topic of discussion is the zoning of the park which entails the desired level of conservation for each part of the park. Each stakeholder has a different preference concerning the zoning for each part of the park, which quickly leads to conflicts of interest. A special player type is the park manager who acts as an arbiter and makes the final decision based on the final input from the players. The game starts with an allocation of roles to players after which they can present their first proposal for each part of the park. After this the players can freely negotiate about their proposals. This negotiation is a multi-party negotiation as each player can send messages through the system to multiple other players. When this negotiation is finished each player can adjust their proposal if necessary and the park manager will then make a final decision. Each player can then receive information about their performance and can also ask the park manager to explain his final decision.

2.2.2 Colored Trails

The game Colored Trails [29] was developed for testing the decision-making procedures in task-oriented settings, it is mostly used for examining agent behaviour as well as human behaviour. It focuses on the interaction between the individual goal and the group goal which is modelled in the game. The game can be played by more than 2 players and consists of a rectangular board containing colored squares. The players get a starting position on this board, a goal position and an initial set of chips. The objective for the players is to reach the goal square. Players can only move to a square which is adjacent to the one they currently occupy. This can only be done however by having a chip with the same color as the square the player wants to move to. This can result in negotiation between two players to exchange chips using a standardized messaging protocol. Some parameters can be changed to vary the game, for example the board visibility can be changed so that players aren't allowed to see the entire board or the knowledge of the other players' chips can be toggled on or off. After the game is over, the results are calculated using a scoring function which uses the number of chips the player has left, the distance to the goal position, the

number of moves made by the player and whether or not the player has reached the goal state. This is the base scoring function of the game, it can be made more complicated by also taking into account the results of other players with a certain weight. This weight can be adjusted to make other player's succes more important than this player's own succes or vice versa. Global goals can thus be modeled by adding a scoring component that can only be maximized when all players reach their goal and are therefore composed of multiple individual goals.

2.2.3 Contract Management Simulation

Agapiou [1] has developed a web-based management simulation game designed for students of architecture. The game was based on an earlier paper-based version that was played for several years. Students are divided into teams in which they compete to get the highest score, this means that there is no real notion of a global goal, but only individual goals which are the same for each member of the team. The game itself is based on several scenarios involving an office construction project of which the students are the contract administrator. The students must select correct actions to perform depending on the previous events. Students can collaborate with eachother and can also enter correspondence with the client of the project among others.

2.2.4 Puzzle game

This is a simple game in which each player gets some puzzle pieces and has to complete a puzzle. However some pieces are missing and some pieces that the player receives are for another puzzle. The objective is then to trade pieces with another player. This needs to be done without communication, so in this game the negotiation is only implicitly contained within the pieces that get shuffled around. This also means that in this game players don't form teams and only have their individual goal to reach.

2.2.5 Diplomacy

Diplomacy [6] is a board game created in 1954 that is special because of the large amount of playing time that is used for negotiation. Players each control a European Power that has to defeat other players. The game consists of negotiation phases in which multi-party negotiation can occur, where some players can even decide to leave the playing room to negotiate with each other. An important point here is that the agreements that are reached by the players are not enforced so players can decide to deceive others. Alliances can also be made, either with or without a leader, during such a negotiation resulting in a team of players that cooperate to reach their own individual goals, there is not really a notion of a global goal in that case however. Also this coalition is not created before the game, and can change quickly so there is no general notion of a team during the game. After the negotiation phase each player can give orders to his units in secret. These two phases alternate until a player has won the game.

2.2.6 Tactical command simulations

There are various examples of tactical command style simulations that are used to train new military staff. These simulations are run in a virtual environ-

ment like Virtual Battlespace 2 [19, 35]. Trainees are usually playing in teams with a commanding officer who gives out the mission and the orders that they should follow. After such a mission the trainees are given feedback on their performance. Negotiation between the students is possible, which can happen as a multi-party negotiation, but the hierarchical nature of a tactical command team usually determines who makes the ultimate decision. Other possibilities for such simulations are those where a trainee controls various Computer Generated Forces (CGF) [19], in that case there is no real negotiation anymore as the CGFs are usually not implemented with that in mind.

2.3 Teamwork

In this chapter we take a look at various research related to teamwork, starting with some definitions on what a team actually is. After that we will take a look at some of the aspects of teamwork that follow from the given definitions in more detail in the following paragraphs. These aspects are useful for designing the agents that play our game. Finally we will end with a paragraph about possibilities of measuring teamwork in a given team, which is useful to track what effect our game has on the teamwork of its players.

2.3.1 Definition

First of all Klaus and Glaser [26] characterize teams by their necessity for coordination and cooperation. Morgan et al. [24] define a team as a "distinguishable set of two or more individuals who interact independently and adaptively to achieve specified, shared and valued objectives", they also add that each team member can be assigned a different role and that the length of team membership is finite. Another more simple definition which can be useful for our purposes is given by Cohen et al. [11] which is:

> A team is a set of agents having a shared objective and a shared mental state and without either, there is no unified activity and hence no team.

From these definitions we can see that the important properties of a team seem to be a shared goal as well as interaction between the team members. The members of a team also do not need to have the same characteristics, this means that each team member can have his own abilities or role within the team. Also there seems to be some need for coordination or in another word collaboration between the team members. Without this there is no way of dividing the different tasks between the members of the team. Finally the team members should have some shared knowledge about the team and the mission.

2.3.2 Shared Mental Models

A mental model is a knowledge structure that allow us to interact with the environment. A mental model can contain various different types of knowledge like relationships between components in the environment, the properties of a component in the environment and expectations of events that could occur [34].

Summarizing they can be used to describe the environment, explain the environment and predict the environment [27].

Similarity between mental models of different team members is positively related to the team performance. Therefore a shared mental model exists when team members have a shared understanding of the team and the task they have to perform. [23] When team members can draw on some shared mental models they can act consistently with other team members [9]. Also there is some knowledge that each member of the team should have in order to work efficiently, like the shared goal the team has, as well as information about each member of team, such as their roles and abilities. Mathieu et al. [27] give various types of mental models that are used in a team, which are technology, job, team interaction and team mental models. The technology model contains information about the equipment that can be used during the task. The second contains knowledge about the different tasks that should be completed and in what order to achieve the overall goal. The third contains information about how the team members interact with each other, what each member's role in this is. The final one contains information about the abilities and properties of each team member. This final one is important according to Cannon-Bowers et al. [9], as the more knowledge it contains the more effective a team can perform because each team member can then adapt it's behaviour to the information it has about other members. For example by predicting that a certain action will be done by someone else, and instead choosing to do a different action.

2.3.3 Communication

In this paragraph we take a look at the different kinds of communication that can occur between team members. The two main different ways of communication are reactive and proactive communication [15]. First of all reactive communication means that team members only send information to another team member when it was asked for. Proactive communication on the other hand means that team members will send information to others without any preceding request for this information. The latter is harder to implement succesfully if the team members do not know what information is needed by other team members. For example, you can avoid this by just sending out all new information regardless of this but that would not be an efficient way of getting the right information to the right place. This then becomes a reason to supply some shared knowledge about the other team members, as to their tasks and abilities, in a shared mental model like the team interaction model explained in 2.3.2. When this is known each team member knows what information is needed by the others. However in the case that this still is difficult to decide or when a team member wants some information he would normally not be needing, reactive communication can fill the gap by letting them request this information from others. Therefore we can conclude that both styles of communication are necessary to facilitate efficient teamwork.

2.3.4 Collaboration

To complete the overall goal a team needs to work together to achieve this. This means that the team needs to collaborate to solve problems to finally achieve

this goal. First of all a plan needs to be made by the team, in order to decide what the course of action is going to be. This must obviously be done collaboratively as each team member usually gets equal say in the matter. This plan would then be included in a shared mental model from which the various members can then draw on during the execution of the task. Conflicts can also occur obviously during planning discussions, when different members want to achieve different things. These conflicts can be solved using negotiation. [15]

Another aspect of collaboration is making other team members aware of change in the environment, thereby enhancing each's knowledge of the environment. This can be called collaborative situation awareness [15]. To complete the task efficiently each team member needs to be kept up to date about the environment. When each team members shares new findings or events in the environment with the others, this can create one single shared mental model that every member can use. Therefore each team member knows about the events that are currently taking place, and what objects are located where in the environment which allows them to make the correct decisions as to their next step.

Another aspect is helping behaviour [15], which basically means when team members help other team members. This behaviour can occur when a task request is made from one member to another, which is followed by an acceptance of that request and the requested task's completion. However another possibility, which is ideal, is that team members help others without needing to be asked for help. This does require extensive knowledge about the other team members however. Dickinson et al. also define seven core components of teamwork [13], one of these is backup behaviour which is a special case of helping. Backup behaviour comprises of helping other team members to perform their tasks. This means that each team member must be able to do these tasks in question otherwise giving assistance is not possible.

2.3.5 Negotiation

Negotiation is one of the four main procedures for dealing with opposing preferences [10], which can occur even in teams that work towards achieving a shared goal. Such a negotiation can take several forms, either a bilateral negotiation (between two parties only) or a multi-party negotiation (between more than 2 parties) [12]. The topic of negotiation can usually be divided into issues for which each issue has a set of possible outcomes for that issue. Each actor in the negotiation has a preferred outcome, depending on their personal preferences, that will most often not be shared by the other actor(s) as they have differing interests. Different strategies can be applied by the parties to arrive at their preferred outcome [10], the first of which is concession making which means that a party will try to accomodate the other's preferences in making their offer. The second is contending which involves getting the other party to yield their preference. The third is problem solving, which tries to find an outcome that is best for all involved parties.

2.3.6 Teamwork Measurement

A final problem is the question of how to measure teamwork in order to be able to say something about if one team performed better than another team. This is useful for answering questions about which variables influence the performance of a team. In our game we also intend to measure the performance of the team, so this is also useful for us. The generally used teamwork measures tend to fall into two categories [30]:

- Team versus individual measures: Individual measures are used to check if each individual member of the team performed well on his own tasks, team measures are used to check if collaboration went well, by checking if team members helped each other, or if new information was sent to the right person for example.
- Outcome versus process measures: Outcome measures check the results of the team's work for performance or quality. Examples of this are the amount of time the deadlines were exceeded, or the amount of errors that were made. However this says nothing about the team process, and a bad process can lead to a good product sometimes. Therefore process measures are used to measure the process of the team, which usually is done by observing the team and their communication and interaction process. Therefore process measures can also be useful. The latter are usually measured qualitatively.

A way to measure the teamwork process was suggested in [4], where the focus is on checking for certain behaviours during the team process. The authors give some teamwork skill dimensions which are the following:

- Giving suggestions or criticisms
- Cooperation
- Communication
- Team spirit and morale
- Adaptability
- Coordination
- Acceptance of suggestions or criticisms

Different behaviours can be linked to these teamwork skill dimensions. These behaviours are grouped into effective and ineffective behaviours. By counting the amount of effective behaviours a measurement can be made for each of the dimensions, that can ultimately be linked to the performance of the team and the outcome of the assignment.

A final way of measuring teamwork is the Team Effective Questionnaire (TEQ) [37]. The questionnaire results in six different TEQ measures, which are performance, conflict, communication, interdependence, attitude and psychological safety. A team is supposed to fill in this questionnaire after their assignment is completed.

3 Game design

In this chapter we take a look at the design of our game, starting with the goals we want to achieve when training players using the game in Section 3.1. Then we will give a quick explanation of the overall game outline in Section 3.2. After this we will compare our game to other games in Section 3.3. Then we will explain the existing Blocks World For Teams (BW4T) environment in Section 3.4, after which we will explain how we expanded this environment for our purposes in Section 3.5. Then we will explain the negotiation phase that is contained in our game and how we designed this phase in Section 3.6. Then we will discuss the agents that were created to play the game in Section 3.7. After this we will discuss the debriefing phase of our game in Section 3.8. Finally we will explain how we prime players for our game in Section 3.9.

3.1 Training goal

In an ideal situation all players in a team will work their hardest to achieve a group goal, which is a goal all team members share, while not letting the desire to reach their own goals get in the way. However in reality this is often not the case, as players will tend to focus on their individual goals, and perceive these to be more important than the group goal. Often these individual goals conflict with the group goal or even with other individual goals, which can be problematic for the team's performance. Therefore one of the training goals of the game is to increase awareness of the importance of the different types of goals. By increasing this awareness we hope that the team is able to perform better in future scenarios by taking this new knowledge into account. Increasing awareness should therefore result in different behaviour by the players, which could mean that they shift their focus towards the group goal instead of their individual goal, or try to accomplish both without compromising performance. However in some situations it is not possible to accomplish both goals without compromosing some performance, in those cases players should decide to forfeit a part of their individual goal for the greater good.

The definition of conflict that we use is the following: There is a conflict between two goals when the achievement of one hinders the achievement of the other in some way. This could be either by making the other goal impossible to achieve or by taking longer to achieve it.

There are a couple of different conflicts that can occur between individual and group goals, which we intend to use in different scenarios of our game. First of all there is the possibility of a conflict between the group goal and the individual goal, where in the worst case scenario this conflict can result in an unreachable group goal if the individual goal is achieved. In other cases only the overall performance will be affected. Second there is the possibility of a conflict between the individual goals of the players (irrespective of the group goal), where it can happen that only one player is able to reach his individual goal. Third there is the possibility of an interaction conflict which we define as a conflict that occurs when multiple instances of an individual goal, while not conflicting each other and also not conflicting with the group goal by itself, together do cause conflict. For training purposes we intend to separate these conflict types into different scenarios so that the players can be made aware of

these separately.

By letting players experience different kinds of conflicts, using different scenarios in the game, and experiencing what effects their choices have on the performance we expect a change in behaviour in future rounds as well as a shift of focus from individual to group goals as well as a better team performance in future rounds.

3.2 Overall Game Design

We can now create a global design of the game. As was mentioned in the previous section the goal is to teach players about different kinds of conflict that can occur during a round and change their behaviour and performance with respect to the group goal. During such a round the team will therefore be given a group goal, that all team members have, as well as individual goals, of which each player has one. Before we can create these rounds we need a game which we can extend for our purposes. We have chosen the Blocks World 4 Teams environment, which will be explained further in Section 3.4. We can create various scenarios for this environment, which will be done in Section 3.5. These scenarios can potentially contain various kinds of conflict between the individual and group goals.

Players should then be able to collaboratively solve these conflicts and create a plan of action to reach the group goal. As mentioned in Section 2.1, in crisis management this process can be seen as a multi-party multi-issue negotiation. Which is exactly what we will allow players to do at the beginning of a round. During this negotiation players are able to discuss various issues pertaining to the game and will eventually reach some outcome with respect to these issues. More details on this negotiation phase, and the issues that we define, can be found in Section 3.6. In order to make our game relatable to crisis management the team can be seen as the above-operational level in crisis management, that gives orders down the chain of command. The players' negotiation outcome will be communicated by us to agents who will play the game in the environment. These agents therefore embody the field level in the crisis management domain. The choice for using agents to play the game also prevents players from changing their plan during the game. The agents will therefore use the negotiation outcome to determine what action to take in addition to their individual goal when necessary, more detail on this in Section 3.7.

After the agents have finished playing the game we intend to hold a short debriefing with players to summarize the results of the round, which should lead them into a change of behaviour in the next round, more details on this debriefing can be found in Section 3.8.

From this we can summarize that a round consists of three main phases:

1. Negotiation about different issues based on individual goals and group goal

2. Agents playing the game based on the negotiation outcome

3. Debriefing in which players are given a summary of the results of the round.

In a single training session we can give players multiple of these rounds, which should lead to an increase in their performance as well as a change in behaviour. In the first round we intend to prime players in order to start of with the "wrong" behaviour after which we can guide them towards improving this. More details on how we prime players are given in Section 3.9.

3.3 Comparison to related games

From the previous sections and the game outline we can now make a summary of the aspects that are crucial to our game. As said earlier our game is meant for crisis management experts, in order to train them to be more aware of conflicts between their goals and the global or individual goals. Because crisis management teams do not have a hierarchical team leader we created a game that can be played by a self-managing team with no pre-defined leader. The game contains a notion of a group goal and individual goals, that are specifically chosen so that there is a conflict between these. As the crisis management decision making process occurs simultaneously between more than 2 actors, the negotiation phase in our game contains a multi-party negotiation as opposed to a bilateral negotiation.

From this we can make a list of properties that are important in a game such as ours. This list can be found below.

Team type This can be either hierarchical or self-managing where hierarchical means there is a team leader that makes ultimate decisions and self-managing means there is no leader and all team members have equal say in matters.

Group goal Whether or not there is a group goal in the game.

Individual goal Whether or not there are individual goals in the game.

Goal conflicts Whether there is a conflict between these goals.

Negotiation type Negotiation can occur bilaterally (between 2 players simultaneously) or via a multi-party negotiation (between more than 2 players simultaneously). Because the negotiation has to be done simultaneously between all participants, a multi-party negotiation, by this definition, can not consist of multiple bilateral negotiations strung together.

In Table 1 we used these criteria to create a taxonomy of the games that we found during our literature survey, our game was also added to the taxonomy. Our game, that we call the Multi-Party Negotiation Game (MPN game), is added at the end of the table.

	Team type	Group Goal	Individual Goals	Goal conflicts	Negotiation type
SimParc	Hierarchical	Yes	Yes	Yes	Multi-party
Colored Trails	Self-managing	Yes	Yes	Yes	Bilateral
Contract Management	Self-Managing	No	Yes	No	Multi-party
Puzzle game	None	No	Yes	No	Bilateral (implicit)*
Diplomacy	None**	No	Yes	No	Multi-party
Tactical command	Hierarchical	Yes	No	No	Multi-party
MPN game	Self-managing	Yes	Yes	Yes	Multi-party

Table 1: Taxonomy of related games

*Implicit means that there is no actual communication but giving and receiving puzzle pieces between 2 players can be seen as some sort of negotiation.
**Coalitions can be made by players during the game, but there is no team that works together throughout the whole game.

SimParc comes close to our vision, however it does not contain a notion of a group goal and uses a hierarchical leader to make the final decision at the end of the negotiation. Colored Trails can contain a group goal which is helping other team members to get the highest possible score, while also containing an individual goal of maximizing your own score. The negotiation capabilities regrettably do not extend beyond bilateral negotiations, however for our game we are interested in multi-party negotiations. The puzzle game that we described does not contain a group goal so there is no real team to speak of. Diplomacy only contains temporary coalitions depending on the actions of players, however we want to have a team that exists during the course of the game. Finally tactical command simulations only contain group goals and use hierarchical team leaders which again does not make them applicable for our purposes.

Therefore you can see that our intended game differs from all games discussed in this chapter, the game that comes closest to our vision is the SimParc game. Therefore we have created our own game which conforms to our criteria which are: self-managing team, group goals, individual goals, conflicts between these and a multi-party negotiation.

3.4 Blocks World for Teams

In order to create our game we needed a suitable environment to work in. One of the most important criteria was that the environment should be simple and not necessarily directly related to crisis management. Because the game is supposed to be played by crisis management experts, having a game related to that subject will be difficult to make realistic from their viewpoint. Therefore the environment should be more abstract, but still contain a notion of global and individual goals. This allows the players to focus on the conflicts instead of focusing on the differences to real life crisis management. We decided to pick the Blocks World for Teams (BW4T) environment [22], as this environment was used for other projects so we already had some experience with it. The Blocks World for Teams environment has also previously been used for other research

related to teamwork. It was developed as a testbed for joint activity of heterogenous teams and is based on the AI problem of Blocks World .

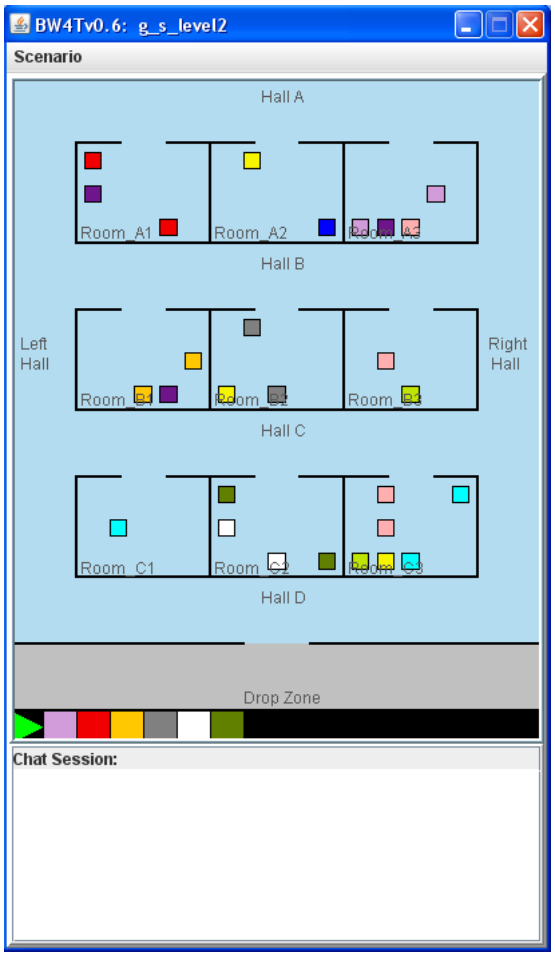


Figure 1: Blocks World For Teams environment

The BW4T environment, which is shown in Figure 1, consists of 9 rooms in a 3x3 positioning, that are connected by several hallways. A special room called the drop zone is also located in this environment. The rooms can contain blocks in various colors which can be picked up and brought back back to the drop zone where the block can be dropped again. The goal of a game instance is to retrieve specific colored blocks in a certain order. The game can be played with multiple players, either human-only, agent-only or mixed teams. Each player gets his own window in which he can only see his own simulated robot, which is the one he can control, and the blocks that are located in the room that the robot occupies. Other players are invisible, therefore in order to complete the goal as quickly as possible it is necessary for players to communicate with eachother and coordinate their actions. A player has the possibility of sending information about the blocks he has found in a room, or sending information

about his current location for example.

