Using a Metacognitive Model to Improve Human Negotiation

Bachelor's Project Thesis

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Abstract: This study addresses the concept of theory of mind in terms of negotiation. Using a metacognitive training agent, our research looks at whether training with this agent that uses theory of mind will improve results in a human to human negotiation. Participants performed a human to human negotiation pre- and posttest. The experimental group trained with a metacognitive agent in a negotiation setting, whereas the control group trained with a cooperative, non-metacognitive agent. The relation of improvement between pre- and posttest and improvement within training was analysed. Both the control and experimental group improved equally in time. There is a marginally significant interaction between the condition and improvement within training on the score. The control group has what looks like a positive linear relation between improvement between pre- and posttest and improvement within training. This indicates that the presence of theory of mind in a training model does not seem to influence performance in this negotiation task.

1 Introduction

People employ their negotiation skills to improve the outcome of a deal they are apart of. When someone needs the collaboration of someone else to achieve a certain objective, this individual will engage in negotiation (Thompson et al., 2010). A negotiation consists of multiple parties each with their specific preferences. In order to reach an agreement, the parties need to communicate and exchange their preferences. After knowing these preferences, a two-sided positive agreement has to be reached. Negotiation is necessary for daily events (e.g. agreeing on a price at a market) as well as for globally influential decisions (e.g. between conflicting countries). Therefore, to ensure individuals bring about the most of a negotiation situation, people need to know how to negotiate, or gain experience with this phenomenon.

According to the "Negotiatior's Dilemma" (Urlacher, 2014), a successful negotiator balances between being cooperative and competitive. This strategy allows for sufficient gain without risking the failure of coming to an agreement. This strategy thus requires satisfaction of certain goals for both parties to be accomplished for an agreement to take place. As follows, negotiators should share their preferences to find the common ground they both can agree on. According to Fisher et al., people should focus on their own goals and the opponent's goals. Reasoning about the opponent's goals, knowledge and strategy is also known as theory of mind (Premack and Woodruff, 1978). Thus, to allow for good negotiation, you should balance between being cooperative and competitive, share preferences with each other and apply theory of mind. A metacognitive agent has been created to help people apply these strategies.

Several tools for aiding people with negotiation or decision making have been introduced (Espinasse et al., 1997; Cao et al., 2015; Carneiro et al., 2013; Lin et al., 2014). These tools serve different specific purposes, but the general goal is to assist or train people with decision making, either in a negotiation setting or not. What these tools do not take into account, is the dynamic aspect of human reactions during communication. Between humans, an aggressive move can result in an aggressive reply, whereas automated decision aids will not recognize aggression or other strategy types, resulting in rather one-dimensional reactions.

This research emphasizes the metacognitive part of the training agent and tries to examine the influence of this agent on negotiation performance.

The metacognitive agent determines the participant's strategy by analysing his actions. The agent then mirrors this strategy and provides the participant with feedback about what the agent beliefs about the user's actions. The metacogntive agent keeps track of the user's strategy, attaching more value to the participant's recent actions than to actions further in the past. An aggressive strategy is characterised by selecting actions such as "This option is impossible" or "I need this option". A cooperative strategy features actions such as "I will consider your option", "I would like this option" and asking what the agent would like. In addition, sharing your preferences is a sign of cooperativeness. Because the agent provides the participant with its internal state, the participants get an idea of the agent's theory of mind, which can lead to applying theory of mind themselves. A cooperative agent is used to train the control group. This agent is equal to the metacognitive agent, except it will always apply a cooperative strategy and it does not provide the participant with any feedback. This agent tends to agree more with the participant, even if this might result in an unfavorable deal for the agent.

The participants will perform a human-to-human negotiation pre- and posttest in pairs. Each negotiation trial has a setting concerning a smoking ban, where the participants have to agree on four topics. The preferences of the parties for each topic are given on a so called preference card. In addition, a game of nines (Kelley et al., 1967) pre- and posttest are performed. However, the data of the game of nines experiment will not be analysed in this article. Between the pre- and posttests, half of the participants engage in an experimental training with the metacognitve agent, whereas the other half will be in the control condition, containing the cooperative negotiation agent. The performance of the participants can be determined by the difference in score between the pre- and posttest, but also by determining the optimality of each trial. A deal is marked as pareto optimal if changing one of the options of the deal leads to a decrease in score for one of the participants. Analysing pareto optimality can determine the degree of optimality of the deals a pair has made. Pareto optimality therefore examines the performance of each pair, whereas the scores represent the performance of an individual.