Something of note is that when a block is dropped in the hallway by accident it will disappear from the environment, the same thing will happen when a block is dropped in the drop zone whether it's the correct color or not. There are different scenario possibilities, that can be ramped up in difficulty, which is done by adding various colors or utilizing more of the rooms that are contained in the environment. In order to force coordination between multiple players, blocks are hidden in rooms and players are only able to see blocks when they are in the same room themselves.

In its current state the BW4T environment is not yet usable for our experiment, as it only contains a group goal that is the same for each player. As we want to add the notion of each player also having some individual task which can conflict with others' goals or the group goal, this required expansion of the environment. The next chapters will elaborate on the steps we have taken to accomplish this.

3.5 Individual goals

As we have chosen to use the BW4T environment to create the game, we already have a notion of a group goal in the game. However to create the different kinds of conflict that can occur with the group goal we need to add individual goals that players should also try to reach. In the following we introduce several kinds of individual goals, and categorize these goals as to what conflict they result in, depending on the chosen scenario. To do this some criteria are needed, which are given below:

Alignment There is an alignment between two goals when the achievement of one does not hinder the achievement of the other.

Beneficial This is a special case of alignment where the achievement of one goal still does not hinder the achievement of the other, but is also actually beneficial for the achievement of the other goal.

Severity The severity means how much of an impact a conflict makes in regards to the performance in reaching the group goal. In this case the performance means the amount of time it takes to reach the group goal.

Integrated plan For some individual goals it is possible to increase the performance in reaching the group goal, by taking the individual goals into account in the planning phase. By creating an integrated plan it is then possible to optimize the performance while also achieving the individual goal. However for some individual goals this is not the case, and increasing performance automatically includes a notion of partially ignoring the individual goal.

Relation to crisis management This signifies whether a certain individual goal can be related in some way to the crisis management domain. As our game

is intended for crisis management experts, such a relation would be useful especially in the case of transferring our game to a more realistic environment. In some cases such a mapping could not be thought of however as will become apparent, these individual goals will therefore be less likely to be chosen.

These criteria are important because we will use them to classify various individual goal choices and they will also be used to make a choice of scenarios later on.

3.5.1 Possible choices

For each of the possible individual goals we give possible choices of group goals and environment parameters, and discuss which combination of both results in which type of conflict, as well as what behaviour we expect a player with this individual goal to exhibit. Next to this we specify the severity of these conflicts, if there is a possibility of creating an integrative plan that accounts for the individual goal. Finally we specify whether it is possible to relate a specific individual goal to a similar situation in the crisis management domain.

1. Collect the most blocks

Explanation

The player needs to collect the most blocks, blocks that aren't needed to reach the group goal count for this individual goal.

Group goals

1. Group goal which contains only blocks of one color.
2. Group goal which contains blocks with multiple colors

Environment choices

1. No other colors in the environment than the colors in the group goal.
2. Other colors than the group goal contains are present in the environment.
3. Environment in which there is an equal amount of blocks per player.
4. Environment in which there is not an equal amount of blocks per player.

Conflict/Alignment between individual and group goal

When choosing group goal 1 with environment 1 there is an alignment as the player can then collect any block he wants in whatever order he wants. All other combinations bring about conflict as ordering problems occur, or the player will take longer by bringing back unnecessary blocks.

Conflict/Alignment between multiple instantiations of individual goal

When choosing environment 3 regardless of group goal, there is no conflict as each player is able to collect an equal amount of blocks.

However when choosing environment 4, it is not possible to do this and therefore there will be a player who won't reach this individual goal.

Conflict/Alignment between multiple instantiations of individual goal and group goal

There is no interaction effect for this individual goal.

Severity

This individual goal can have a large impact on the performance when a lot of wrong blocks are collected.

Integrated plan

For this individual goal, when a conflict occurs, it not possible to create an integrated plan to optimize performance while still reaching this individual goal.

Expected player behaviour

The expectation is that players will spend a lot of time by collecting blocks that aren't necessary to reach the group goal, before trying to actually reach the group goal.

Relation to crisis management

No relation.

2. Collect the most blocks relevant for the mission

Explanation

The player needs to collect the most blocks that are necessary for the group goal, blocks that aren't needed to reach the group goal don't count for this individual goal. These blocks should therefore also be dropped of at the right time, or else they won't count for the group goal.

Group goals

1. Group goal which contains an equal amount of blocks per player.
2. Group goal which does not contain an equal amount of blocks per player.

Environment choices

1. Any environment.

Conflict/Alignment between individual and group goal

This individual goal does not hinder the achievement of the group goal in any situation, so there is no conflict.

Conflict/Alignment between multiple instantiations of individual goal

Here there is a conflict, when choosing group goal 2 and environment 1, as in this case one player has to collect more blocks than another to reach the group goal meaning that other's individual goal will be unreachable.

In the case of group goal 2 and environment 1, there is alignment as each player can collect an equal amount of blocks and will therefore all reach this individual goal.

Conflict/Alignment between multiple instantiations of individual goal and group goal

There is no interaction effect for this individual goal.

Severity

This individual goal mostly has a small impact on the performance, however in the case that there is no equal division of players to blocks it can happen that the group goal is never reached meaning a very large impact on the performance.

Integrated plan

For this individual goal, when a conflict occurs, it not possible to create an integrated plan to optimize performance while still reaching this individual goal.

Expected player behaviour

The expectation here is that the player will intentionally withhold information about the blocks it has found in the world. The reason for this is that if the others don't know about these blocks the player can bring them back himself and then reach his individual goal as well as the group goal.

Relation to crisis management

In the crisis management domain a fireman or paramedic could decide for himself that he want to do the most work, needed to reach the group goal, as possible. The motivation for this could be trying to get a promotion or not trusting other people with the job.

3. Collect the fewest blocks

Explanation

The player should collect the fewest blocks.

Group goals

1. Group goal contains equal amount of blocks per player.
2. Group goal does not contain equal amount of blocks per player.

Environment choices

1. Any environment.

Conflict/Alignment between individual and group goal

When choosing group goal 1, regardless of environment, there is no conflict as each player can collect an equal amount of blocks. When choosing group goal 2, regardless of environment, there is a conflict as players won't want to collect extra blocks.

Conflict/Alignment between multiple instantiations of individual goal

If you choose group goal 2, regardless of environment, when one player reaches this individual goal it can mean that other players will not reach it.

Conflict/Alignment between multiple instantiations of individual goal and group goal

There is no interaction effect for this individual goal.

Severity

This individual goal can have a very large performance impact when it results in the group goal not being finished.

Integrated plan

For this individual goal, when a conflict occurs, it not possible to create an integrated plan to optimize performance while still reaching this individual goal.

Expected player behaviour

Players will assign themselves an explorer role, and will tell others to pick up the blocks they've found. Dishonesty could also occur by telling others you've picked up more blocks than you actually have, which would trick them into picking up more as well.

Relation to crisis management

No relation.

4. A collection of X colors is forbidden

Explanation

The player can only collect blocks of colors not contained in X. Others are forbidden. X can differ per player.

Group goals

1. Group goal which contains no colors in X.
2. Group goal which contains colors in X.

Environment choices

1. Any environment.

Conflict/Alignment between individual and group goal

When choosing group goal 1, regardless of environment, there is no conflict, as the player can pick up all the necessary colors. When choosing group goal 2, regardless of environment, there is a conflict, as the player can't pick up some necessary colors.

Conflict/Alignment between multiple instantiations of individual goal

Regardless of the group goal and environment choice the individual goal does not conflict with itself.

Conflict/Alignment between multiple instantiations of individual goal and group goal

There is no interaction effect for this individual goal.

Severity

This individual goal can have a very large performance impact when it results in the group goal not being finished. In other cases it has a smaller impact when other players have to be called over to collect a block that one player can't collect.

Integrated plan

For this individual goal, when a conflict occurs, it not possible to create an integrated plan to optimize performance while still reaching this individual goal.

Expected player behaviour

The player will only collect blocks with a color not contained in X and will tell others to pick up the rest.

Relation to crisis management

In the crisis management domain it is not the job of a police officer to rescue victims, therefore he will then wait for a paramedic to arrive.

5. A collection of X colors is obliged

Explanation

The player must collect blocks of colors contained in X when he is in the same room as them. X can differ per player.

Group goals

1. Group goal which contains only one color which is in X.
2. Group goal which contains multiple colors some of which are in X.
3. Group goal contains multiple color none of which are in X.

Environment choices

1. Environment in which only the colors located in the group goal are present.
2. Environment in which colors that are in X are located in rooms where other group goal colors are also present.

Conflict/Alignment between individual and group goal

When choosing group goal 1 and environment 1 there is no conflict, as there are no ordering problems. When choosing group goal 2 and environment 2 there is a conflict as ordering problems can occur by bringing back a color before it's necessary. This can make the group goal unreachable, if this specific block would be needed later on for the group goal. When choosing group goal 3 and environment 2 there is a similar conflict, however this does not make the group goal unreachable as the colors in X aren't needed for the group goal.

Conflict/Alignment between multiple instantiations of individual goal

Regardless of the group goal and the environment this individual goal does not conflict with itself.

Conflict/Alignment between multiple instantiations of individual goal and group goal

There is no interaction effect for this individual goal.

Severity

The performance impact depends on how many unnecessary blocks need to be cleared away before a group goal block can be picked up.

Integrated plan

For this individual goal, when a conflict occurs, it not possible to create an integrated plan to optimize performance while still reaching this individual goal.

Expected player behaviour

The player will pick up and dispose of blocks with color X before picking up other colors located in the same room.

Relation to crisis management

If a building contains a victim that isn't injured to such an extent that immediate assistance is needed, or if the victim was not expected to be there, he would not be a top priority for the team. However a single paramedic could still feel obliged to help this person and will do so.

6. A collection of X colors is forbidden and a collection of Y colors is obliged

Explanation

The player can only collect blocks of colors not contained in X. The player must collect blocks of colors contained in Y when he is in the same room as them. X and Y can differ per player.

Group goals

1. Group goal which contains no colors in X and contains only one color which is in Y.
2. Group goal which contains colors in X.
3. Group goal which contains multiple colors some of which are in Y.
4. Group goal contains multiple color none of which are in Y.

Environment choices

1. Environment in which only the color located in the group goal is present.
2. Environment in which colors which are in Y are located in rooms where other group goal colors are also present.

Conflict/Alignment between individual and group goal

When choosing group goal 1 and environment 1, there is no conflict. When choosing group goal 1 and environment 2, it will take longer to achieve the group goal, so there is a slight conflict. When choosing group goal 2 and any environment, there will always be a conflict as the player can't pick up some necessary blocks. When choosing group goal 3 and environment 2 there is a conflict as ordering problems can occur by bringing back a color before it's necessary. This can make the group goal unreachable. When choosing group goal 4 and environment 2 there is a similar conflict, however this does not make the group goal unreachable as the colors in X aren't needed for the group goal.

Conflict/Alignment between multiple instantiations of individual goal

Regardless of the group goal and the environment this individual goal does not conflict with itself.

Conflict/Alignment between multiple instantiations of individual goal and group goal

There is no interaction effect for this individual goal.

Severity

The performance impact depends on how many unnecessary blocks need to be cleared away before a group goal block can be picked up. It can also be very large when the group goal is unreachable due to some colors being forbidden.

Integrated plan

For this individual goal, when a conflict occurs, it not possible to create an integrated plan to optimize performance while still reaching this individual goal.

Expected player behaviour

The player will pick up and dispose of blocks with color Y before picking up other colors located in the same room. The player will also only collect blocks with a color not contained in X and will tell others to pick up the rest.

Relation to crisis management

This is a combination of the previous two.

7. Search all rooms

Explanation

The player has to enter all rooms. The player can choose to pick up blocks as well.

Group goals

1. Group goal with amount of blocks greater than the amount of rooms.
2. Group goal with amount of blocks smaller than the amount of rooms.

Environment choices

1. All rooms contain a block necessary for the group goal (which are not already present in another room).

2. Some rooms contain no necessary blocks for the group goal.

Conflict/Alignment between individual and group goal

When choosing group goal 1 and environment 1, there will be a necessity to search all rooms anyway so there is no conflict. When choosing any other combination, it can happen that this individual goal will result in unnecessary exploration, which is in conflict with the group goal.

Conflict/Alignment between multiple instantiations of individual goal

Regardless of the group goal and the environment choice this individual goal does not conflict with itself.

Conflict/Alignment between multiple instantiations of individual goal and group goal

When choosing group goal 1 and environment 1, players can stand in each other's way by searching rooms that others want to enter, which means there is an interaction conflict even though a single individual goal does not conflict with the group goal in this situation.

Severity

The performance impact becomes larger when more and more rooms are searched than are necessary to be searched. This effect becomes greater when more players have this individual goal.

Integrated plan

For this individual goal, when a conflict occurs, it is possible to create an integrated plan to optimize performance while still reaching this individual goal. This can be done by assigning the rooms in a certain order to all players to ensure that they don't bump into each other at times.

Expected player behaviour

The player will be conflicted with bringing a block back or continuing the exploration, as bringing a block back brings the group goal one step closer to completion before being able to finish this individual goal. He can ask others to pick up blocks instead, or first visit all rooms before achieving the group goal.

Relation to crisis management

It is conceivable that a fireman does not trust the information he gets from police officers due to them having a different perspective of the situation. In that case a fireman could decide to search all of the buildings regardless, just to make sure there aren't any victims left.

8. Don't enter a subset of rooms

Explanation
Some rooms are forbidden, the player can't enter them. This can differ per player with this individual goal.

Group goals

1. Any group goal.

Environment choices

1. Environment in which all group goal blocks are located in rooms that are not forbidden.
2. Environment in which some or all group goal blocks are located in rooms that are forbidden.

Conflict/Alignment between individual and group goal
When choosing group goal 1 and environment 1, the individual goal is actually beneficial for reaching the group goal as it prevents the player from searching rooms that he doesn't need to search. This means that the group goal will be reached faster than it would have without this individual goal. When choosing group goal 1 and environment 2, there is a conflict as the player can't enter some necessary rooms.

Conflict/Alignment between multiple instantiations of individual goal
Regardless of the group goal and the environment choice this individual goal does not conflict with itself.

Conflict/Alignment between multiple instantiations of individual goal and group goal
There is no interaction effect for this individual goal.

Severity
The performance impact can be very large if the group goal blocks are located in rooms that can't be entered.

Integrated plan
For this individual goal, when a conflict occurs, it is not possible to create an integrated plan to optimize performance while still reaching this individual goal.

Expected player behaviour
The player will only collect blocks that are located in rooms he can enter, he also only explores those rooms. He will probably request others to search the rooms he can't enter.

Relation to crisis management
A policeman or paramedic is not allowed to enter certain buildings, when the fire has not yet been extinguished. Only firemen are allowed to enter these then.

9. Find a specific X colored block

Explanation

The player needs to find a specific colored block by himself, he therefore has to be in the same room as that block at some point in time. Other players telling him where it is does not count as achieving this individual goal, as he still has to go to that room himself.

Group goals

1. Group goal which contains color X.
2. Group goal which does not contain color X.

Environment choices

1. Color X is located in a room in which other group goal blocks are located.
2. Color X is located in a room in which no group goal blocks are located.

Conflict/Alignment between individual and group goal

When choosing group goal 1 and any environment, there is no conflict as the player has to find color X anyway. When choosing group goal 2 and environment 1, there is no conflict because to reach the group goal the player will automatically find color X. When choosing group goal 2 and environment 2, there is a conflict as the player could have to do some longer searching to find color X.

Conflict/Alignment between multiple instantiations of individual goal

Regardless of the group goal and the environment choice this individual goal does not conflict with itself.

Conflict/Alignment between multiple instantiations of individual goal and group goal

When choosing group goal 1 and environment 1, players can stand in each other's way by searching rooms that others want to enter, which means there is an interaction conflict even though a single individual goal does not conflict with the group goal in this situation.

Severity

The performance impact is mostly small due to the player only needing to find one block that he is likely to find during his seach anyway.

Integrated plan

For this individual goal, when a conflict occurs, it is not possible to create an integrated plan to optimize performance while still reaching this individual goal.

Expected player behaviour
The player will first try to find the X-colored block before trying to reach the group goal.

Relation to crisis management
No relation.

10. Collect a wrong block on purpose

Explanation
The player needs to pick up and bring back a color that is not necessary to reach the group goal. He can also choose to bring a block back in the wrong order.

Group goals

1. Any group goal

Environment choices

1. Any environment

Conflict/Alignment between individual and group goal
Regardless of environment and group goal choice, this individual goal will always conflict with it. In extreme cases this could result in an unreachable group goal by bringing back a block in the wrong order, in the case that this block is necessary later on to reach the group goal.

Conflict/Alignment between multiple instantiations of individual goal
Regardless of the group goal and the environment choice this individual goal does not conflict with itself.

Conflict/Alignment between multiple instantiations of individual goal and group goal
There is no interaction effect for this individual goal.

Severity
The performance impact can be small or large depending on what block is brought back.

Integrated plan
For this individual goal, when a conflict occurs, it is not possible to create an integrated plan to optimize performance while still reaching this individual goal.

Expected player behaviour
The participant will first bring back a wrong block on purpose before finishing the group goal.

Relation to crisis management
No relation.

11. Collect some or only wrong blocks on purpose

Explanation
Mostly the same as the previous only the player needs to bring back more wrong blocks.

Group goals

1. Any group goal

Environment choices

1. Any environment

Conflict/Alignment between individual and group goal
Regardless of environment and group goal choice, this individual goal will always conflict with it. In extreme cases this could result in an unreachable group goal by bringing back a block in the wrong order. In comparison to the previous individual goal, this will have a higher chance of making the group goal unreachable as more errors must be made. In the case of collecting only wrong blocks this will ensure that the group goal is never reached.

Conflict/Alignment between multiple instantiations of individual goal
Regardless of the group goal and the environment choice this individual goal does not conflict with itself.

Conflict/Alignment between multiple instantiations of individual goal and group goal
There is no interaction effect for this individual goal.

Severity
The performance impact can be small or large depending on what blocks are brought back wrongly.

Integrated plan
For this individual goal, when a conflict occurs, it is not possible to create an integrated plan to optimize performance while still reaching this individual goal.

Expected player behaviour
The participant will first bring back a few wrong blocks on purpose before finishing the group goal. This time however other players should not denote this as a simple mistake as it happens too often for that.

Relation to crisis management
No relation.

12. Move X amount of blocks to other rooms

Explanation
The player needs to transfer a block to another room (not the Drop Zone), X amount of times. This room can be chosen by the player.

Group goals

1. Any group goal

Environment choices

1. Any environment

Conflict/Alignment between individual and group goal
Regardless of the group goal and environment choice, this individual goal will always conflict with it, because it will take some time to complete this individual goal.

Conflict/Alignment between multiple instantiations of individual goal
Regardless of the group goal and the environment choice this individual goal does not conflict with itself.

Conflict/Alignment between multiple instantiations of individual goal and group goal
There is no interaction effect for this individual goal.

Severity
The performance impact becomes greater when X is greater as more time needs to be taken to complete this individual goal.

Integrated plan
For this individual goal, when a conflict occurs, it is not possible to create an integrated plan to optimize performance while still reaching this individual goal.

Expected player behaviour
The player will first transfer blocks to other rooms X amount of times before trying to reach the group goal. What is important here is that he can either tell other players where he's brought the blocks or not, we suspect that a player will tell others where the block has been moved if he is aware that they need to have this knowledge. Depending on this it could take even longer for other players to try to relocate the blocks that have been moved.

Relation to crisis management

It could happen that there is a very injured person in a certain building, making a paramedic decide to not transfer him to the hospital immediately but first giving some medical aid in a building nearby. Another possibility is that the victim would need to be transfered to a helicopter that is stationed at a nearby building.

3.5.2 Final choice

Now that we have an extensive list of possible individual goals we can make a choice between them using the previously specified characteristics. Table 2 provides an overview of the properties of each proposed individual goal.

	Conflict type					
	Group goal	Individual goal	Interaction	Severity	Integration	Relation to CM
1	X	X		Large		
2		X		Large		X
3		X		Large		
4	X			Large		X
5	X			Varying		X
6	X			Varying		X
7	X		X	Varying	X	X
8	X			Large		X
9	X		X	Small	X	
10	X			Varying		
11	X			Varying		
12	X			Varying		X

Table 2: Properties of individual goals

From this table we can make a final choice on the scenarios that we are going to incorporate in the final game. The criteria we use for this are the following:

- A scenario should only contain one of the three types of conflict. This is done to not overwhelm the players of the game and for simplicity's sake.
- The game should be able to incorporate all three types of conflict, however keep each of them separate in one scenario.
- The severity of the conflict should be as large as possible in order to make the conflict more apparent to players.
- We also want a scenario in which a team can make an integrative plan to deal with the conflict instead of giving up their individual goals. Increasing awareness about a conflict should increase the chance of the team making such a plan.
- The individual goal should be related to the crisis management domain, which would allow expansion of this individual goal in a more realistic environment in the future. Also for this game it is good if it has some

relation with crisis management as it is intended for crisis management experts.

Now we can choose a scenario for each type of conflict.

Individual goal conflict For this type of conflict only three individual goal choices are possible, which are 1,2 and 3. However of these three only individual goal 2 has a relation with crisis management, making it the only possible choice. Therefore we can construct the following scenario for this type of conflict:

Group goal: Red,Yellow,Purple,Blue, Blue, Red

Individual goal: Collect the most blocks relevant for the mission

Environment:

The environment is chosen randomly as the configuration of blocks is not important for this type of conflict.

Room A1: Pink, Green
Room A2: Blue, Red
Room A3: Empty
Room B1: Red
Room B2: Yellow, Green, Blue
Room B3: Blue, Red
Room C1: Yellow, Red
Room C2: Blue, Blue
Room C3: White

Interaction conflict For this type of conflict only two individual goal choices are possible, which are individual goal 7 and 9. However as individual goal 9 has no relation with crisis management and in addition has a lower severity we can not choose it over individual goal 7. Therefore individual goal 7 will be used to represent this type of conflict with the following scenario:

Group goal: Red,Blue,Green,Yellow,Red,Red,Blue,Green,Yellow

Individual goal: Search all rooms

Environment:

The environment is now chosen in such a way that each room needs to be explored in order to find all necessary blocks, this means that there is no conflict when only one player does this, but an interaction conflict occurs when all players do this.

Room A1: Red
Room A2: Blue
Room A3: Green
Room B1: Yellow
Room B2: Red
Room B3: Red, Purple
Room C1: Blue
Room C2: Yellow, Pink
Room C3: Green, Purple, Pink

Group goal conflict For this type of conflict the most choices are possible, therefore we make this choice last. However when excluding all individual goals with no relation to crisis management 1,9,10 and 11 are not possible anymore.

If we also exclude individual goals which have already been chosen for the other conflict types, we only have a small list left. In this list any choice can be made as all have a potentially large severity level. Our choice is to use 8, with the following scenario:

Group goal: Red, Blue, Green, Red, Blue, Yellow

Individual goal: Don't enter some rooms

Player 1: A1, B2, C3

Player 2: A1, B1, C2

Player 3: A1, C2, B1

This configuration was chosen because there now is a room that no player can enter. This is used in combination with the blocks configuration to create a group goal conflict.

In the case of more players (3 is the minimum for a multi-party negotiation), these extra players can be given a subset of rooms as well.

Environment:

The environment is chosen in such a way that there is a necessary block in a room that no player can enter according to their individual goal, this creates an obvious conflict with the group goal as it become unreachable when no player drops their individual goal.

Room A1: Yellow

Room A2: Purple

Room A3: White

Room B1: Green, Blue

Room B2: Blue

Room B3: Red

Room C1: Red

Room C2: Red

Room C3: Pink

3.6 Negotiation Phase

A crisis management team needs to make decisions about the proper course of action. However as a crisis management team does not usually have a team leader, instead consisting of various individuals with differing roles with corresponding responsibilities and preferences, decisions are not easily made. This is because the various preferences amongst the team members do not necessarily align, and team members will usually only address their own goals and responsibilities. For example, in the case of a huge fire the police would want to evacuate civilians from the area to keep them safe, while the fire brigade does not want this as this would create panic. Therefore this decision-making process can be seen as multi-party negotiation containing multiple issues that are to be negotiated about [36]. The final outcome of this negotiation contains the plan of action for the crisis. As our game is intended for training crisis management experts, there will also be a negotiation phase before the game starts. In this negotiation phase the players will need to make a decision on how they are going to play the game, by taking into account their own individual goals as well as the group goal. This outcome will be given to the agents (which will be explained in Section 4.3), that will play the game based on this. This allows the players to see the direct effect of their negotiation outcome, and also prevents

players from changing their plans constantly during the game.

Negotiation Domain Agents cannot be programmed to handle negotiation outcomes with unforeseen issues, this is why we need to create a negotiation domain that is fixed. Therefore we need to have a list of issues that players will be allowed to negotiate about. This is also important for the future, as we also have plans to add agent players to the team who will also participate in the negotiation. If players are allowed to think of new negotiation issues this will not be possible as agents would not be able to negotiate about these. In order to determine the issues for this domain two small experiments were performed. The goal of these experiments was to first create a list of issues that were relevant for this domain in the first experiment, with the second experiment being intended for refining this new list of issues.

For the first experiment we had a group of three people in order to have a true multi-party negotiation, who were first given an explanation of the environment that the game would be played in as well as an explanation on the course of the experiment. As this was not intended for statistical significance, but more as an exploratory experiment, one group was thought to suffice. We prepared three scenarios for them to talk about, that are identical to the three scenarios given in Section 3.5.2. These scenarios therefore contained all three types of conflict. For each scenario the players were given their individual goal as well as the group goal of the game. After this the players were allowed to discuss freely about their plan of action. There was no negotiation protocol as we were only interested in the issues that would arise. This discussion was recorded and the recording was analyzed later on to decide what issues were discussed and which outcomes were reached. After the first scenario reached an outcome, we continued the same process for the second and third scenario. From this analysis we constructed a list of issues that was used for the second experiment. For the protocol used for this experiment see Appendix A.1.

For the second experiment we also used three people, to again have a multi-party negotiation. However instead of letting the players discuss freely, we gave them the list of issues that resulted from the previous experiment. In addition they were allowed to not discuss some issues on that list if they did not want to and they were also allowed to add new issues. The purpose of this second experiment was to refine the list of issues as much as possible before making a final choice. For the protocol used for this experiment see Appendix A.2.

The list of issues that was created after the first experiment did not need to be changed after the second experiment as no new issues were found. Therefore we could finalize our list of issues/values as the list that resulted from the first experiment, which was the following:

Information Sharing
Which type of information each player will send to other players when able to.
Values: A choice of none/some/all of the following:
Your location

Where you're going to
What blocks you've found in a room
The blocks you picked up
The blocks you dropped

Exploration Order
Which rooms are explored by each player in what order.
Values: For each player each room gets a number from 0-9 indicating the sequence in which they should be explored. Rooms that are designated 0 are not to be explored by that player. Different rooms can have the same value, this indicates that for that sequence number it doesn't matter which room is visited first.

Blocks
Which of the goal blocks are picked up by a certain player or are allowed to be picked up by all players.
Values: For each player a set of numbers which indicate the index of the blocks they are allowed to pick up for the group goal. Therefore the first block that the team should pick up should be indicated with the number 1. Multiple players can have the same index in their set meaning that they all are allowed to pick up that block when they've found it.

Wait until all individual goals have been reached?
Before returning the final block should that player wait until the other players have reached their goal.
Values: Yes or No

Allowed to enter rooms other than the ones you are supposed to explore?
Allowed to enter rooms other than the ones in the exploration list. Important when getting information on blocks located in rooms that other agents explore.
Values: Yes or No

Who drops individual goal?
Values:
No one
Player name

Random

We intend to allow for a partial negotiation outcome, meaning that it isn't necessary to come to an agreement for all issues. The agents will still be able to work with a partial outcome, however it can turn out that the game is not completable, for example when no agreement is reached on who enters what room. In that case the agents will not be able to explore rooms. The same holds for no agreement on what blocks should be picked up by what player.

3.7 Agent strategy

As mentioned in the previous section the actual game will be played by agents, after the players have finished their negotiation. The main reason for this is

that players can then see the direct result of their decision, as otherwise they would have the ability to not uphold the agreement. This however means that the agents should also not deviate from the negotiation outcome. Therefore the agents will only use the negotiation outcome in order to play the game, and will not deviate from this. At some points the agents can do some small reasoning with their individual goal, which mostly holds for the individual goal of exploring all rooms. However this is designed as to not deviate from the negotiation outcome.

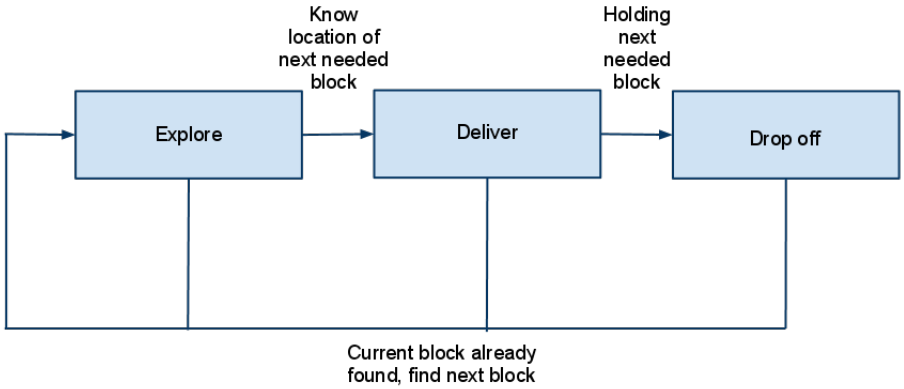


Figure 2: General strategy

The resulting agents that we created work with a general cycle of tasks that is adapted at certain points depending on what the negotiation outcome is and in very few cases depending on their individual goal. The general plan the agents follow can be seen in Figure 2, which shows three tasks that are performed in a cycle, which are the exploration, delivery and drop off tasks. In the next paragraphs we will go into detail about how the reasoning process of the agents works during these three tasks.

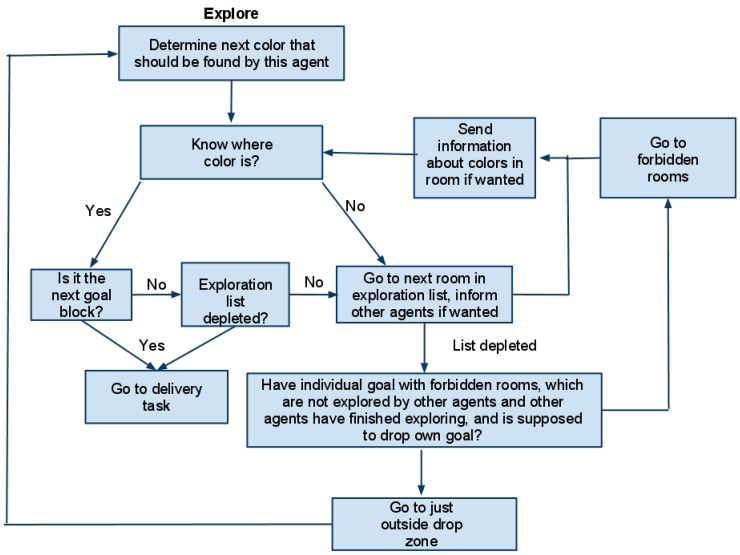


Figure 3: Exploration Strategy

A game starts with an exploration phase, which is shown in Figure 3, as the agents do not know at the start which blocks are contained in which rooms. In this exploration phase they try to find the next block that is needed. The agents will only use the exploration order defined by the players to find the next block they are supposed to collect. The agents start with the first subset of rooms (in random order when more than 1) and will continue to the second (and further) subset after these have been explored. When this list is depleted it will go wait in front of the drop zone as other agents could still send it information for that block. As can be seen in the figure an agent will not start to return a block earlier than needed which could result in it waiting in front of the drop zone until another agent returns an earlier block. This would be an unnecessary time waste and in this case the agent will explore the remaining rooms in its exploration list first.

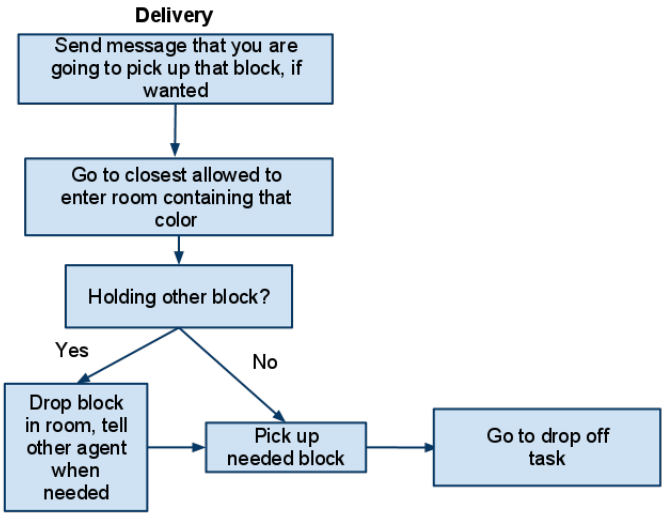


Figure 4: Delivery Strategy

After the exploration phase the agent will go through the delivery phase, which is shown in Figure 4. In this phase the agent will pick up the needed block from the room that is closest to its current location. Things that the agent takes into account for this decision are the issue of being able to enter other rooms than the ones in its exploration list as well as possible forbidden rooms that are indicated by its individual goal, which do not hold if the agent is supposed to drop its individual goal. It will also notify other agents that it is picking up this block when indicated in the negotiation outcome, the other agents will then try to find their respective next blocks. In the case that the agent is already holding another block it will drop it in the room, of which it will also notify other agents if necessary.

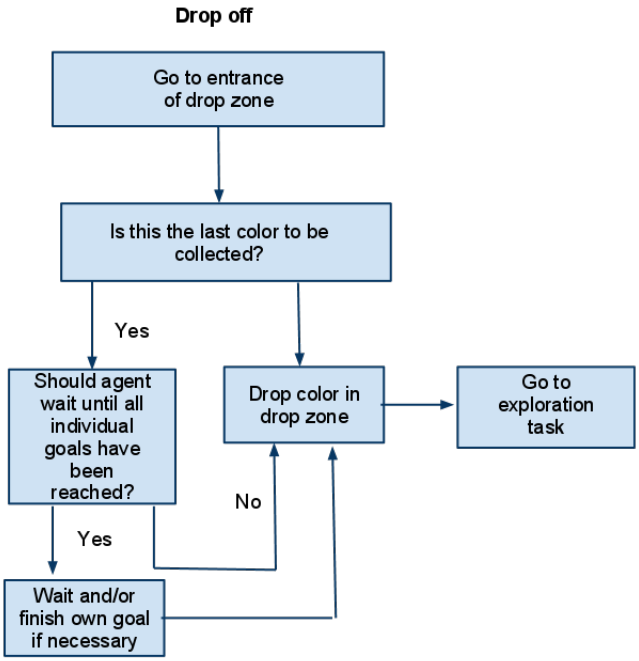


Figure 5: Drop Off Strategy

After the delivery phase the agent will move to the final phase which is the drop off phase, this phase is shown in Figure 5. In this phase the agent will drop off the block it is holding in the drop zone, a special case happens when this is the last needed block. In that case the negotiation issue of waiting until all individual goals have been reached can become important when set to Yes. The agent will then wait until other agents have finished their individual goals before dropping the block. In the case that the agent has the goal of exploring all rooms it can decide to finish this goal as well. This also depends on what agent is supposed to drop his goal, in this case the agent will not wait for that particular agent.

One thing hasn't been depicted in these pictures as it holds during all phases, which is that the agent will send its current location to other agents when specified in the negotiation outcome. Like this example, other communication is also done proactively as soon as possible when new information needs to be sent.

Another note is that the agent can be interrupted at all times during these tasks, which can happen by either the environment signalling that the current block has been dropped in the drop zone or by receiving a message from another agent telling that it is picking up a certain block. In these cases the agent will update what block it should be getting next and will then start at the exploration phase again.

3.8 Debriefing

The debriefing phase is intended to show players what the good and bad points were of the previous negotiation, what the performance of the resulting outcome was and how to possibly improve on the bad points in the next round. This is done by checking for certain behaviours during the negotiation which are then reported to the players, the checklist used for this can be found in Appendix E. This includes how many concessions were made by players during the negotiation, how many concessions were made on their individual goals, how cooperative they were with eachother and when they shared their individual goals to each other.

The players are also told how fast the agents completed the scenario and how this compares to the base line. This base line was created by doing some tests with an agent team that completed the scenario as quickly as possible while ignoring their individual goals. The base line results can be found in Appendix B. In the case that the resulting performance was not close to the optimal time, they are reprimanded in the name of the government (who gave them this assignment, as explained in an earlier section on priming).

At first the debriefing only contained a formal report of what happened during the negotiation, however two pilot experiments showed that the debriefing did not have a large effect on changing the behaviour of the players. Therefore we added the comparison with an optimal time in order to actually show players the difference and therefore encourage them to improve in the next round.

3.9 Priming

We wanted to find a way to prime participants into focusing on their individual goal in the first round. Because we want to train people in focusing more on the group goal, having them do it wrong in the first round would allow us to correct them on this in the debriefing phase which will be explained in a further section. From consultation with negotiation expert Mark van Gurp[1], we gathered three methods to prime participants. These were chosen because they are simple to implement, and could be effective according to the expert.

For the first method participants were instructed before the game to reach the best possible outcome. Mark van Gurp told us that most people would assume you want them to reach the best outcome for their individual goal instead of the group goal and would focus on reaching their individual goal as best as they can.

The second method that we used for priming, which is complimenting players for trying to reach their individual goal which is a form of positive reinforcement, was implemented using a training scenario, that each participant has to finish. They are given an individual goal of not entering all rooms except C1 and C2, and are told to collect a red block. They can then fill in a strategy after which the agent will play that scenario. When they manage to complete

[1] http://praction.nl/

their individual goal in this scenario, the game will compliment them on that.

The third method was creating a home front for the players that they would feel a connection to and in result would work hard to get the best possible result for this home front. This is also because they would then feel to not want to dissappoint the home front. This was implemented by assigning each participant to a fictional company which had to work with two other companies (the other participants) to complete a goal given by the government. They were told that their company also had its own goal that it wanted to achieve. This was also based on our consultation with the expert, as in real negotiations negotiators also usually have a company that they represent, that wants them to perform well in the negotiation on their behalf. By also creating such a feeling in the participants they would ideally also try to reach their individual goal more. This one was implemented after a pilot experiment suggesting that the first two methods weren't sufficient, as players still did not deem their individual goal as very important.

4 Implementation

In this chapter we will explain the implementation of our game. First of all we will discuss the existing Blocks World for Teams environment in Section 4.1. After this we will discuss the expansion we made to this environment in Section 4.2. Finally we will give an explanation on how the agents were implemented in Section 4.3.

4.1 Blocks World for Teams

The Blocks World for Teams (BW4T) environment is written in Java and uses a simulator (MobileSim) separate to the environment to control the robots. MobileSim[2] is software for simulating MobileRobots and their environments for debugging with the Advanced Robot Interface for Applications (ARIA) library[3]. Maps for this environment can be created using Mapper3. These maps contain only line data, meaning that they can only simulate walls and static obstacles, but not moving obstacles. The ARIA library or the ARNL library can be used to send navigation commands to a robot in the environment. It is also possible to do this from a remote client using the ArNetworking protocol. The BW4T environment only uses MobileSim to load a map (which only contains the rooms and hallways as can be seen in Figure 6), and to navigate the robot through this map using 2D points in a path. The location and rotation of the robot is sent back to the BW4T environment from the MobileSim environment continuously, that is used by the BW4T environment to update its own graphical representation of the map. This graphical representation is more extensive as it also contains the blocks and the group goal.