The important difference between the control and experimental condition is showing the participant theory of mind. Since theory of mind is a crucial aspect of good negotiating, teaching this to participants is essential. Due to the metacogntive capabilities of the experimental agent and its feedback to the participant, we hypothesize the metacognitive agent will improve the participant's negotiation score between pre- and posttest more than the cooperative agent.

2 Methods

2.1 Participants

The participants for this experiment consisted of 28 students from universities in Groningen. There was a distribution of 17 females and 11 males, aged between 19 and 28 years old. All participants volunteered for this study and were provided a payment of 16 euros. The participants originated from a large variety of countries.

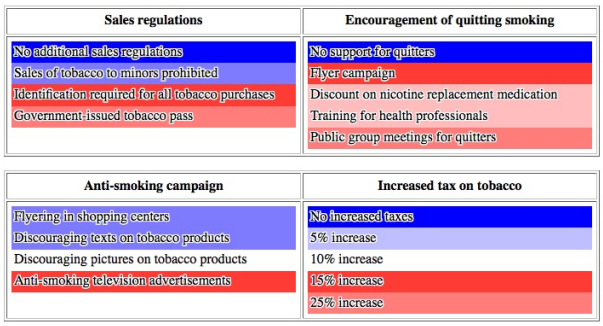

Figure 2.1: A preference card containing four topics on a campain to reduce smoking. Red colours represent bad options and blue options are preferable.

2.2 Material and stimuli

An informed consent form was used to provide the participants with the risks of participating in this study (see Appendix A). Furthermore, a payment form had to be filled in by the participant in order for the researcher to know where to deposit the research payment (see Appendix B).

Preference cards were used to provide the participants with information about their viewpoint in the negotiation (see Figure 2.1). The cards contained four topics, of which two of them had four options and the other two had five options. Each option had a certain colour, which was correlated with the preference and a value. A red coloured option was disfavored and corresponded with a negative value, where a darker shade coincided with a larger negative value. Preferred options were presented as blue, where a darker shade conformed to a larger positive value. A neutral preference was coloured white and had a value of zero. The score for each deal was calculated by adding the values of the four options that were part of a negotiated deal. The four topics remained the same during pre- and posttest, but the preferences varied between each trial. The preferences of the four- and five-option topics of the pretest were switched to create the posttest, resulting in equal difficulty but dissimilar trials compared to the pretest. Furthermore, for each trial there were always one or multiple deals where both parties would have a positive score. The pre- and posttest had a fixed order, starting with two difficult trials, followed by two intermediate, and concluded by two easy trials. The difficulty of the trials was determined by the correlation between the preferences of both parties.

Additional materials included a metacognitive version of the game of nines (Kelley et al., 1967). The data gathered with this application was analysed in a different article. Furthermore, a negotiation program was created with the cognitive architecture ACT-R (Anderson et al., 2004), which was used for training. This program consisted of an interface showing the preferences similar to the preference cards, a chatbar containing the communication between the participant and the agent, and several buttons the participant could use to communicate with the agent (see Figure 2.2). Communication consisted of a reaction to what the agent said (e.g., "I will consider your option") and performing an action of your own (e.g., "I propose option ..."). Two conditions could be selected for the negotiation agent. The control condition contained a cooperative agent, which did not give any feedback to the user. The experimental condition contained a metacognitive training agent which provided feedback on its internal state, as well as the score for each deal and whether the deal was pareto optimal. The training consisted of nine trials with an equal distribution of easy, intermediate and hard settings, in a random order.

The experimental, or metacognitive, condition had a simple pictorial face added to the interface, which represented its internal state. The agent's state could be happy if the user was cooperative, neutral if the user was neither cooperative nor aggressive, or angry, if the user maintained an aggressive strategy. The metacognitive agent tried to deduce the strategy of the user by analysing his actions. The metacognitive agent stated in the chatbar whether an action made by the user was seen as cooperative, neutral or aggressive (see Figure 2.2).