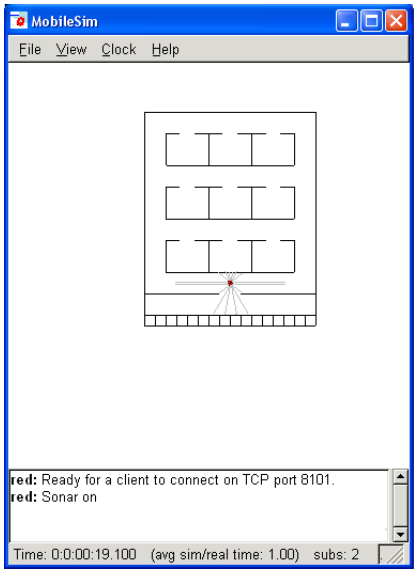


Figure 6: MobileSim environment

[2]http://robots.mobilerobots.com/wiki/MobileSim
[3]http://robots.mobilerobots.com/wiki/ARIA

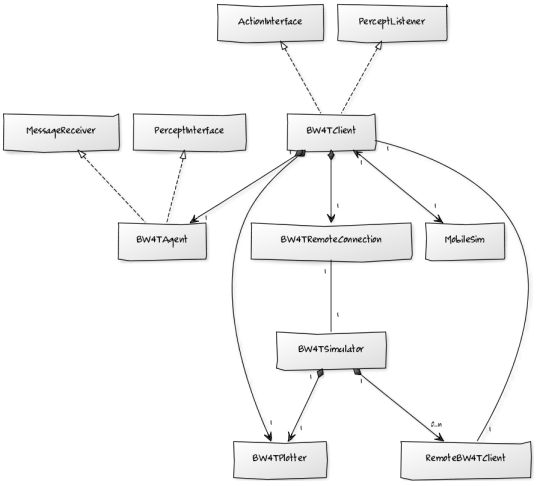


Figure 7: BW4T Class Diagram

A class diagram of the BW4T environment can be seen in Figure 7. The central point of BW4T is the BW4TSimulator, that acts as the server for the game. The server has its own GUI in which all players are visible. All players connect to this server with the BW4TClient which contains a BW4TRemoteConnection for this purpose, and get all the necessary information about the game when needed through the RemoteBW4TClient contained in the server. This server does not use MobileSim, this is only used by the BW4TClients which each load their own instantiation of MobileSim to navigate the robots and they update the server about the robot's location. The server uses this information to update the location of each robot in its own GUI. When a new client joins the game the server adds a new listener to its list of listeners. Information is received in the clients by implementing the PerceptListener interface, that can handle the following types of information:

- goal(ArrayList<Color> colors), this is used to distribute the global goal among all clients.
- goalIndex(Integer currentGoalIndex), this is used to distribute the index of the block that should now be searched for among all clients.
- player(String playerID), this used to notify all players about other clients that are playing the game as well.
- roomStatus(String roomID, String status), this is used to notify all clients of a room being either occupied or unoccupied.
- box(String boxID, Color color, Point2d position), this is used to inform a client of the blocks that are located in a room when the player connected to the client enters it.
- at(String boxId), this is used to inform a client that it is at a certain box, so it can be picked up.
- notAt(String boxId), this is used to inform a client that it is not at a certain box, so it can then not be picked up.

- holding(String boxId), this is used to inform a client that it is holding a certain block.
- notHolding(String boxId), this is used to inform a client that it is not holding a certain block.

Each client can use this information that it gets from the server to update its graphical representation of the environment. Normally a client is controlled by a human player which can be done using a pop-up menu which shows all the commands that the player can give the robot. However it is also possible to do this with an agent. Such an agent can perform the same actions as a human player which are defined in the ActionInterface. These are the following actions:

- goTo(String locationID), this is used to go to a certain room.
- stop(), this is used to stop the previous action from continuing.
- pickUp(), this is used to pick up a block when on it.
- putDown(), this is used to drop a block.

These actions are performed by the BW4TClient that contains the BW4TAgent. This client then forwards the specific action either to the MobileSim environment (which is only used for the goTo action) or to the BW4T simulator. These in turn give feedback on either a succesful or unsuccesful completion of the action, which is forwarded to the agent using the earlier described percept interfaces. The agent can then decide what its next step is.

This action interface also contains special commands that facilitate the sending of messages between the players. These are the following:

- sendMessage(String message), this sends a message to all other players.
- sendMessage(String receiver, String message), this sends a message to a certain receiver.
- receiveMessage(String sender, String message), this is used when a message has been received from a certain sender.

Because human-agent communication should also be possible the environment contains an enumeration of possible messages the players can send. This also prevents human players from sending information that an agent does not understand. In the case of sending a message from an agent to a human player, the messages are automatically converted to a natural sentence. Possible messages include giving information about where a player is, where he is going and which colors he has located in a certain room. It is also possible for players to request certain information from others, to which they can in turn respond.

As said before by continuously sending and receiving all this information the clients and the server can update their respective graphical representation of the game. This is done using the BW4TPlotter which reads in the map of the environment (this is the same map that is used by the MobileSim environment) and creates a graphical display of it. Artifacts can be added to this map, which includes blocks and robots. By updating the information about the game the

visibility of these blocks can be changed as well as the location of the robots. Each window also contains a representation of the global goal along with its completion rate. A chat box is also contained in each window, in which all received messages are displayed. A final note is that in the simulator window all players are shown as well as all the blocks, while in the client window only one player is shown, and only the blocks in the same room as him are shown.

4.2 Expansion with Individual Goals

In order to make the BW4T environment usable for our purposes, we needed to add new features to it. These features were added in such a way that the original environment was not changed, which in turn makes sure that later updates of the BW4T environment would not cause conflicts with our version. Our environment is therefore an extension of the original BW4T environment. A class diagram is shown in Figure 8, with new elements being show in green. Most of the elements are similar to the original BW4T environment, however below we will explain what features were added, and how we implemented these.

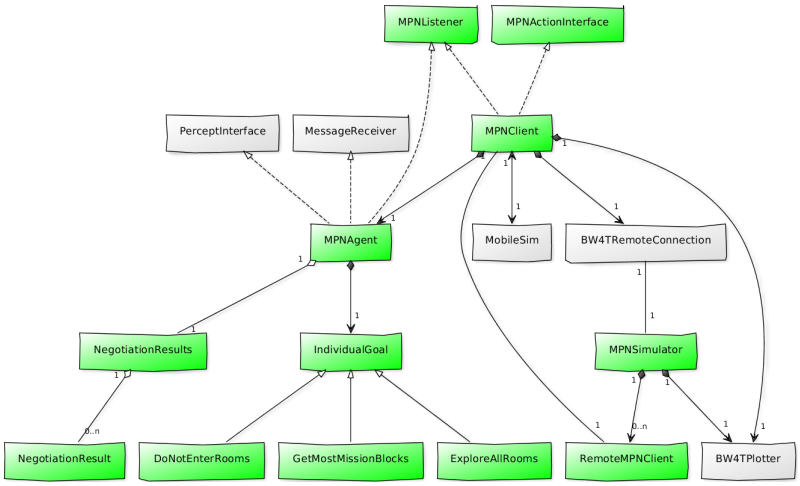


Figure 8: MPN Class Diagram

First of all each agent should have their own individual goal in addition to the global goal that all agents share. In order to accomplish this the scenario creation abilities of the BW4T environment also needed to be expanded. In the original environment a scenario could be defined by the following two properties:

- A collection of blocks, each with a certain color and location in the environment
- A list of colors, that represent the group goal

Our own scenario type was created to expand the existing scenario type, we added one new property which is the following:

- A mapping from each player to individual goal

The scenarios that we chose in Section 3.5 were included in our expansion. Figure 9 shows an example of a scenario in which the player has the individual goal to not enter some rooms. A general notion of an individual goal was implemented which was used to implement the three individual goals necessary for these scenarios. This was necessary as at some points the agent do need to know what individual goal they have. BW4T was also adapted so that these individual goals are sent to the correct player at the start of a game, as the original environment did not send different types of information about the scenario to different players. For this we created our own percept interface, which works similarly to the ones described in Section 4.1. This also means that when creating an agent for this expansion, you need to implement this percept interface in addition to the percept interfaces of the original BW4T environment, otherwise this agent will not be compatible with this expansion.

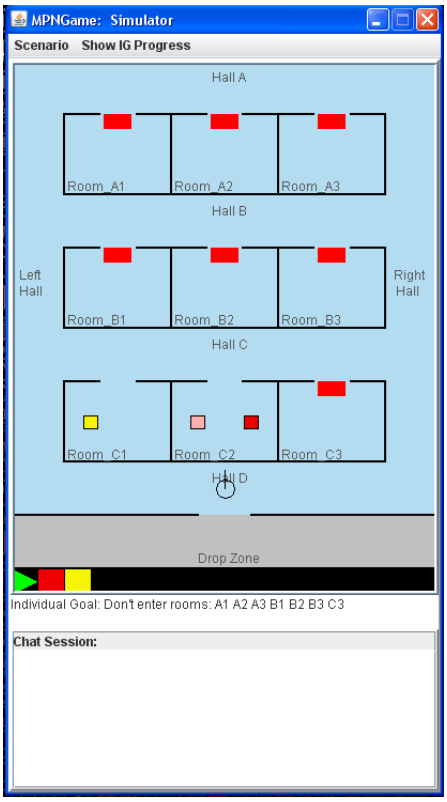


Figure 9: Training Scenario

Second we needed the possibility of inserting the negotiation outcome from the negotiation that players do before the agents start the simulation. This can now be done before the server is started, in the game manager. This game manager must be started first, after which all remote clients can connect to it. Each remote client has its own playerId, that is used to add a new settings tab to the game manager in which the negotiation outcome for that player can be filled in, which can be seen in Figure 10. There is also a general tab for the issues

for which the outcome is identical for each player, which can be seen in Figure 11. These tabs contain the settings for each negotiation issue that resulted from our experiment described in Section 3.6. After the partial/full outcome is filled in, the server can be started after which each client can be launched. In the server window, the scenario can be chosen after which the game will start. The negotiation outcome is then sent to all other players, and is contained in an instance of the NegotiationResults class.

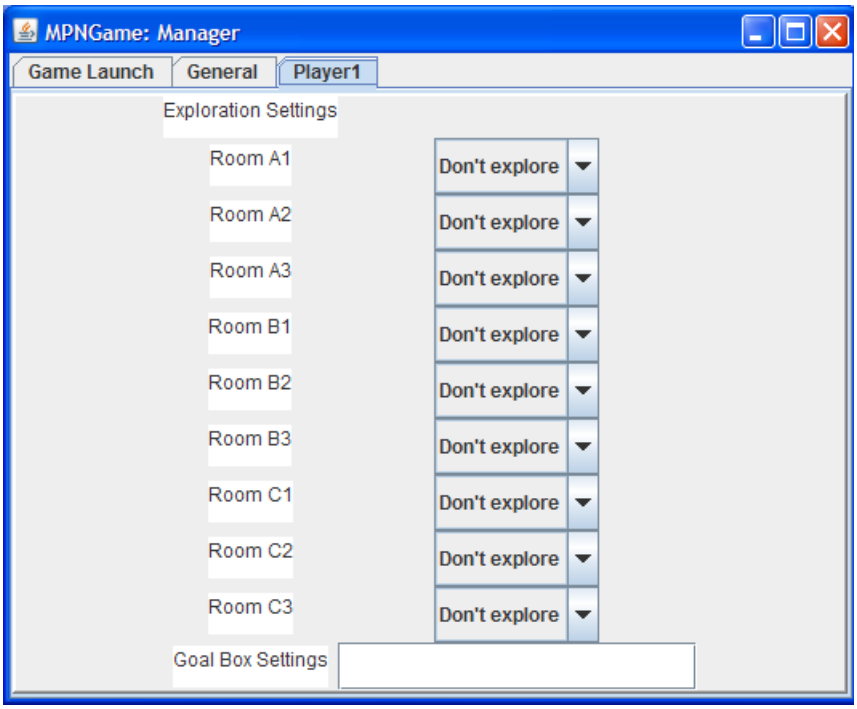


Figure 10: Player-specific Negotiation Settings

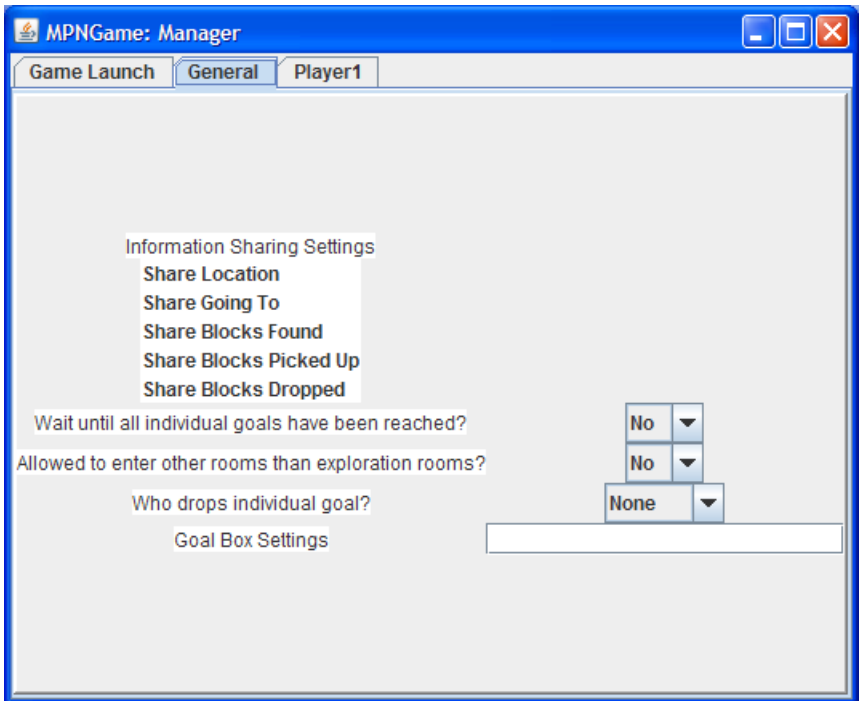


Figure 11: General Negotiation Settings

Finally the server and client windows were adapted so that they were able to show information about the individual goal of each player and their progress. In the original environment only the progress of the global goal was shown which was the same for each player. As it would be too crowded to show the progress of the individual goal for each player in the server window, users can now choose to show the individual goal of one player and can freely switch to other players. The progress is shown graphically in the environment as well as textually below the environment, which was shown in Figure 9. The progress of each player is updated dynamically at relevant points, i.e. entering a room, by the server. The clients work similarly however they only have the ability to show the progress of the player coupled to that client, they do not give information away about other players' progress. All this was done using methods already contained within the BW4TPlotter which therefore did not need to be adapted for this purpose.

A final expansion was the addition of logging necessary information with regards to the completion of individual goals as well as the group goal. The expansion keeps track of each player's progress as well as the team's progress and calculates the performance score at the end of a simulation and saves it to a log file when the simulator is closed. The team's progress is defined as the amount of seconds it took to complete the game. Player's progress is defined differently for each individual goal:

- Explore all rooms: (9-Amount of rooms explored)*100
- Get most mission blocks: 0 when reached, else 100 + 100*(Blocks collected by player that has collected most blocks - blocks collected by this player)

- Don't enter some rooms: 100*(Amount of rooms entered that were forbidden)

Care was taken to not maximize player's performance when they did manage to reach their individual goal partially, scores were also normalized to a three digits scale, mostly by multiplying with 100, in order to be more close to the group performance. This was all implemented in the MPNSimulator as it already tracked all necessary information for all players.

4.3 Implementation of Agents

The agents that are able to play our game were extended from existing agents that were able to play the game by themselves. The extension entailed adding the communication abilities which allow the agents to update their mental model of the environment and the other agents with information received from other agents. Sending information will allow the agent to alter the mental models of the other agents. This could mostly be done using the message interface already present in the BW4T environment, however one new message has been added to this interface which is a message that tells other players what block index (corresponding to the index in the group goal list) you are picking up next.

The mental models of the agents are implemented as data objects that contain the necessary information needed to perform the reasoning process. These are the following:

- Block locations, which is stored in an array for each room that contains the colors located in this room
- Explored rooms, which is stored by an array of the current index in the exploration list as well as the rooms corresponding to that index. When these rooms are explored the index is incremented.
- Next block to be picked up
- Negotiation outcome, which is stored using a separate outcome for each player name, in which each issue is filled in for each player.
- Individual goal
- Group goal

The reasoning of the agents was implemented using a method for each task as described in Section 3.7. These methods follow the same structure that was explained in that section, and can be interrupted at any time by the environment when a new block needs to be found. This has the effect of the agent restarting at the Explore task for this new block. When the game has been finished the environment notifies the agents of this, after which they will stop.

5 Experiment

In this section we will describe the experiment we performed using our training game. First we will give the goal of this experiment in Section 5.1. Then we will explain the experimental design in Section 5.2. After this we will present the measures that we used for this experiment in Section 5.3. Then we will close with the results of the experiment in Section 5.4 and a discussion of these results in Section 5.5.

5.1 Experiment Goal

The goal of the final experiment we held was to determine what the training effects were of various combinations of scenarios. The negotiation expert (Mark van Gurp[4]) that we consulted told us that we should not expect a large difference in performance between rounds, as our experiment will probably only alter the viewpoint of a participant but not their negotiation abilities. Therefore in the current state we should see the game as an experience for the participants in which we should ideally see some change in behavior in the second round reflecting the different viewpoint with which they take part in the negotiation. This different viewpoint will thus not necessarily lead to improved performance, but only increases the odds that participants starts a negotiation with this altered viewpoint in the future. In this experiment we also measure the amount of conflict in each round, in order to determine if particular scenario combinations (and conflict types) result in a different severity of conflict.

5.2 Experimental Design

The general structure of the game in this experiment is the same as in our game design. Players are first primed to focus on their individual goals. Then for each round the participants receive the group and individual goals, after which they are allowed to negotiate the issues for ten minutes. The agents play the game based on their outcome, and after this a debriefing is given.

As mentioned before we intended to test the effect of various combinations of different scenarios. For this experiment we used 3 scenarios, that are described in more detail in Appendix B. In order to keep the amount of combinations from growing too large we decided to do the experiment with 2 rounds. Therefore 6 combinations could be made, so the experiment was held with 6 groups with 3 participants each, creating a total of 18 participants. The groups are displayed in Table 3.

[4] http://praction.nl/

Group	Round 1	Round 2
1	Explore	Mixed
2	Mixed	Explore
3	Most Blocks	Mixed
4	Mixed	Most Blocks
5	Most Blocks	Explore
6	Explore	Most Blocks

Table 3: Experiment Groups

One of these three scenarios is a new scenario in which multiple individual goals were present. From earlier pilots we gathered that with each participant having the same goal they could quickly deduce what the individual goal the other participant have. Therefore a mixed scenario should be more interesting, while still retaining the same type of conflict. For the details on the configuration of this scenario we refer you to Appendix B. This scenario was exchanged with the scenario where every participant had the individual goal of not entering certain rooms, which was given in Section 3.5. This could be done as the same type of conflict (conflict with the global goal) was present in both scenarios. The full protocol used for the final experiment can be found in Appendix B. The instructions that were given to the participants can be found in Appendix C.

5.3 Measures

We want to measure three things in this experiment. First of all the performance of the groups in each round, which will be explained in Section 5.3.1. Second the change in behaviour of the participants between both rounds, which would show the effectiveness of our training. This was measured by observation and by questionnaire. Both will be explained in Section 5.3.2. The third is the amount of conflict as well as the conflict resolution performance that participants perceived during each round, which will be explained in Section 5.3.3.

5.3.1 Performance

We measure the performance of the agent team in each round, which is an example of an outcome measure [30]. If the behaviour of the participants changed this could indirectly influence the performance of the agents when compared to the base line result. The performance is defined as the amount of time (in seconds) to finish the game played by the agents. In the case that this game cannot be completed, the performance is maximized.

5.3.2 Change in behaviour

The change in behaviour is measured using two methods. The first method is a questionnaire which is given to the participants after both rounds of the experiments are finished. The questions are answered using a 5-Likert scale ranging from very little-very much. The questionnaire contains questions on their behaviour/viewpoint during the negotiation which are the following:

- How much concessions did you/your teammates make on individual/group goal
  These questions are asked to determine how much they felt they made concessions on each type of goal, if our training is effective we would expect a lower degree of concessions on the group goal in the second round in combination with a high degree of concessions on the individual goals.

- How much time was spent on discussing group/individual goal
  When participants shift focus from individual goal towards the group goal we would expect them to spend more time discussing the group goal and less on discussing their individual goals.

- How much did you try to reach individual/group goal
  Shifting focus from individual goal towards the group goal should show in participants trying more to reach the group goal instead of their individual goals.

- How important is individual/group goal
  This question should answer the current viewpoint of the participant on what goal is more important. We would expect an increase of importance attributed towards the group goal in the second round in combination with a decrease of the importance attributed towards their individual goals.

When a participant answers a question differently in the second round, this could indicate that our training had some effect on their behaviour. Finally the questionnaire contains open reflection questions that ask if they would have changed their behaviour in retrospect and why. The latter would also indicate that our training had some effect on their mindset. The reflection questions were added after the first pilot experiment in order to determine whether the mindset of players changed even if the second round did not see any change in behaviour. The questionnaire can be found in Appendix D

The third method is observing the negotiation, which checks for the same types of behaviour that are asked of the participants in the questionnaire. This is a similar method as proposed by [4]. The behaviour we check for are the following:

- Amount of disagreements
  This could then be compared with the perceived conflict of participants.

- How many of these were resolved
  This should indicate the conflict resolution performance

- When were individual goals shared
  Sharing their individual goals earlier is better as it would allow them to solve problems that arise collaboratively.

- How many concessions were made for the individual/group goal
  Same reasoning as for the questionnaire items, can also be used for comparison with those items.

- How much time was spent discussing the individual and group goals
  Same reasoning as for the questionnaire items, can also be used for comparison with those items.
- How do they sit
  From consultation with crisis management expert Willem van Santen[5] we added this item on how the participants sit during the negotiation, as this could also be used to determine how their attention towards the process changes depending on if this differs in the second round.

These behaviours are checked by analyzing videos of the negotiation, the complete checklist can be found in Appendix F with instructions on how to fill it in added to the experiment protocol in Appendix B.

5.3.3 Conflict

In order to measure perceived conflict the conflict questionnaire from [32] is used. Their definition of conflict is the following: "the interference by one individual or group in the attempts by another individual or group to achieve a goal". This definition is mostly equal to our definition of the achievement of one goal affecting the achievement performance of another goal negatively, therefore we deemed this questionnaire to be usable for our purposes.

Perceived conflict resolution performance is also measured using the conflict resolution questionnaire from [32], for the same reasons listed above.

5.4 Results

In this section we will give the results of the measurements of changes in behaviour as well as measurements on perceived conflict that were done during the experiment. The central tendency of the individual Likert items is displayed using the median result of all three participants in a group, after coding the results from 1 to 5 with 1 representing very little and 5 representing very much. Averaging the individual Likert items, which are ordinal data, was not done as this is only valid for interval data. The Likert scales for conflict and conflict resolution were averaged to come to a total result. We will not discuss everything in this section, instead highlighting important results, so for the complete list of results please see Appendix H and Appendix G.

5.4.1 Performance

In Figure 12, you can see the results for the time to complete the task for each group in each round. The graph shows result of the team in seconds subtracted with the base line result in seconds. In both cases where the time is 500, the game was not finished. Therefore in these cases the time is maximized. Taking this into account we see that only one group was close to the base line that we provided, even surpassing it. For the other groups we can see that in most cases there was an increase in time in the second round. It also seems that the explore scenario causes the highest difference in time, this is probably because in this

[5] http://peakandvalley.nl/

scenario all players have to search all the rooms which causes a large time delay with respect to the base line result.

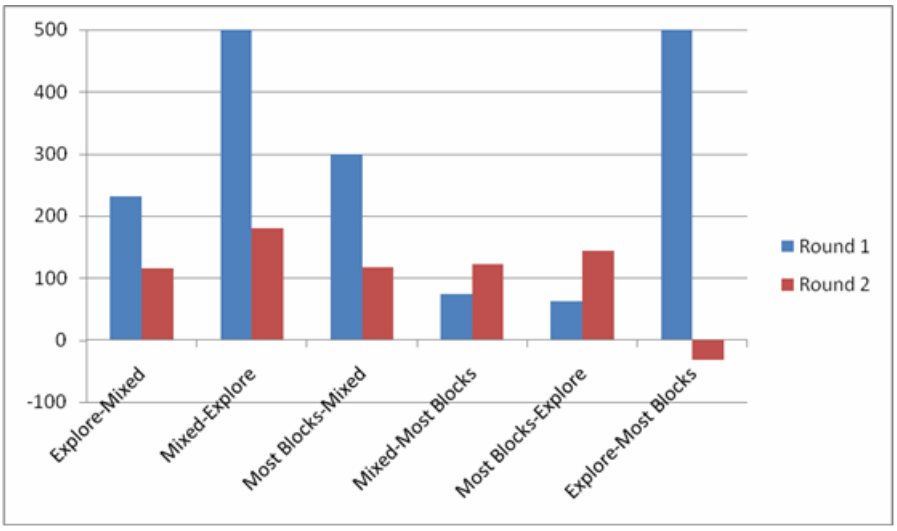


Figure 12: Performance

5.4.2 Change in behaviour

Concessions own goal In Figure 13 you can see the result for the amount of concessions that were made on participant's individual goal, as rated by themselves (Question 9). If our training is effective you would expect an increase in concessions made on the individual goals. We see this effect in group three and six as there was a dramatic increase in both as to the amount of concessions made. However a big decrease can be found in group five.

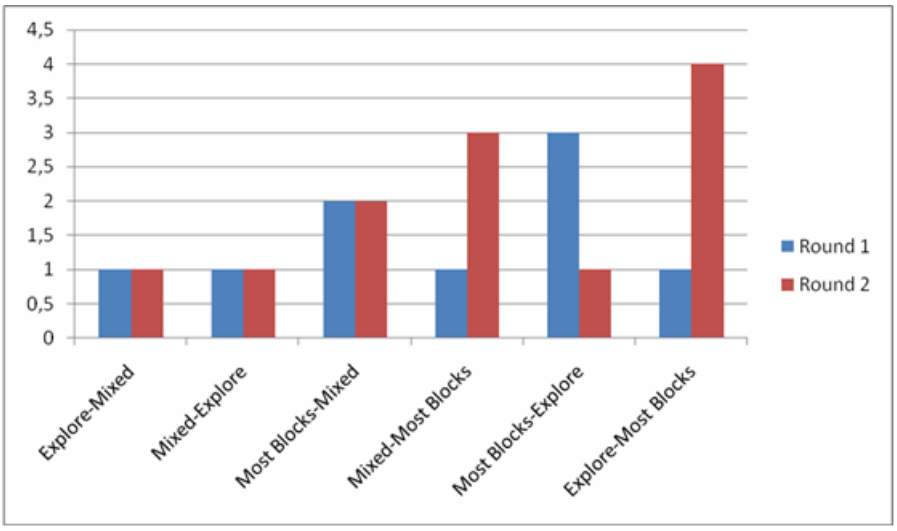


Figure 13: Perceived concessions own goal (self)

In Figure 14 you can see the result for the amount of concession participants felt that their teammates made on their individual goals (Question 10). The result is mostly similar to the concessions that they thought they made themselves.

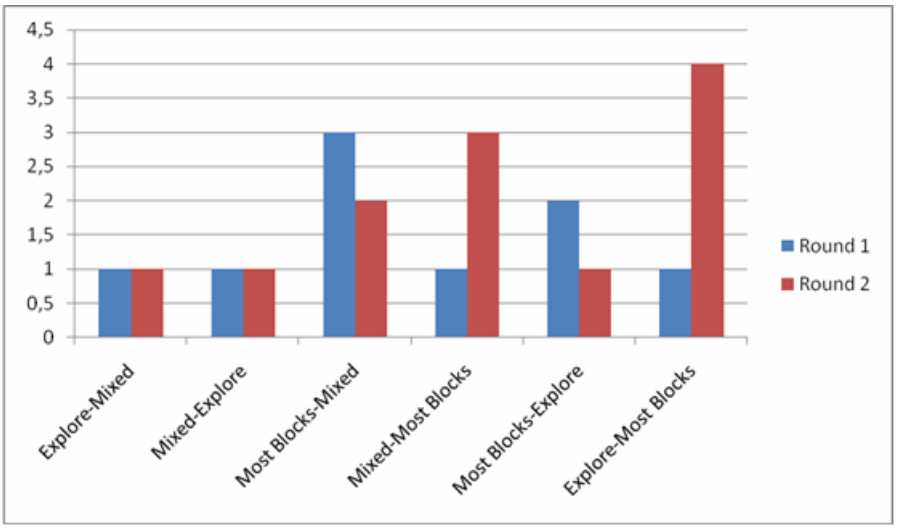


Figure 14: Perceived concessions own goal (teammates)

In Figure 15 you can see the amount of concessions made on the individual goals by the participants during the negotiations as was observed by us. Most groups made fewer or an equal amount of concessions, there were two groups that made more concessions on their individual goal in the second round. These are the same groups as in the previous section, namely the ones that ended with the most blocks scenario.

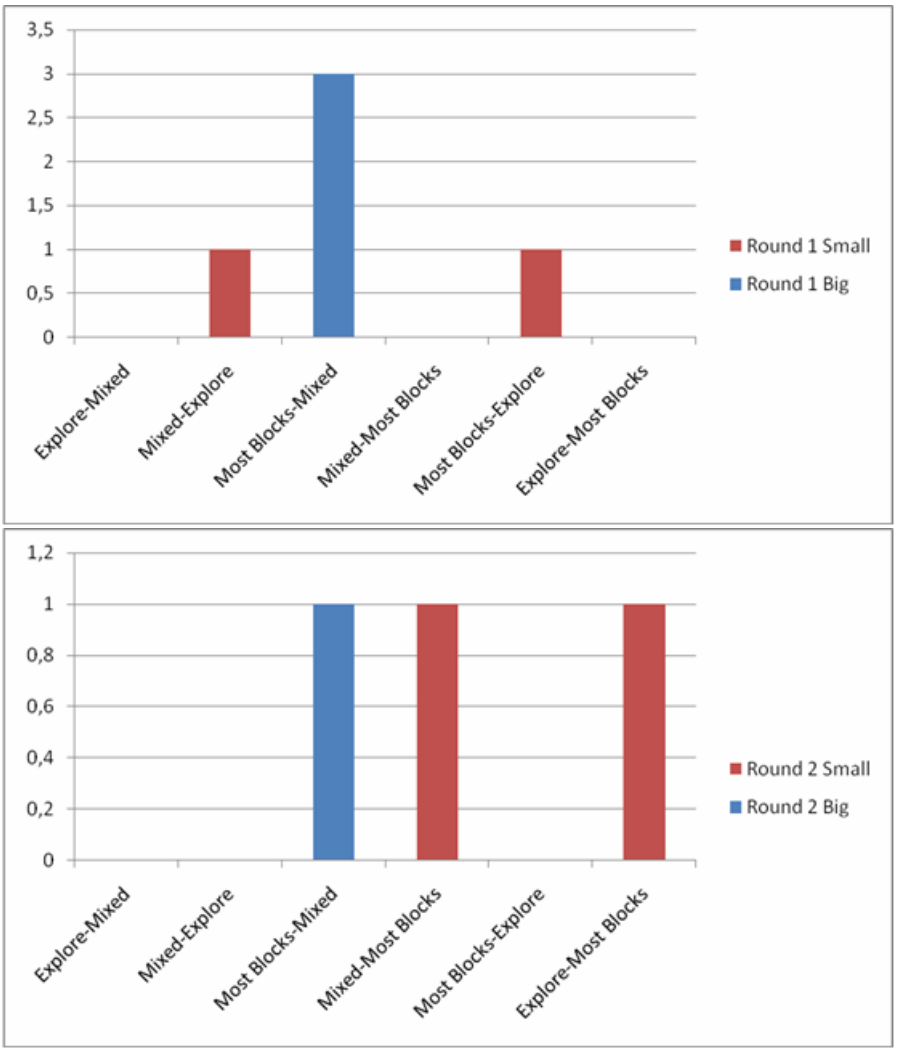


Figure 15: Observed concessions individual goal, round 1 (upper) and round 2 (lower)

When comparing the results for the questionnaire and our observation for the concessions made on the individual goals of participants, we see that they agree with each other. In both cases there were 2 groups that increased the amount of concessions on their individual goals in the second round. These were the groups with the Most Blocks scenario in the second round. As mentioned before this scenario forces participants to choose who reaches this individual goal. However both groups decided to leave this to chance and tried to optimize the group goal's performance, which is interesting as the result could also have been that no agreement is reached with each player trying to finish the game by themselves, as was seen during an earlier pilot experiment. This would indicate that they deemed the group goal as more important than their individual goal, which is what we want to achieve with this game. Another question is what effect the debriefing had on this, and whether the same result would have been

gotten if they were not debriefed on the first round. This could be answered by performing another experiment where some groups are not debriefed and comparing the results. A final note is that the reverse is true for groups that had Most Blocks as the first scenario, in these cases the amount of concessions decreased, however this decrease is smaller than the increase seen in the cases where Most Blocks was the second scenario.

Concessions group goal In Figure 16 you can see the results for the amount of concessions made on the group goal made by participants, as specified by them (Question 13). If our training is effective the concessions made on the group goal should decrease in the second round. We see that most of them are decreases, with one increase and 2 remaining equal. Most changes were little however in group 2 there was a big decrease.

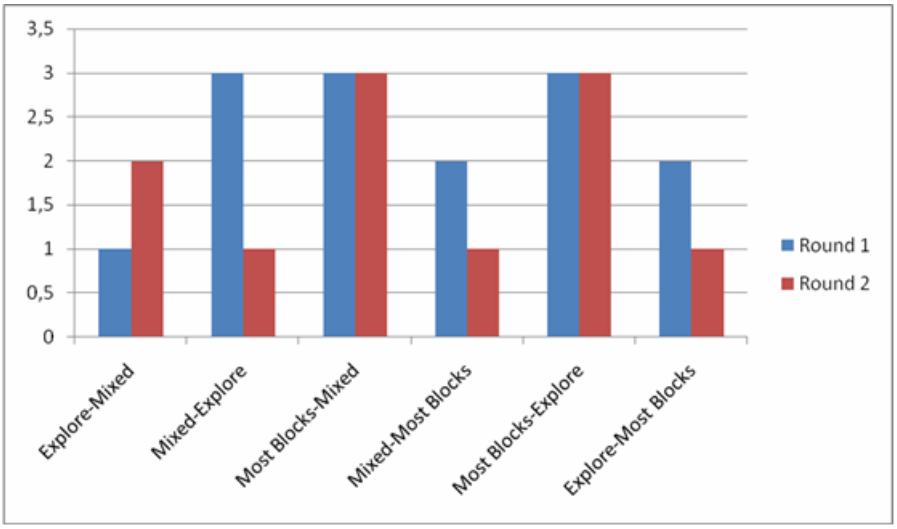


Figure 16: Perceived concessions group goal (self)

In Figure 17 you can see the results for the amount of concessions made on the group goal made by participants' teammates, as specified by them (Question 14). The results are mostly similar to the concessions that they felt they themselves made.

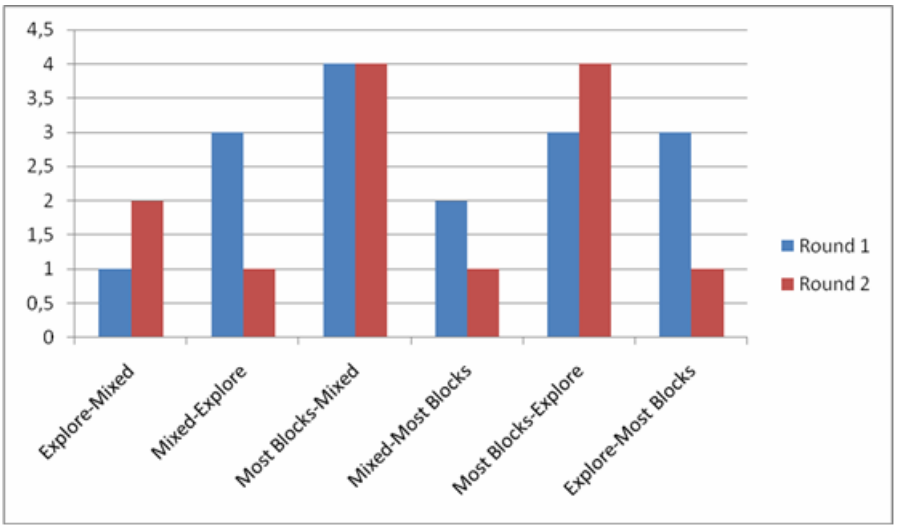


Figure 17: Perceived concessions group goal (Teammates)

In Figure 18 you can see the amount of big and small concessions that were made for the group goal during the negotiation for each round and group as observed by us. A few groups did not make more or fewer concessions in the second round when compared to the first. Some made more concessions on the group goal. However there were two groups that made fewer concessions on the group goal in the second round, of which one made no concessions on the group goal at all in the second round. These are the groups that ended with the most blocks scenario.

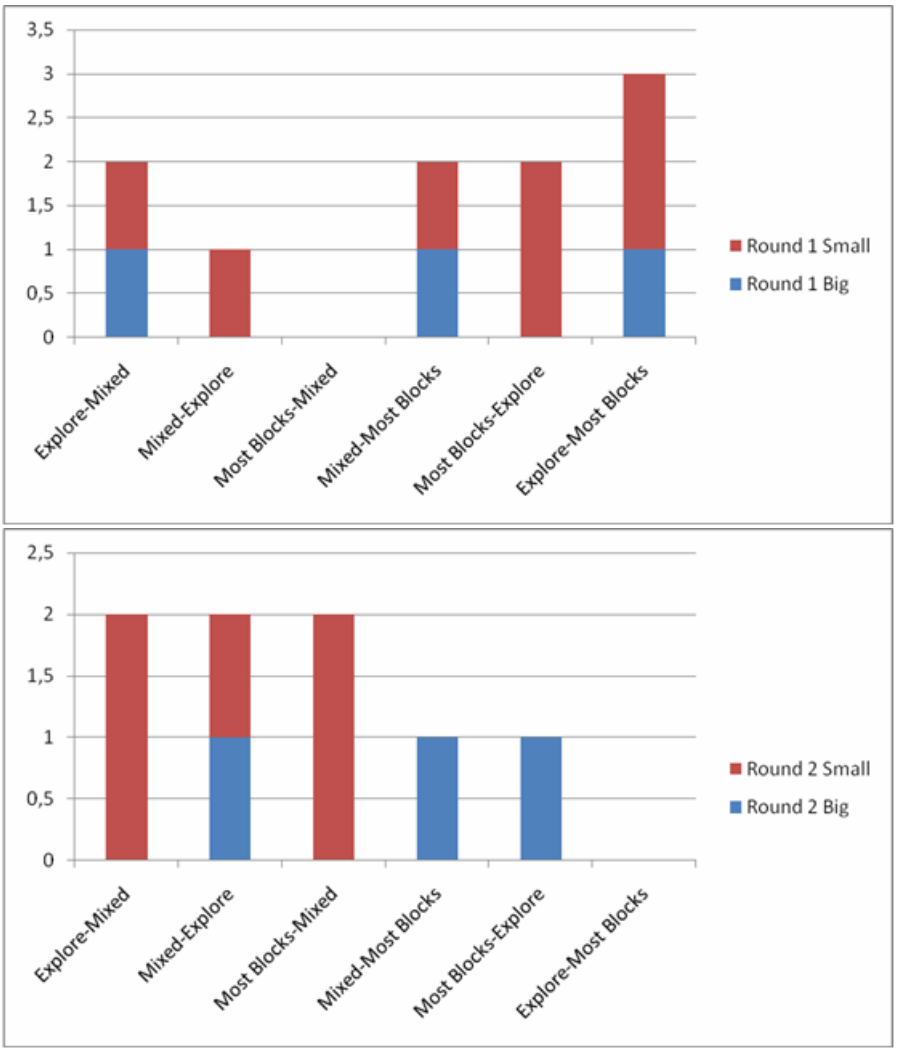


Figure 18: Observed concessions group goal, round 1 (upper) and round 2 (lower)

The observations we made mostly agree with the participants' perception. We can see that our training did seem to have the effect we expected in some of the groups. However one interesting result regarding concessions on the group goal is shown in the Mixed-Explore group. Their subjective results show a decrease in the amount of concessions while the objective measurement shows an increase. Therefore, for some reason, they valued the concessions made in the second round as lesser than the concessions made in the first round. An explanation for this could be that in the first round they did not manage to finish the game successfully, which would skew their opinion positively on the result of the second round in which it was finished successfully, however still a lot slower than the base line. In their eyes this would obviously still be a definite improvement on the first round.

Another interesting result is the first group as they perceived an increase in concessions made on the group goal while we observed a small decrease. This could have to do with their definition of a concession and its extremity.

Importance of goals In Figure 19 you can see the results for the importance of the various goals as specified by the participants for each group (Questions 8,12 and 17). If our training was effective the importance of the group goal should increase while the importance of the individual goals should decrease. Changes however were mostly minor except for the last group in which the importance of the individual goals dropped severely whereas the importance of the group goal increased greatly in the second round.

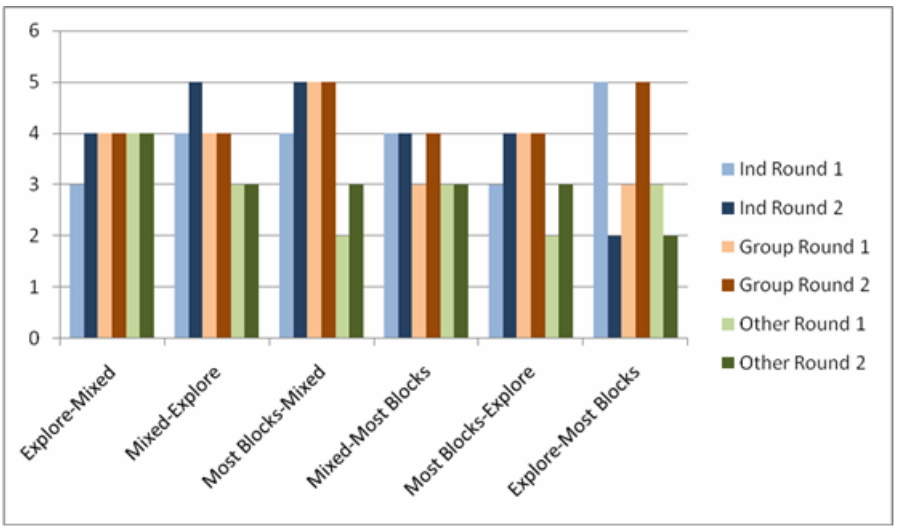


Figure 19: Importance of goals

Discussion group goal In Figure 20 you can see the amount of discussion participants felt there was on the group goal (Question 15). If our training is effective more time should be spent on the group goal in the second round, and less on the individual goals. In this experiment the biggest increase was seen in group 6, others showed either a small increase or decrease.