2.3 Design

The design of this experiment included a human-to-human negotiation and game of nines pretest, a training period, and a game of nines and human-to-human negotiation posttest. Each negotiation trial, both human-to-human as well as training trials, had several possible outcomes, each with its own score specified for both parties. The score of each deal was calculated by adding points attributed to the selected options for each of the four topics. A selection of deals could be marked as being pareto optimal, where there was no possibility of increasing one or both scores without reducing the score of the other. A function was created in R (R Development Core Team, 2008) to determine pareto optimality. Furthermore, for each trial, this function calculated the difference in points between the scores of both parties and the most equally distributed pareto optimal deal.

The training was split up into two conditions. Half the participants experienced a cooperative training, where the agent gave the participants no feedback. The other half of the participants went through the experimental training, where the participants receive feedback on their performance as well as information of the agent's assumptions about the participant. In case of a non-optimal deal, the experimental agent provided what deal would have been more profitable (for both or either party).

2.4 Procedure

At arrival of the experiment, participants had to fill in the consent form and leave their bank ac-

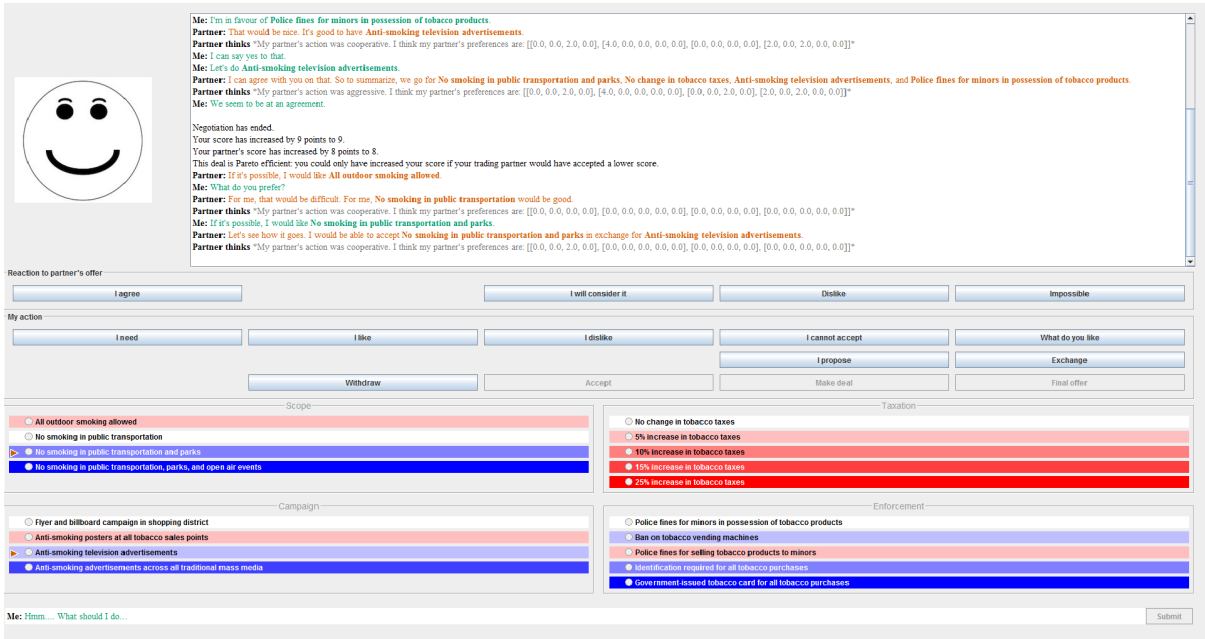

Figure 2.2: The interface of the training model. Above is the metacognitive model with information about its internal state. Here, the "partner" corresponds to the agent. The cooperative has no pictorial face or sentences concerning what the agent thinks.

count details. Next, the participants were asked to sit in a dimly-lit, largely sound-proof room with a table, chairs and a small table-light. The researcher was sitting at the head of the table, making notes and recording the experiment. The two participants were sitting face to face and had instruction forms in front of them. Attached to the instructions were six negotiation trials, as represented in Figure 2.1. After reading the instructions, the researcher provided the participants with a small summary and helped them start up the first trial. By negotiating, a final deal both participants were content with had to be made. The final deal was then marked by the participants and this was repeated for the remaining trials.