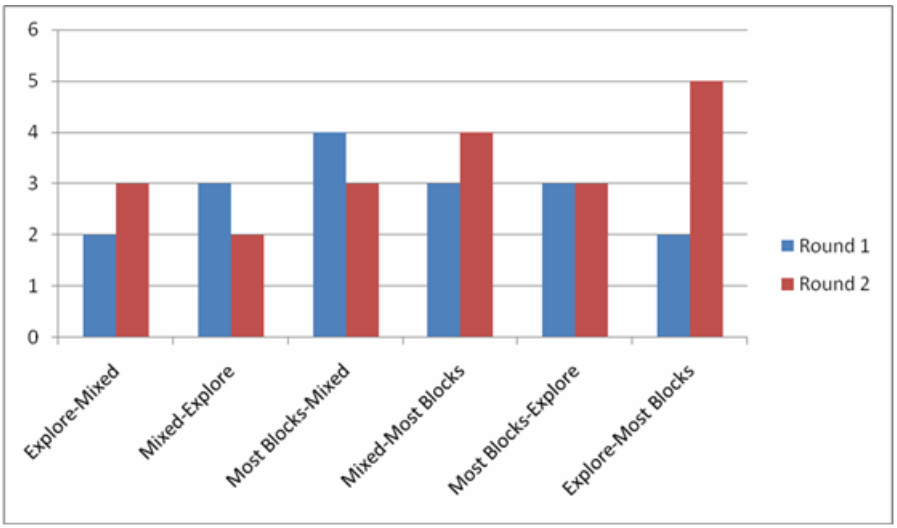


Figure 20: Perceived discussion group goal

In Figure 21 you can see the measurements we did on the discussion of the group goal. The figure displays the percentage of the total time (in seconds) that was spent on discussing the group goal. The result was a small decrease in most, with one dramatic decrease in the third group. There was also a big increase in group six.

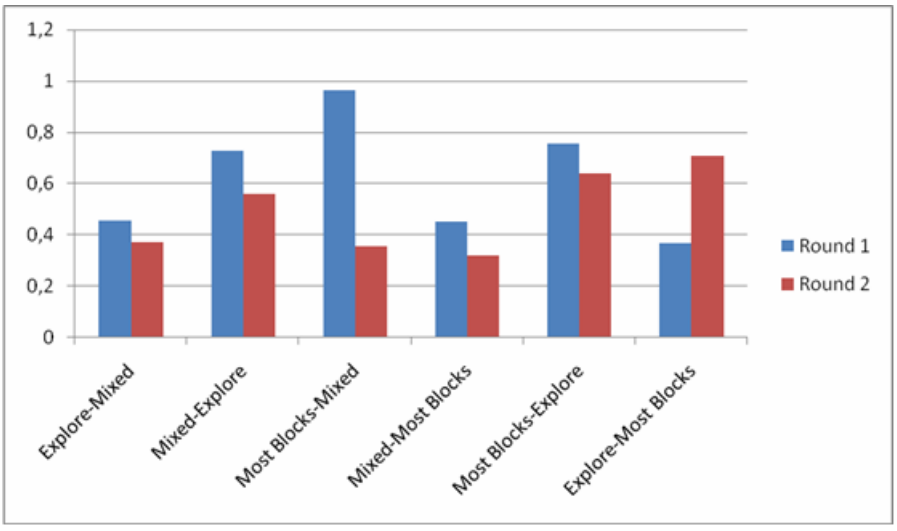


Figure 21: Observed discussion group goal

The results for the discussion of the group goal were not always consistent as some groups felt they discussed the group goal more in the second round than in the first, while objective measurements resulted in the opposite. A decrease is obviously expected combined with the fact that the time spent discussing the individual goals increased across the board. An explanation could be that

participants had a different vision on what constituted discussing the group goal and individual goal than we used in our objective measurement. However there was still one case in which both subjective and objective measurement agreed, which was the last group (Explore-Most Blocks).

Discussion individual goal In Figure 22 you can see the results for the amount of discussion on the individual goals (Question 18). If our training is effective this would decrease in the second round. This increased in most groups, with some groups displaying a bigger increase than others.

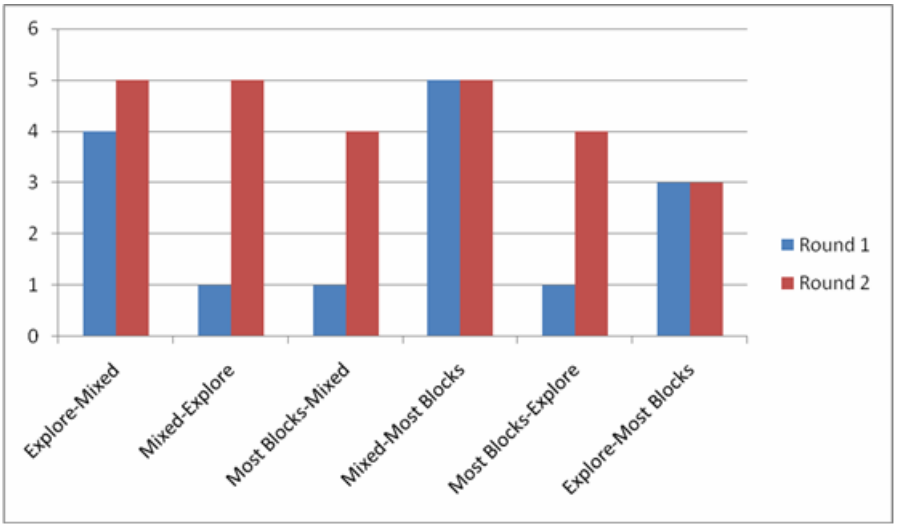


Figure 22: Perceived discussion individual goal

In Figure 23 you can see our measurement for the discussion of the individual goals, this figure shows the percentage of the total time (in seconds) that was spent on discussing the individual goals. This percentage increased in the second round for most groups, with two groups displaying a very large increase. However there was one group which showed a decrease in the second round.

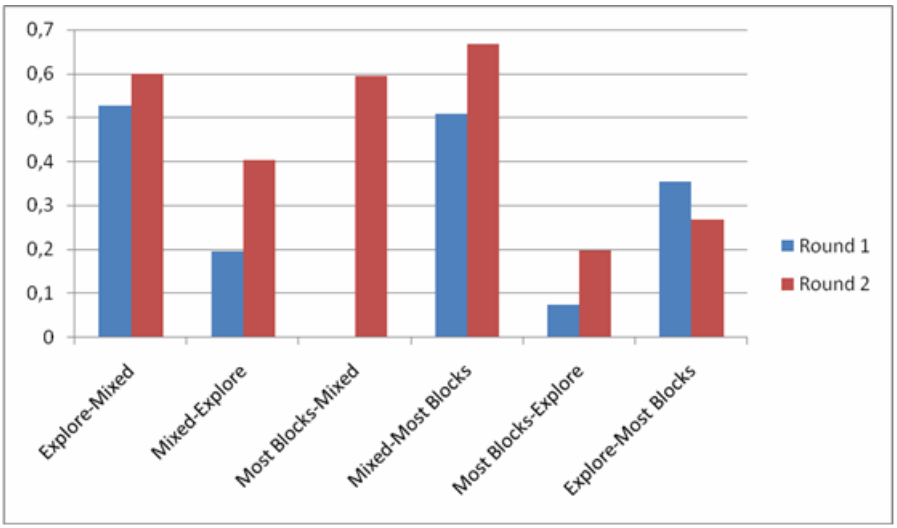


Figure 23: Observed discussion individual goal

Sharing individual goals Table 4 shows for each group and round at what point during the negotiation they shared their individual goals with each other. If our training is effective we would expect that this point would move forward in the second round as we advice them on this during the debriefing. For all groups that did not share their individual goals at the beginning, this point indeed moved forward in the second round with most of the groups sharing their individual goals at the beginning of the second round. Therefore in this case our training seemed to be effective independent of scenario choice.

This result can probably also be linked with the results for the amount of discussion done for the individual goals, as this increased both subjectively and objectively for most groups. Due to them sharing their individual goals earlier in the second round, the amount of time that can be used to discuss these also increases. A major question for us is then, what caused this? A hypothesis would be that the debriefing caused this change as they were told in our debriefing to share their individual goals earlier if they did not do this already, but to verify this another experiment would need to be done in which some groups continue to the second round without the debriefing.

Group	Round 1	Round 2
Explore-Mixed	At the beginning	At the beginning
Mixed-Explore	Not at all	At the beginning
Most Blocks-Mixed	Not at all	At the middle
Mixed-Most Blocks	At the middle	At the beginning
Most Blocks-Explore	Not at all	At the beginning
Explore-Most Blocks	At the middle	At the beginning

Table 4: Sharing Individual Goals

Reflection A lot of participants, in retrospect, decided that they would have changed their behaviour during the rounds, which is what we expected if our training showed to be effective. Most of the changes were related to finding a different strategy in order to complete the group goal quicker, as well as sharing the individual goals earlier when this was not done. However there were some participants who were satisfied with less than optimal results, because their individual goal was reached as well. They therefore did not find time delay more important than not (entirely) reaching their individual goal. For these participants perhaps another method to show the difference of importance of the individual and group goals could be found.

5.4.3 Conflict

Conflict In Figure 24 you can see the results for the amount of conflict that the participants noticed in each round of the experiment (Questions 1,2 and 3). The amount of perceived conflict increased for most groups, however four groups showed a bigger increase than others. Two of these were the groups that ended with the most blocks scenario, in which each player had to collect the most mission blocks. This scenario forces the participants to make a decision about who is going to reach this goal or if no one is going to. There is no way to enable all players to reach this goal which could generate more conflict than other scenario in which this is possible. However the other two groups that did not end with this scenario and also displayed a large increase in conflict. The first of these, the Most Blocks-Mixed group was probably caused by players not discussing their individual goal in the first round and therefore not having a lot of conflict in that round. The second, which was the Most Blocks-Explore group, was probably caused by the disagreement between two participants in the second round about what room division would be more optimal. This disagreement could regrettably not be solved within the negotiation time limit, which could make them perceive this conflict as worse.

The cause of the increase of perceived conflict does not seem to be related to a specific choice of scenario, but could perhaps be attributed to the increase of time spent towards discussing individual goals in the second round as it is the individual goals that cause the conflicts.

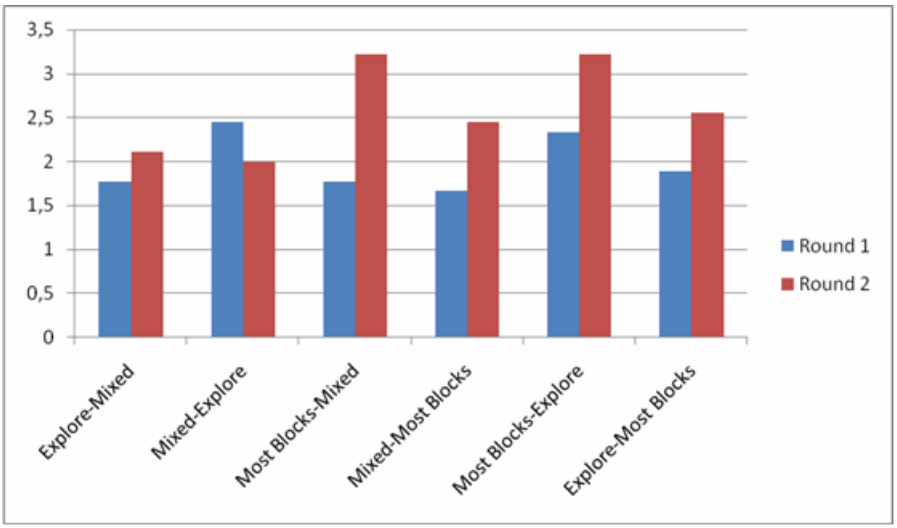


Figure 24: Perceived conflict

Conflict Resolution In Figure 25 you can see the results for the perceived conflict resolution for each round (Questions 4,5 and 6). There was only one group, the Explore-Most Blocks group, that showed a big increase in conflict resolution. The cause for this is probably that this group tried to optimize the speed of their plan in the second round while letting chance decide who of the group was going to reach his individual goal. By doing this they managed to get a performance that was better than our base line, which probably affected their score for this component. They also made an agreement in which chance would determine who would reach the individual goal. Other groups got similar results with one group, the Most Blocks-Explore group, showing a slightly bigger decrease which was probably caused by the unresolved disagreement mentioned in the previous paragraph.

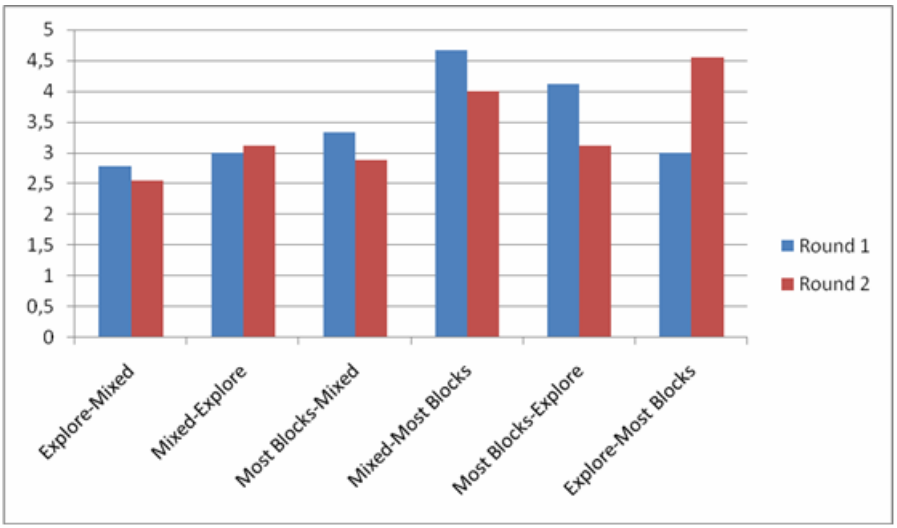


Figure 25: Perceived conflict Resolution

5.5 Discussion

Now we can check whether the resulting effects of the training have matched up with our expectations, and how much the choice of scenario was an influence on this. A result that matched our expectation was a change in behaviour that was measured amongst all groups in that they shared their individual goal earlier in the second round. The question that we want to answer then is whether this is an effect of our debriefing or whether these results would still be gotten without the debriefing. Both these questions could be answered by a further experiment in which the effects of the debriefing are measured against a control group without a debriefing phase. If the debriefing would then seem to have an actual effect then it would be useful to keep it in our game as the debriefing could actually be seen as our training.

As for the change in concession behaviour we saw that there were two groups that matched our expectations in both individual goal concessions and group goal concessions. These were the groups with the Most Blocks scenario in the second round. In one of these groups it also drastically changed the perception of the importance of the goals in the second round. This change in the participants is something that we wanted to achieve with our training game, however we need to know whether this is caused by the choice of scenario or by our debriefing. However as our debriefing was identical in for all groups the scenario would seem to be the most likely cause for this change.

So why did the training not change the behaviour as expected, in aspects other than the sharing of individual goals, of the participants in the second round when other scenarios were offered? There could also be some kind of combined effect of both debriefing and the Most Blocks scenario in the second round, which did not occur with other scenarios. Perhaps by explaining to them the importance of the group goal in the debriefing and after that giving them

a scenario in which not all individual goals can be reached is an incentive for players to focus on the group goal. The reflection questions for these groups also showed that they were pleased with the result, and did not mind that their individual goal was not reached entirely.

When looking at the reflection questions for other groups, these showed that some participants from other groups would change their behaviour in retrospect towards focusing more on the group goal and finding a strategy that would achieve it faster. So even in those groups, despite them not showing a change in behaviour, there seems to be a shift to a different viewpoint. It could be that when one more round was offered in addition to the two that we performed in our experiment, that a change in behaviour that would agree with our expectations would become more apparent. In the future perhaps some experiments should be done with three rounds in order to see whether this has more impact on the behaviour of participants.

As mentioned before for some participants the delay in completing the group goal was not important enough to (partly) drop their individual goal. For these participants the training did not seem to have an effect on their viewpoint. A possibility to solve this problem is changing the environment towards a more realistic crisis management simulation. This could alter the results of this experiment as it is conceivable that when placed in a situation where (virtual) lives are at stake, the behaviour of participants also changes. Because the environment we now use is fairly abstract it could be easier for participants to have a bad performance in the group goal, as only time is a factor and there is no real penalty except a reprimand during the debriefing. However as this game is intended for crisis management experts, we could still run into the problem of not being able to create a realistic enough environment. This could result in them being distracted by things that are not entirely as in real life.

Something that went against our expectations for most groups is that the amount of time spent discussing the individual goals increased in the second round , while we expected this to decrease when their viewpoint changed. The opposite was true for the amount of time spent discussing the group goal. This could be explained by the fact that participants shared their individual goals earlier in the second round in most groups. However the group that did share their individual goals at the beginning in the first round also did not see a large difference in time spent discussing them.

A final question is whether the training effects that we did notice for some groups will maintain themselves in the long term. To test this we propose another experiment in which various rounds are separated by a certain time interval, in order to see whether the change in behaviour remains over a longer period of time.

6 Conclusion

In this thesis we presented a training game intended for improving the crisis management decision making process. The crisis management decision making process can be seen as a multi-party multi-issue negotiation with each party having its own goal in addition to the group goal that all parties want to achieve. Currently each party focuses too much on its own goals instead of the group goal. Our game can be used to train crisis management experts in order to negotiate more collaboratively, and shift the focus on individual goals towards the group goal.

We expanded the Blocks World 4 Teams environment, to include individual goals in addition to the group goal that was already present. Several scenarios were created that each incorporated a different type of conflict. The game is played for multiple rounds, with each round containing a different scenario. Players are first primed to focus on their individual goals in the first round. At the start of a round players first negotiate about the plan of action using the negotiation domain we created. Agents will play the game based on the negotiation outcome after the negotiation has finished, this allows players to see the effects of their plan. When the agents have completed the game a debriefing is given to the players that summarizes their behaviour during the negotiation as well as compares their performance to the optimal result. This debriefing should then change the behaviour of players in the following round.

An experiment was held in order to test the effect of different scenario combinations on the behaviour of the participants. Three scenarios were used, all combinations of two made a total of 6 different combinations. Each combination was tested with one group of three participants. Behaviour was measured using a questionnaire, the performance of the agents as well as observing participant behaviour during the negotiation. Separate measurements were done on the amount of perceived conflict during the negotiations in each round.

A change in behaviour that was noted in all groups was that individual goals were shared earlier in the second round. More concessions seemed to be made when the Most Blocks scenario was chosen in the second round, however we can not say whether this is caused entirely by the debriefing or whether this is an inherent property of this scenario. Reflection on both rounds on part of some participants showed that, despite no big changes in behaviour in the second round, they would still change their behaviour in retrospect. Concludingly there seemed to be some changes in behaviour from the first round to the second round however questions that remain are how much all changes can be attributed to the debriefing or whether they are inherent to a certain choice of scenario. Another question is whether these changes actually maintain themselves in participants when more time has passed.

7 Future work

First of all further experiments should be done to determine what the causes were of the changes in behaviour that we noticed during our final experiment. We propose another experiment in which a control group, that is given no debriefing between rounds, is compared to the experiment group, that is given a debriefing between rounds. Using the same scenario combinations for both groups should show whether the debriefing adds a significant training effect. We should also consider using three rounds in this experiment, that could make a change in behaviour more apparent as some participants in our experiment mentioned they would change their behaviour in retrospect.

We should also test whether the training effect is maintained for a long term duration in participants and whether this change manifests itself in real life negotiations. Another experiment should be done to verify this, with participants being called back after some time period has passed and then being put into a more realistic crisis management negotiation. This should indicate whether the game actually improves the crisis management decision making process.

Knowing what effect the debriefing has on each scenario, an optimal combination of scenarios could be chosen after which the game could be finalized. Further research should then focus on automating more parts of the game. Most importantly we will investigate the use of automated negotiation agents that replace two of the team members, using the Genius environment [20]. This has multiple advantages, first of all only one human player will be needed to play the game, secondly these agents can be programmed to display different negotiation tactics like being very competitive or collaborative.