After the face to face negotiation, the participants were guided to two secluded booths. Here, they were asked to read the instructions of the game of nines experiment. When finished reading, an experimenter would start up the game of nines and provided a small summmary concerning the game. When the participant finished the game of nines, he or she gave a sign to the researcher, who then started the training program. The experimenter instructed the participant on how to use the training agent and let the participant start the training. If the participant had any questions, they could call for an experimenter to elucidate him. When the participant is finished with the training, the posttest of the game of nines experiment was started and executed by the participant. After both participants were finished with the game of nines posttest, it was ensued by the face to face negotiation posttest. The posttest was performed in the same room and in the same manner as the pretest. After finishing the negotiation posttest, the participants were thanked, remaining questions were answered, and they were debriefed about the experiment.

2.5 Measures

Several variables were measured within this experiment. The score of each trial was measured, of which the optimality could be determined, as well as the difference between the score and the most equal pareto optimal deal. In addition, during the training, the agent concluded the participant's

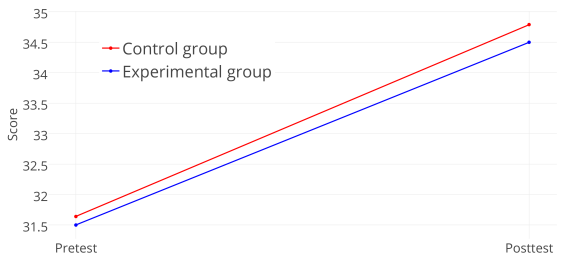

Figure 3.1: Improvement of the scores between the pre- and posttest for the experimental (blue) and control (red) group.

strategy, which could be used to roughly actuate the participant's strategy during the human-to-human trials.

2.6 Analysis

The purpose of this design was to determine a possible correlation between the training condition and the improvement between the pre- and posttest. The performance of each individual was analysed, which put the focus on the individual score rather than the pareto optimality of each pair. The main effect of the improvement within the training on the improvement over the pre- and posttest was examined, as well as the main effect of the condition on between-test improvement. Furthermore, the main effect of the interaction of improvement within training and the condition on the improvement was analysed.

3 Results

Prior to the analysis, the score for each trial had to be calculated. Inconsistently selected options, where participants did not select the same option, were marked as zero points. One trial has been removed due to multiple inconsistent options. No participant was removed from the data. The total score of the pretest was subtracted from the total score of the posttest, resulting in an indication of the performance difference between the pre- and posttest (see Figure 3.1). Furthermore, the learning slope of the training trials was calculated by fitting a linear model to the nine scores of the nine training trials for each participant.

A one sample t-test has determined the overall improvement between pre- and posttest (M = 2.57, SD = 7.70) is not equal to zero, t(27) = 1.77, p = 0.088. In addition, a two-sample t-test has determined there is an insignificant difference (t(26) = -0.19, p = 0.85) between the improvement of the experimental group (M = 2.29, SD = 9.03) and control group (M = 2.86, SD = 6.42).

All trials combined, the data consisted of 28 participants. Each instance had a specified condition and difference in score between pre- and posttest (M = 2.57, SD = 7.70), as well as the learning slope of the training (M = -0.090, SD = 0.41). The score-slope plot in Figure 3.2 shows higher scores at higher slopes for the control condition. The instances of the experimental condition are spread over the whole plot.

A repeated measures ANOVA was performed to analyse the influence of the condition, training slope and the interaction between the two on the score difference between pre- and posttest. The analysis shows no significant influence of the condition F(1, 24) = 0.028, P = 0.870, the training slope F(1, 24) = 0.236, P = 0.632, or the interaction between the slope and condition F(1, 24) = 3.07, P = 0.0925.

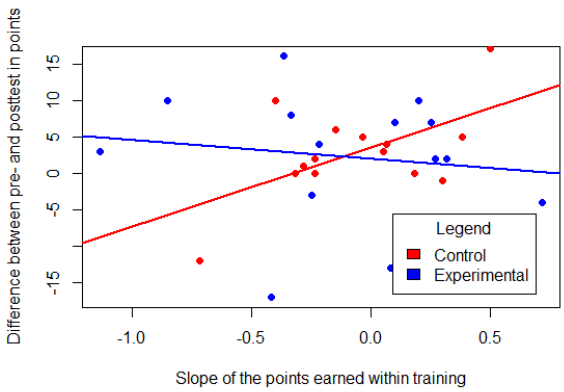

Figure 3.2: The relationship between the improvement within the training and the improvement between pre- and posttest.

4 Discussion

As Figure 3.1 shows, both the control and experimental group improve their scores almost similarly between the pre- and posttest. However, the experimental group does not show a significantly larger improvement in time compared to the control group. Since we hypothesized the metacognitive agent to improve negotiation skills more than a cooperative agent, the hypothesis can be rejected. The graph in Figure 3.2 shows the dependency of the improvement in time on the improvement within training. This graph shows what looks like a positive linear relationship between the training slope and the difference in score between the tests for the control group. However, the experimental group shows no correlation between the two measured variables. It can be concluded that the control condition contained a better setting to learn the negotiation task compared to the experimental condition. The distribution of the participants in the experimental condition combined with the improvement in the control condition might indicate that participants are just not ready yet for a metacognitive negotiation approach. A simple negotiation training already improves negotiation skills. This can also be concluded by the analysis of variance, which is marginally significant, but in an unexpected direction.

According to Figure 3.1, both groups show similar improvement in time. Figure 3.2 suggests the improvement of the control group is correlated with the performance during training. However, the improvement of the experimental group cannot be explained by the performance during the training. Therefore, the improvement of negotiation skills of the experimental group can be assigned to a learning effect.

An explanation for the experimental group not to improve as was expected, is the duration of the training. The whole experiment (both negotiation, game of nines and training) lasted approximately two hours, of which only thirty minutes consisted of training. Furthermore, during this short training, the participants had to learn the interface of the agent, which requires time. A longer training allows the participants to reason more about the information the metacognitive agent provides. This could lead to a better understanding of the agent and the application of theory of mind.

Another cause for the performance difference between pre- and posttest is the negotiation partner. Every participant had to negotiate with an unknown opponent. The strategy this opponent uses influences the final score of the participant. This might have led to some participants having a very large or low score. Using a fixed negotiator for each participant, who applies a consistent strategy, will lead to a better indication of the participants' score. Furthermore, this makes a comparison between participants more valid.

The participants in the metacognitive group had to apply a cooperative strategy for the metacognitive agent to become cooperative. If the metacognitive agent is cooperative, it can be abused by the player. However, after the experiment, participants report the training model to be using an aggressive strategy. This indicates an aggressive strategy applied by the participants as well. This might indicate that the participants did not understand the training program correctly, and it supports the assumption that participants are not ready yet for a metacognitive training approach, and thus theory of mind.

This research shows that a simple cooperative training agent allows an increase in negotiation performance, as well as a metacognitive training model. Further research should focus on the training conditions and duration. Furthermore, the manner of testing the negotiation skills should be more controlled. Performing this research without an additional task can also decrease the possibility of fatigue and boredom.

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A Consent Form

Form of Consent

You will participate in an experiment about negotiation.
In this study, you will play a negotiation game with one other participant.
The data will be stored and analyzed anonymously, to ensure your privacy.
Participation in this study is voluntary. You may quit at any time.
You will receive 16 euros for your participation.
The experiment will last roughly 2 hours.

Thank you for your participation
Marten de Jager
Isabelle Labat-Rochecouste

I agree to participate in the experiment on negotiation.

Name & Signature of Participant Date

B Payment Form

rijksuniversiteit groningen / faculteit wiskunde en natuurwetenschappen / financieel beleid & administratie

Uitbetaling aan (buitenlandse) proefpersonen (FIOD)

Uitbetaald aan / Payed to:

Naam / Surname: _____

Voornaam / Firstname: _____

Adres / Address: _____

Postcode / Zipp code: _____

Woonplaats / City: _____

Fiscaal nummer: _____

Geb. Datum / Date of Birth: _____

Banknummer / Bankaccountnumber: _____

Bedrag Honorarium / Fee: _____

Bedrag Onkosten / Expenses: _____

Voor betaling aan buitenlandse proefpersonen aub ook de gegevens hieronder in vullen:

Name Bank:	
Bank Address:	
Zippcode:	
City:	
Country:	
BIC (Swift):	
IBAN code:	
Routing/Aba/BLZ:	
Currency:	

Voor de volgende verleende diensten: / for the following services:

_____

_____

Projectcode: _____

Groningen, _____

Handtekening voorzitter basiseenheid/projectbeheerder,

_____

In te vullen door FBA

Crediteurnr	**Fact. datum**	**Fact. nr.**	**Bedrag**	**BTW**
				GBO

Projectcode	**Structuurdeel**	**Kostencode**	**Bedrag**	**Omschrijving**

(Buitenlandse) proefpersonen FIOD

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