These agents could be programmed to support different personalities using an existing personality model. An example of such a model is the Big Five model [28, 16] which is a hierarchical organization of personality traits. These traits have been divided into five dimensions, which are Extraversion, Agreeableness, Conscientiousness, Neuroticism and Openness to Experience. To represent a certain personality each of these dimensions is given a value. For social interaction only two of these factors are necessary, namely Extraversion and Agreeableness [14].

Another popular model uses the different psychological types devised by Jung [25], to create different categories in which people can be grouped. This is the Myers-Briggs Type Indicator (MBTI) model. This model consists of four dichotomies which are:

- Extraversion/Introversion (E/I), which shows where energy flows from a person, where Extraversion types are more action oriented and want to interact with others frequently so energy flows outwards, while Introversion types tend to reflect more and prefer to work alone which means that energy flows inwards on them.
- Sensing/Intuition (S/N), which determines where a person gets their information from, where Sensing types tend to rely on facts only and do not want to make guesses, while Intuition types can use abstract plans

and are interested in future possibilities and use their own mind to create information.

- Thinking/Feeling (T/F), which determines how a person makes decisions, where Thinking types tend to make decisions based on rules or law, while Feeling types make decisions based on what is the best outcome or what is preferred by others or even on their instinct.

- Judgment/Perception (J/P), which shows how much structure people prefer in their live, where Judgment types are more systematical and tend to organize and plan frequently, while Perception types are more spontaneous and unsystematical.

An example that uses the MBTI model is described in Campos et al. [7], where an agent architecture was created that includes a personality model of the agent. In this architecture the personality model is used to determine how some processes are performed. All 4 dichotomies of the MBTI model can be included in it's configuration, where the authors give the example of Sensing type agents that will try to seek a concrete action to do, while Intuition type agents can try to find all possibilities for actions to take.

Another example by the same authors also uses the MBTI model, but only the Sensing/Intuition and Thinking/Feeling dichotomies [8]. In this example a small simulation was built in a firefighting environment where an agent has to decide whether to choose between two plans of action, where neither plan is is the best in the sense that in both plans things can go wrong in sich a way that the plan does not succeed. During the planning phase a Sensing agent will only commit to a concrete plan while a Intuition agent will commit itself to an abstract plan, meaning with some details not yet resolved, after which a concrete plan is made on-the-fly. Thinking agents will attribute their own beliefs to other agents, and Feeling agents will try to walk in another agent's shoes. The way that this was implemented in makes it possible to apply these agents in other situations, like what is possible for humans as well.

A final example that uses the Big Five model is the EMOTE system [3], where the animations of an avatar are influenced by the values that are given for each of the five factors in the Big Five model. This linkage was not verified for correctness yet though.

Another part of the game that could be automated is the debriefing which could also be given by a virtual avatar. This avatar could use emotions to display happiness at a favorable result and either sadness or angryness at a less than favorable result. This could enhance the training effect, however research should be done as to what emotion has the best effect on changing participant behaviour.

There were some elements that did not make in in our final game but that were considered at the beginning. The game could still be expanded to add these elements. The first of these is adding the possibility of helping behaviour as explained in Section 2.3.4, where one player requests another player to do a certain task for him after which the other player should decide whether to oblige or not. This mechanic could be used to allow players to help other players in

reaching their individual goal without sacrificing too much time. This could also need a broader negotiation domain that incorporates issues related to helping behaviour. Another mechanic that could be added is the possibility of hierarchical teams, that would allow the game to be applicable for team dynamics in these situations.

Finally in the future the game could be moved towards a more realistic crisis management environment. However a research question is whether this would have a better training effect than our more abstract game. We hypothetize that our abstract version would be better as crisis management experts could get distracted by errors in a crisis management simulation. Experiments should be done to see whether our hypothesis holds. For these experiments the individual goals that were used for our scenarios should be able to be translated towards a crisis management counterpart.

A Negotiation Experiment Protocol

A.1 Open negotiation

Participants:
Three players, as we are only interested in the topics that arise during the negotiation. As we also want a multi-party negotiation we need more than two players, therefore three players is our choice.
Protocol

Introduction
1. Each player reads the environment instructions
2. Each player reads the experiment instructions
3. Each player plays the warming up scenario of BW4T separately.

Scenario 1:
Global goal: Red,Blue,Green,Yellow,Red,Red,Blue,Green,Yellow
Individual goal: Search all rooms
Environment (will not be used during the experiment, as it is supposed to be unknown to the players):
Room A1: Red
Room A2: Blue
Room A3: Green
Room B1: Yellow
Room B2: Red
Room B3: Red, Purple
Room C1: Blue
Room C2: Yellow, Pink
Room C3: Green, Purple, Pink
1. Give each player the global goal
2. Give each player their individual goal separately, they don't know other's individual goal then.
3. Let them negotiate freely. We are only interested in the issues and their outcome, so the protocol is unimportant.
4. Note the issues that are discussed and write down the outcome

Scenario 2:
Global goal: Red,Yellow,Purple,Blue, Blue, Red
Individual goal: Collect the most blocks relevant for the mission
Environment (will not be used during the experiment, as it is supposed to be unknown to the players):
Room A1: Pink, Green
Room A2: Blue, Red
Room A3: Empty
Room B1: Red
Room B2: Yellow, Green, Blue
Room B3: Blue, Red
Room C1: Yellow, Red
Room C2: Blue, Blue
Room C3: White

1. Give each player the global goal
2. Give each player their individual goal separately, they don't know other's individual goal then.
3. Let them negotiate freely. We are only interested in the issues and their outcome, so the protocol is unimportant.
4. Note the issues that are discussed and write down the outcome

Scenario 3:
Global goal: Red, Blue, Green, Red, Blue, Yellow
Individual goal: Don't enter some rooms (player 1: A1, B2, C3, player 2: A1, B1, C2, player 3: A1, C2, B1)
Environment (will not be used during the experiment, as it is supposed to be unknown to the players):
Room A1: Yellow
Room A2: Purple
Room A3: White
Room B1: Green, Blue
Room B2: Blue
Room B3: Red
Room C1: Red
Room C2: Red
Room C3: Pink
1. Give each player the global goal
2. Give each player their individual goal separately, they don't know other's individual goal then.
3. Let them negotiate freely. We are only interested in the issues and their outcome, so the protocol is unimportant.
4. Note the issues that are discussed and write down the outcome

Documents for players

Instructions:

1. Environment instructions
The BW4T environment consists of 9 rooms in a 3x3 grid, which are connected by several hallways. A special room called the drop zone is also located in this environment. A player can move freely to any room as long as the room is not occupied by another player, in this case he will need to wait until the other player has left the room before being able to enter it. The rooms can contain blocks in various colors which can be picked up and dropped at another location. The goal of a game instance is to retrieve specific colored blocks in a certain order from their respective rooms to the drop zone, this goal is called the global goal of the game. Each player gets his own window in which he can only see his own avatar and the blocks that are located in the room that the avatar occupies. Other players are therefore invisible. A player has the possibility of sharing information with others however. In addition to this global goal (collecting certain blocks in a certain order) each player also has an individual goal that he wants to achieve. This individual goal must however be completed before the global goal is, as the game is over when the global goal is completed.
2. Experiment instructions

The experiment is done to determine what topics are important to discuss before the game starts, the outcomes of your negotiation will be used to determine this. The experiment will consist of three scenarios. You will negotiate about each scenario in sequence. Before the negotiation starts each player will receive the global goal of the scenario as well as their individual goal. An important thing to note is that you don't have any knowledge about which blocks are located in what room yet. Your individual goal is unknown to the other players. After you've obtained this information you can discuss with each other how you are going to play the game. During this discussion you are free to discuss any topic you like. After you have finished we will write down the outcome and the next scenario will begin using the same process.

A.2 Closed negotiation

Participants
Three players, as we are only interested in the topics that arise during the negotiation. As we also want a multi-party negotiation we need more than two players, therefore three players is our choice.

Protocol

Introduction
1. Each player reads the environment instructions
2. Each player reads the experiment instructions
3. Each player plays the warming up scenario of BW4T separately.

Scenario 1:
Global goal: Red,Blue,Green,Yellow,Red,Red,Blue,Green,Yellow
Individual goal: Search all rooms
Environment (will not be used during the experiment, as it is supposed to be unknown to the players):
Room A1: Red
Room A2: Blue
Room A3: Green
Room B1: Yellow
Room B2: Red
Room B3: Red, Purple
Room C1: Blue
Room C2: Yellow, Pink
Room C3: Green, Purple, Pink
1. Give each player the global goal
2. Give each player their individual goal separately, they don't know other's individual goal then.
3. Let them negotiate freely about the topics that are given, and let them add new ones if they want to. We are only interested in the issues and their outcome, so the protocol is unimportant.
4. Note the issues that are discussed/not discussed and write down the outcome

Scenario 2:

Global goal: Red,Yellow,Purple,Blue, Blue, Red
Individual goal: Collect the most blocks relevant for the mission
Environment (will not be used during the experiment, as it is supposed to be unknown to the players):
Room A1: Pink, Green
Room A2: Blue, Red
Room A3: Empty
Room B1: Red
Room B2: Yellow, Green, Blue
Room B3: Blue, Red
Room C1: Yellow, Red
Room C2: Blue, Blue
Room C3: White
1. Give each player the global goal
2. Give each player their individual goal separately, they don't know other's individual goal then.
3. Let them negotiate freely about the topics that are given, and let them add new ones if they want to. We are only interested in the issues and their outcome, so the protocol is unimportant.
4. Note the issues that are discussed/not discussed and write down the outcome

Scenario 3:
Global goal: Red, Blue, Green, Red, Blue, Yellow
Individual goal: Don't enter some rooms (player 1: A1, B2, C3, player 2: A1, B1, C2, player 3: A1, C2, B1)
Environment (will not be used during the experiment, as it is supposed to be unknown to the players):
Room A1: Yellow
Room A2: Purple
Room A3: White
Room B1: Green, Blue
Room B2: Blue
Room B3: Red
Room C1: Red
Room C2: Red
Room C3: Pink
1. Give each player the global goal
2. Give each player their individual goal separately, they don't know other's individual goal then.
3. Let them negotiate freely about the topics that are given, and let them add new ones if they want to. We are only interested in the issues and their outcome, so the protocol is unimportant.
4. Note the issues that are discussed/not discussed and write down the outcome

Documents for players

Instructions

1. Environment instructions

The BW4T environment consists of 9 rooms in a 3x3 grid, which are connected by several hallways. A special room called the drop zone is also located in this environment. A player can move freely to any room as long as the room is not occupied by another player, in this case he will need to wait until the other player has left the room before being able to enter it.
The rooms can contain blocks in various colors which can be picked up and dropped at another location. The goal of a game instance is to retrieve specific colored blocks in a certain order from their respective rooms to the drop zone, this goal is called the global goal of the game. Each player gets his own window in which he can only see his own avatar and the blocks that are located in the room that the avatar occupies. Other players are therefore invisible. A player has the possibility of sharing information with others however. In addition to this global goal (collecting certain blocks in a certain order) each player also has an individual goal that he wants to achieve. This individual goal must however be completed before the global goal is, as the game is over when the global goal is completed.

2. Experiment instructions
The experiment is done to determine what topics are important to discuss before the game starts, the outcomes of your negotiation will be used to determine this. The experiment will consist of three scenarios. You will negotiate about each scenario in sequence. Before the negotiation starts each player will receive the global goal of the scenario as well as their individual goal. An important thing to note is that you don't have any knowledge about which blocks are located in what room yet. Your individual goal is unknown to the other players. After you've obtained this information you can discuss with each other how you are going to play the game. A list of topics to negotiate about will be provided, you can choose to leave topics out or add new ones however. You can choose the order in which you go through the given topics. After the negotiation is finished the next scenario will be given and the process will be repeated.

3. Negotiation Issues

1. What information do you share?
2. Who explore which rooms and in what order?
3. Who picks up what blocks?
4. Wait until all individual goals have been reached?
5. Allowed to enter rooms other than the ones you are supposed to explore?
6. Who drops their individual goal?

B Experiment Protocol

Participants

3 per group with 6 groups total

Equipment

- Four computers with the MPN-Game installed on them, set up in a square so players can't see other screens.
- Camera
- Stopwatch
- Pen (3x)
- Experiment Instructions (3x)
- Consent Form (3x)
- Negotiation Outcome Form (2x)
- Questionnaire (6x)
- Document containing player goals per scenario (1x)
- Behaviour Checklist (2x)

Preparation

Before the experiment starts the three computers belonging to the players should have the training program running. The computer belonging to the experimenter should have the game manager running.

Introduction phase

Type	Actions
Participants	Reading instructions Signing consent form Filling in strategy for training scenario Watching result of strategy
Experimenter	Handing out instructions and consent forms Explaining training scenario Starting training scenario when participant has filled in strategy

In this phase the players will get to know the MPN environment as well as the setup of the experiment. First of all we give the players instructions for the experiment, and an explanation of the MPN environment and how the agents in it will work. They will also be given a consent form which they must sign.

After this a small training session will be held in which each player plays the game individually. The experimenter must explain to the participants that they

can fill in their orders for the agent for this scenario, in which they need to find a red block, while having an individual goal of not entering all rooms but C1 and C2. In this case the needed block is in room C1 or C2. This scenario was chosen because it should not take much time to complete it while still showing the participant how everything works. When they've filled in their strategy in the form that is contained in the program, the experimenter can start the training scenario, in which the participant can watch their agent. This also allows them to become familiar with the workings of the agent as well as the issues that should be discussed in the later phases of the experiment. After this training is completed the players will be complimented on their result when they've managed to achieve the individual goal, with the aim of them subconsciously focusing on their own goal afterwards. This will be done by displaying the sentence: "You've achieved both goals, good job!" if the individual goal has been reached when the training mission is completed.

Experiment phase

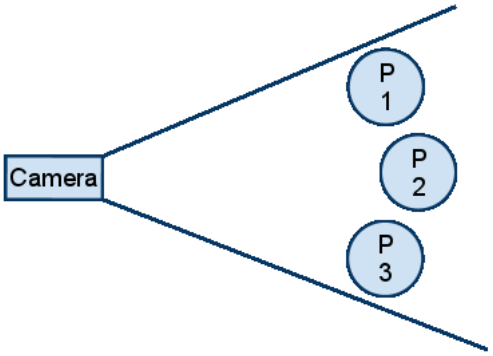
This phase consists of two rounds, which will be played in order. For each round the experiment will go through the following phases:

Negotiation

Type	Actions
Participants	Negotiate issues Fill in outcomes in form
Experimenter	Hand out individual and global goals for this scenario using the document provided with the experiment Hand out negotiation outcome form and ask players to fill in their outcome before the time is up Start camera Start clock Fill in debriefing checklist Warn players at 5 minutes and 1 minute left. When players ask questions, only answer with what is contained in the instructions End negotiation when time is up and collect outcome form

At the start of each round each player will receive their individual goal as well as the group goal of that round. The players will then be allowed to negotiate about the issues we give them. They only have 10 minutes to finish this negotiation (which simulates the time pressure existing in real crisis management teams and forces them to make quick decisions). They should fill in their outcome in the form that is provided to them.

The negotiation itself will be recorded on video which will be used to locate occurrences of certain behaviour after the experiment. The negotiation time starts when the recording is started.The positioning of the camera is shown in the following picture:



The debriefing checklist will be used to gather information for the debriefing.

Playing the game

Type	Actions
Participants	Watch game
Experimenter	Prepare computer(s) for next round Fill in outcome in game Start the simulator, launch the agents, start scenario

The experimenter will receive the outcome from the players, and will fill in the outcome in the environment.

The agents will then play the game based on this outcome. This is done by launching the simulator and then the agents and after this selecting the right scenario in the simulator.

The performance of the team will be calculated automatically by the MPN environment and will be saved to a log file after the game has finished. This calculation contains a separate score for the group performance and the individual performance. The group performance is calculated by the overall time it took to complete the round, while the individual performance is calculated by taking a maximum score and penalizing the players for not completing their individual goals or penalizing them for dropping their individual goal. If the round was not able to be completed the group performance will be maximized.

Debriefing

Type	Actions
Participants	Listening to debriefing
Experimenter	Check performance of game Perform debriefing

After the agents have finished the round or it turns out that it can't be finished anymore the players be debriefed on their performance in that round. In the debriefing, summarize to the players what the result of the last round was and whether this result is satisfactory for the government, and if not what was

the cause of this. The experimenter will use the results from the negotiation behaviour checklist to answer these questions as well as the log file that was saved after the agents completed the scenario.

The experimenter will answer the following questions:
Was there any cooperation between players or did they focus mostly on their own interests? Use the negotiation outcome to determine this, did they share information, did they wait until all individual goals were achieved?

When there is a disagreement between the team members, do they make concessions? Use the first question in the behaviour checklist to determine this. The experimenter tells them whether they made concessions when there was a disagreement.

Do they make concessions on their individual goal's achievement to improve the global goal's achievement? Use the second question in the behaviour checklist to determine this.

Did they share their individual goal and when did they do this? Use the third question in the behaviour checklist to determine this. The experimenter will advise the players to share their individual goal at the beginning if they did not do this in the previous round. This way they can quickly work to a common solution, and focus on the group goal.

What was the team performance? Use the performance log file to determine this. The first line in the log file contains the amount of seconds it took to complete the scenario which is the team's performance.

How much does this differ from the baseline result? If it differs greatly (more than 1 minute), you should mention to the players that the government is not very happy with this result and really expects them to do better in the next round.

In the case that the suboptimal result was caused by the player(s) focusing on their individual goals mention this to them and say that the government would prefer very much if they would focus more on the global goal as it is more important than their individual goals. This can be detected by looking at the negotiation outcome for waiting until all players have reached their individual goal when players have the individual goal of searching all rooms, or by the outcome for who drops their individual goal in the case of a player having an individual goal of not entering certain rooms.

In the case of it being caused by them not working together at all (by not sharing information or only trying to reach own goal), you should mention that the government expects them to be a team and work together as the global goal is most important.

After two rounds

After the debriefing of the second round, the experimenter hands out the questionnaires (two for each participant). He instructs them to fill in one for each round. After the questionnaire has been filled in, the experiment is finished.

Scenarios

The following are the three scenarios that will be used for the experiment (which can be in either order), these individual goals were chosen for their conflict with the global goal as this is most important for our purposes:

Scenario Explore:
Group goal: Red,Blue,Green,Yellow,Red,Red,Blue,Green,Yellow
Individual goal: Search all rooms
Environment (will not be given during the experiment, as it is yet unknown to the players):
Room A1: Red
Room A2: Blue
Room A3: Green
Room B1: Yellow
Room B2: Red
Room B3: Red, Pink
Room C1: Blue
Room C2: Yellow, Pink
Room C3: Green, Pink, Pink
Baseline completion time: 9 minutes

Scenario Mixed:
Group goal: Red, Blue, Green, Yellow
Individual goal:
player 1: Collect the most mission blocks
player 2: Search all rooms
player 3: Don't enter rooms: A1, C2, B1
Environment (will not be given during the experiment, as it is yet unknown to the players):
Room A1: Yellow
Room A2: Pink
Room A3: White
Room B1: Green, Blue
Room B2: Blue
Room B3: Red
Room C1: Red
Room C2: Red
Room C3: Pink
Baseline completion time: 6.5 minutes

Scenario Most Blocks:
Global goal: Red,Yellow,Purple,Blue, Blue, Red
Individual goal: Collect the most blocks relevant for the mission

Environment (will not be used during the experiment, as it is yet unknown to the players):
Room A1: Pink, Green
Room A2: Blue, Red
Room A3: Empty
Room B1: Red
Room B2: Yellow, Green, Blue
Room B3: Blue, Red
Room C1: Yellow, Red
Room C2: Blue, Blue
Room C3: White
Baseline completion time: 6 minutes

Time outline

- Introduction (10 min.)
  - Reading instructions
  - Signing consent form
- Training (10 min.)
- Experiment
  - Round 1:
    - Negotiate (10 minutes)
    - Questionnaire (5 minutes)
    - Agents play game (10 minutes)
    - Debriefing (5 minutes)
  - Round 2:
    - Negotiate (10 minutes)
    - Questionnaire (5 minutes)
    - Agents play game (10 minutes)
    - Debriefing (5 minutes)

Total time ~1.5 hours

After experiment

After the experiment the experimenter watches the videos of the negotiation and fills in the behaviour checklist. Concessions for group goal should be counted for big and small concessions with the following definitions:

- Big: Large delay for reaching group goal
- Small: Small delay for reaching group goal

For example having all players search every room causes a large delay, while only allowing one player to pick up a certain block is a small delay.
Concession for the individual goals use the following definitions:

- Big: Certain to not reach the individual goal
- Small: Chance to not reach the individual goal

For counting the time spent discussing individual and group goal, time spent discussing on how to reach the individual goal is counted towards the former, while time spent discussing on how to reach the group goal optimally goes toward the latter. When discussing a strategy geared towards reaching individual goals, this counts to that time.

B.1 Negotiation Outcome Form

Group:
Round:
Information Sharing

Your Location	

Where you're going to	
What blocks you've found in a room	
The blocks you picked up	
The blocks you dropped	

Exploration Order

	Player 1	Player 2	Player 3
Room A1			
Room A2			
Room A3			
Room B1			
Room B2			
Room B3			
Room C1			
Room C2			
Room C3			

Blocks

Everyone	

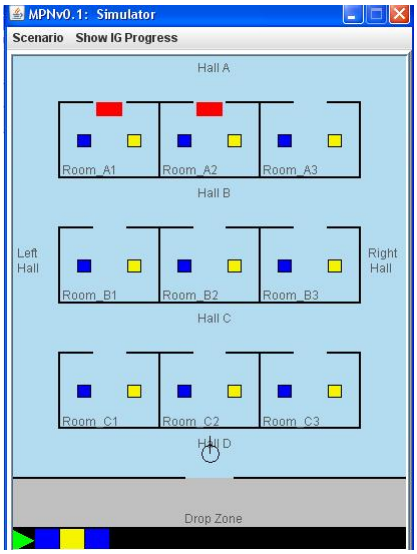
Player 1	
Player 2	
Player 3	

Wait until all individual goals have been reached? ☐ Yes ☐ No
Allowed to enter rooms other than the ones you are supposed to explore? ☐ Yes ☐ No
Who drops individual goal? ☐ Noone ☐ Player 1 ☐ Player 2 ☐ Player 3

C Experiment Instructions

Experiment

During the experiment you act as a representative for your company. Your company has been chosen by the government to work together with two other companies to complete certain missions in the MPN environment. These missions must be solved as quickly as possible as there is some time pressure. Your company also has its own goal that it wants to reach during such a mission, of which it will notify you at the start of the negotiation. They have given you the task to negotiate on their behalf and will back you every step of the way. The two other companies have also sent out representatives, who you will negotiate with. For this negotiation your company trusts that you will make sure it reaches the best possible outcome.



The MPN environment, in which you must complete the goals, consists of 9 rooms in a 3x3 grid (the rooms are A1-A3, B1-B3 and C1-C3), that are connected by several hallways. A special room called the drop zone is also located in this environment. A player can move freely to any room as long as the room is not occupied by another player, in this case he will need to wait until the other player has left the room before being able to enter it.

The rooms can contain blocks in various colors which can be picked up (only one at a time) and dropped at another location. Dropping a block in a hallway will make it disappear as will dropping it in the drop zone. The goal of a game instance is to retrieve specific colored blocks in a certain order from their respective rooms to the drop zone, this goal is called the group goal of the game.

Each player gets his own window in which he can only see his own avatar and the blocks that are located in the room that the avatar occupies. Other players are therefore invisible. A player has the possibility of sharing information with others however. An important point is that your company's goal can only be completed before the main goal is completed, and not after as the game will have ended then.

Before the negotiation starts your company will allow you to introduce yourself to the environment by playing a mission by yourself. In this mission, next to the group goal, your company also wants you to reach a specific goal that is of interest to them.

After this introduction phase to the environment the experiment will start in the first round. There will be 2 rounds in total. Each round goes through three phases:

Negotiation

At the start of each round you will negotiate with the other representatives about the plan for that round. You will be given the goals for that round before the negotiation. During this negotiation you are allowed to discuss freely as long as the outcome is compatible with the list of issues given to you. The issues are basically the questions that need to be answered during your negotiation. Each issue has some constraints on what is an allowable outcome. You only have 10 minutes for this negotiation. After this time is up your partial/full outcome will be used. You should write down your outcomes so that these can be used in the next phase.

Playing the game

After the negotiation you will not play the game yourselves, computer-controlled agents will do this instead. This is why your outcome has to meet the constraints as it needs to be filled into the agents. In the next section you can see a short explanation on how these agents will work. You will only be able to watch the agent that represents you.

Questionnaire and debriefing

After they have finished, a debriefing will be done.

The same process will be done for the remaining round after which the experiment is completed. At the end of the experiment you will need to fill in 2 questionnaires about the 2 rounds in the experiment.

Agents

The behaviour of the agents is based on the negotiation outcome. That is, unless enough is specified in the outcome, the agents will not execute the appropriate tasks. The agents will only reason with the negotiation outcome, which means that it can be possible that they can't do much if only a partial outcome was reached during your negotiation. The most important things that the agents need to do something useful is a room exploration order as well as a blocks division. This will allow them to search rooms for blocks and bring them back. If neither or one of both is not filled in the agents will most likely not be able to finish the round. The agents will only pick up a block, when it's the next block that needs to be brought back. Therefore they won't spend a lot of time waiting with a block in front of the drop zone, instead of this they will continue

their exploration and go back to retrieve the block when it's the current block that needs to be brought to the drop zone.

Negotiation Issues

Information Sharing
Which type of information each player will send to other players when able to.
Values: A choice of none/some/all of the following:
Your location
Where you're going to
What blocks you've found in a room
The blocks you picked up
The blocks you dropped

Exploration Order
Which rooms are explored by each player in what order.
Values: For each player each room gets a number from 0-9 indicating the sequence in which they should be explored. Rooms that are designated 0 are not to be explored by that player. Different rooms can have the same value, this indicates that for that sequence number it doesn't matter which room is visited first.

Blocks
Which of the goal blocks are picked up by a certain player or are allowed to be picked up by all players.
Values: For each player a collection of numbers which indicate the group goal index of the blocks they are allowed to pick up. Multiple players can have the same index in their collection meaning that they all are allowed to pick up that block when they've found it.

Wait until all individual goals have been reached?
Before returning the final block should that player wait until the other players have reached their goal.
Values: Yes or No

Allowed to enter rooms other than the ones you are supposed to explore?
Allowed to enter rooms other than the ones in the exploration list.
Values: Yes or No

Who drops individual goal?
Values: No one or a player name or randomly decided

D Questionnaire

Name:

Age:

Gender:

Nationality:

Occupation:

Round:

Perceived conflict

1. During your involvement how much conflict did you notice between yourself and others?

☐ Very little ☐ Little ☐ Some ☐ Much ☐ Very much

2. How much disagreement were you directly involved in?

☐ Very little ☐ Little ☐ Some ☐ Much ☐ Very much

3. To what extent were any issues debated among other members and yourself?

☐ Very little ☐ Little ☐ Some ☐ Much ☐ Very much

Conflict resolution

4. To what extent were differences of opinion resolved to the mutual satisfaction of conflicting parties?

☐ Very little ☐ Little ☐ Some ☐ Much ☐ Very much

5. How frequently were mutually agreeable solutions reached in the disagreement between you and other members?

☐ Very little ☐ Little ☐ Some ☐ Much ☐ Very much

6. To what extent were conflicts resolved to your satisfaction?

☐ Very little ☐ Little ☐ Some ☐ Much ☐ Very much

Goal focus + conflict awareness

7. To what extent did you try to reach your own goal in this round?

☐ Very little ☐ Little ☐ Some ☐ Much ☐ Very much

8. How important is your own goal?

☐ Very little ☐ Little ☐ Some ☐ Much ☐ Very much

9. To what extent did you make concessions on your own goal?

☐ Very little ☐ Little ☐ Some ☐ Much ☐ Very much

10. To what extent did your teammates make concessions on their own goals?

☐ Very little ☐ Little ☐ Some ☐ Much ☐ Very much

11. To what extent did you try to reach the group goal in this round?

☐ Very little ☐ Little ☐ Some ☐ Much ☐ Very much

12. How important is the group goal?

☐ Very little ☐ Little ☐ Some ☐ Much ☐ Very much

13. To what extent did you make concessions on the group goal?

☐ Very little ☐ Little ☐ Some ☐ Much ☐ Very much

14. To what extent did your teammates make concessions on the group goal?

☐ Very little ☐ Little ☐ Some ☐ Much ☐ Very much

15. To what extent was the group goal discussed during the negotiation?

☐ Very little ☐ Little ☐ Some ☐ Much ☐ Very much

16. To what extent did you help to reach other's goals?

☐ Very little ☐ Little ☐ Some ☐ Much ☐ Very much

17. How important are other's goals?

☐ Very little ☐ Little ☐ Some ☐ Much ☐ Very much

18. To what extent were all players' individual goals discussed during the negotiation?

☐ Very little ☐ Little ☐ Some ☐ Much ☐ Very much

19. Were you satisfied with the outcome of the negotiation? Why (not)?

20. Would you have done something differently in the negotiation? If yes, what? If not, why not?

E Debriefing Checklist

Group:

Round:

(During Negotiation)

1. When there is a disagreement between the team members, do they make concessions?

☐ Mostly ☐ Sometimes ☐ Rarely

2. Do they make concessions on their individual goal's achievement to improve the global goal's achievement?

☐ Mostly ☐ Sometimes ☐ Rarely

3. Did they share their individual goal and when did they do this?

☐ At the beginning ☐ In the middle ☐ At the end ☐ Not at all

(After game)

4. What was the agent's performance?

F Behaviour Checklist

Group:
Round:

1. How much time do they discuss the group goal?

2. How much time do they discuss their individual goals?

3. When do they share their individual goals?
   ☐ At the beginning ☐ In the middle ☐ At the end ☐ Not at all

4. How many disagreements are there?

5. How many of these disagreements were resolved?

6. How many concessions were made on the group goal?

7. How many concessions were made on their individual goals?

8. How long did the total negotiation take?

9. Way they sit

   (a) Leaning back
   ☐ Mostly ☐ Sometimes ☐ Rarely

   (b) Sitting forward
   ☐ Mostly ☐ Sometimes ☐ Rarely

   (c) Staring at empty space
   ☐ Mostly ☐ Sometimes ☐ Rarely

   (d) Looking down at papers
   ☐ Mostly ☐ Sometimes ☐ Rarely

G Behaviour Results

Group + Round	1	2	3	4	5	6	7	8	9
Explore-Mixed Round 1	255	295	At the beginning	2	2	1 big, 1 small	0	560	Leaning back: Rarely Sitting forward: Mostly Staring at empty space: Rarely Looking down: Mostly
Explore-Mixed Round 2	160	258	At the beginning	1	1	2 small	0	430	Leaning back: Rarely Sitting forward: Mostly Staring at empty space: Rarely Looking down: Mostly
Mixed-Explore Round 1	394	106	Not at all	2	1	1 small	1 small	540	Leaning back: Rarely Sitting forward: Mostly Staring at empty space: Rarely Looking down: Mostly
Mixed-Explore Round 2	168	121	At the beginning	1	1	1 big, 1 small	0	300	Leaning back: Rarely Sitting forward: Mostly Staring at empty space: Rarely Looking down: Mostly
Most Blocks-Mixed Round 1	520	0	Not at all	1	0	0	3 big	540	Leaning back: Rarely Sitting forward: Mostly Staring at empty space: Rarely Looking down: Mostly
Most Blocks-Mixed Round 2	197	330	At the middle	2	2	2 small	1 big	555	Leaning back: Rarely Sitting forward: Mostly Staring at empty space: Rarely Looking down: Mostly

Table 5: Behaviour Results (1)

Mixed-Most Blocks Round 1	270	304	At the middle	1	1	1 big, 1 small	0	598	Leaning back: Rarely Sitting forward: Mostly Staring at empty space: Rarely Looking down: Mostly
Mixed-Most Blocks Round 2	154	320	At the beginning	2	2	1 big	1 small	480	Leaning back: Rarely Sitting forward: Mostly Staring at empty space: Rarely Looking down: Mostly
Most Blocks-Explore Round 1	445	44	Not at all	1	1	2 small	1 small	588	Leaning back: Rarely Sitting forward: Mostly Staring at empty space: Rarely Looking down: Mostly
Most Blocks-Explore Round 2	351	109	At the beginning	1	0	1 big	0	548	Leaning back: Rarely Sitting forward: Mostly Staring at empty space: Rarely Looking down: Mostly
Explore-Most Blocks Round 1	210	203	At the middle	1	1	1 big, 2 small	0	573	Leaning back: Sometimes Sitting forward: Mostly Staring at empty space: Rarely Looking down: Mostly
Explore-Most Blocks Round 2	301	114	At the beginning	2	2	0	1 small	425	Leaning back: Rarely Sitting forward: Mostly Staring at empty space: Rarely Looking down: Mostly

Table 6: Behaviour Results (2)

H Questionnaire Results

	Age	Gender	Nationality	Occupation
Explore-Mixed				
1	27	F	Chinese	PhD Student
2	30	F	Canadian	PhD Student
3	26	F	Dutch	PHD Student
Mixed-Explore				
1	23	M	Dutch	Master Student
2	20	M	Dutch	-
3	20	F	Dutch	-
Most Blocks-Mixed				
1	21	M	Dutch	Student
2	25	F	Chinese	PhD Student
3	26	M	Chinese	PhD Student
Mixed-Most Blocks				
1	30	M	US/Dutch	PhD Student
2	23	F	Dutch	Student
3	25	M	Dutch	Student
Most Blocks-Explore				
1	21	M	Dutch	Student
2	25	F	Chinese	-
3	21	M	Dutch	Student
Explore-Most Blocks				
1	29	M	Dutch	Student
2	22	M	Dutch	Student
3	20	M	Surinamese	Student

Table 7: Demographics Results

	Round 1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Explore-Mixed																			
1		3	3	4	1	5	5	5	5	1	1	4	4	2	2	2	5	5	5
2		1	1	1	1	1	1	5	3	1	1	5	5	1	1	4	4	4	4
3		1	1	1	4	3	4	4	3	1	1	5	3	1	1	1	2	3	4
Mixed-Explore																			
1		2	2	2	2	2	3	5	4	1	2	5	5	1	1	2	4	3	1
2		3	3	3	4	4	3	3	5	2	1	1	2	4	4	4	3	3	1
3		2	2	3	3	3	3	5	4	1	1	3	4	3	3	3	3	2	5
Most Blocks-Mixed																			
1		1	1	2	3	3	3	3	4	1	1	5	5	1	1	3	1	1	1
2		2	2	3	2	2	3	4	4	3	3	4	4	4	4	4	2	2	1
3		1	1	3	5	4	5	5	4	2	4	5	5	4	4	5	3	3	4
Mixed-Most Blocks																			
1		1	2	1	5	5	5	5	4	1	1	3	3	2	2	3	4	2	5
2		1	2	2	5	5	5	5	4	1	1	5	5	1	1	3	5	3	5
3		1	2	3	3	5	4	5	5	1	2	3	3	2	2	3	4	3	5
Most Blocks-Explore																			
1		2	2	4	5	5	4	3	4	2	1	4	3	3	3	2	1	2	1
2		2	2	2	4	4	4	4	3	3	2	4	5	4	4	5	1	3	1
3		2	2	3	4	4	3	2	3	4	4	4	4	3	3	3	3	2	1
Explore-Most Blocks																			
1		1	1	1	1	1	3	5	5	1	1	3	3	1	1	1	3	3	3
2		2	1	4	5	4	4	5	4	1	1	3	3	3	3	2	4	3	3
3		2	2	3	2	3	4	5	5	5	2	3	5	2	5	3	1	1	1

Table 8: Results Round 1

	19	20
Explore-Mixed		
1	It's okay but can be improved. I didn't know the "task" means and the protocol of the agents.	Yes, let the agents pick up before exploring all the rooms
2	Yes	would have improved the search strategy
3	Yes, but took a long time	No, solution worked
Mixed-Explore		
1	No group goal was failed	Yes, discuss our own goals and by not letting everyone go for one color, but maybe two colors (overlap)
2	No, we didn't reach an agreement. And my own goal would probably not be reached, same for the group goal.	Yes, discuss our own goals and come to a compromise
3	We should have discussed the group goal more since we did not complete it.	Yes I would have decided to let everyone find all the blocks
Most Blocks-Mixed		
1	No I forgot to pick up blocks	Yes I would have negotiated more about the individual goals
2	No because we didn't negotiate properly	Yes I may share my individual goal with others and take other's choices into account for my choice
3	Yes, we are trying to accomplish the global goal while maximizing the individual goal	No we achieved both the group and individual goal
Mixed-Most Blocks		
1	Yes everyone's goals got met	Yes, discuss how we could pick up blocks more efficiently
2	Yes, good to know what everyone's goal is and to not feel cheated	told each other the goals faster
3	Yes, I just wonder how we could improve the time (without any concessions)	No goals are reached
Most Blocks-Explore		
1	Somewhat I didn't get much of my own goal since I didn't tell the others. Was afraid they'd want to sabotage for they might have the same goal (they had) But I wasn't hindered so neutral feeling	Group goal was quite fast and the little extra exploration from the others was good for reaching my individual goal. It was a nice division between getting individual goal and a fast group goal
2	Yes actually I was not very clear about the whole process of the experiment	Yes I would think about a new way to achieve the group goal to save more time
3	Yes unfortunately the result wasn't the expected outcome	I would have changed the input of the program with hindsight, might have been good to tell the rest about individual goal
Explore-Most Blocks		
1	Yes we reached all goals but made a mistake with the information sharing	More focus on sharing information, since we didn't think it through
2	Yes but I think the goal was not fully clear to the group which ended in a failure	Yes with more knowledge it would turn out different
3	Yes I got my way but it resulted in a failure of the mission	Yes I would have prioritized the group goal

Table 9: Reflection Round 1

	Round 2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Explore-Mixed																			
1		2	2	4	1	5	5	5	5	1	1	4	4	2	2	2	5	5	5
2		1	1	1	1	1	1	5	4	1	1	5	5	1	1	5	4	4	5
3		2	3	3	1	4	4	4	3	2	2	4	3	2	2	3	4	3	4
Mixed-Explore																			
1		2	1	2	2	2	3	4	3	2	2	5	5	1	1	1	4	3	4
2		1	1	5	5	5	5	5	5	1	1	4	3	2	2	2	5	4	5
3		2	2	2	2	2	2	5	5	1	1	4	4	1	1	4	4	3	5
Most Blocks-Mixed																			
1		2	3	5	2	2	4	5	5	1	1	5	5	1	1	3	5	5	5
2		2	3	4	3	2	3	5	5	2	2	4	5	4	4	5	4	3	4
3		3	3	4	4	3	3	4	4	2	4	3	5	3	4	3	4	3	4
Mixed-Most Blocks																			
1		2	1	3	3	4	3	4	4	3	3	4	4	1	1	5	2	2	5
2		2	3	3	4	4	5	3	3	5	5	5	5	1	1	3	2	3	5
3		2	3	3	4	4	5	4	5	3	3	4	4	4	3	4	4	4	4
Most Blocks-Explore																			
1		2	5	4	2	2	4	5	4	1	1	2	3	4	4	5	5	3	3
2		2	2	3	4	3	3	5	4	4	4	3	4	3	4	3	3	4	5
3		3	4	4	3	4	3	5	4	1	1	4	4	2	2	3	4	3	4
Explore-Most Blocks																			
1		2	3	4	5	5	5	3	2	5	5	5	5	1	1	3	1	1	3
2		2	3	4	4	4	4	3	2	4	4	5	5	1	1	5	2	2	5
3		1	1	3	4	5	5	2	2	3	3	5	5	5	5	5	2	2	3

Table 10: Results Round 2

	19	20
Explore-Mixed		
1	-	-
2	yes, we worked well together	would have changed the search strategy
3	Yes	no, but we could have thought longer on some points
Mixed-Explore		
1	Yes, since we did all reach our own goals and the group goal	Yes, but took very long. Better would be to give everybody a block of three to find and pick up blocks
2	Yes, because I was happy to reach my goal	No, the group goal in no time was not my first goal on my to-do-list
3	Much, we reached our individual goals and the group goal	Yes, I would try make it faster not wait until everybody reached their own goal and maybe sacrifice our individual goals a bit. Maybe by deciding that we all should enter 3 rooms instead of all.
Most Blocks-Mixed		
1	Yes only with picking up the blocks we could have worked more together	Yes work more together with picking up blocks
2	Yes because we reached both our individual goals and group goal	Yes I may change my choice to make our performance more efficient especially the overall performance
3	Yes because all our goals are achieved	Yes my individual goal is not accomplished
Mixed-Most Blocks		
1	Yes everyone's goals got met	Yes discuss strategy more
2	Yes, no one feels cheated	No, but would have changed the amount of rooms to search
3	No, time was bad, inefficient and not goal focused enough	Yes, stick to my goal
Most Blocks-Explore		
1	Yes it went my way Just wrong in overestimating the AI	Maybe set a more specific exploration order. Otherwise I was content
2	Yes we thought about both group and individual goals	No since we achieved the group goals and individual goals almost at the same time. We didn't need to wait to achieve either of the two goals
3	Everyone reached their personal goal, but some changes in the input might have resulted in a faster time.	No, I feel the negotiations have resulted in an optimum for both the player's goals and the group goal. However a different input might have resulted in a faster time
Explore-Most Blocks		
1	Yes we won!	No, not possible with the set goals
2	Yes this was an efficient solution without putting one of the group members in a negative situation	No this was the best option
3	Yes we had the best time results	No I wouldn't me and my company are very happy

Table 11: Reflection Round 2

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