Lydia Ould Ouali[1], Charles Rich[2] and Nicolas Sabouret[1]

[1] LIMSI-CNRS, UPR 3251, Orsay, France
Université Paris-Sud, Orsay, France
{ouldouali, nicolas.sabouret}@limsi.fr
[2] Worcester Polytechnic Institute
Worcester, Massachusetts, USA
rich@wpi.edu

1 Interpersonal relationship

Social relationship and its effects on behavior lies at the heart of social science. It was proved that understanding interpersonal relationship is crucial for social cognition [6]. Most of the literature that get interested in the conceptual analysis of interpersonal relationship have agreed that the essence of relationship appears in the nature of interaction that occurs between relationship partners. Moreover, social relationship is a dynamic system that may develop and change continuously over interactions [6, 9]. Communication between relationship partner will grow in stages from the initial interaction where partners share superficial information to a more deeper relationship where partners can share more personal information. Therefore, the social relationship of partners affects their behavior and their strategy of dialogue.

2 Representation of interpersonal relationship

The aim of this section is to relate the work of N.HASLAM [3] who get interested on the mental representation of social relationship. In summary, there are three different representation in the literature.

The first is the dimensional representation. It is the most common representation that consists on represent relationships in a dimensional circle (c.f wiggins model). Therefore, any relationship can be situated and valuated in this *continuous* dimensional space.

The second representation is the lawful representation. Laws are defined in the same circle's dimension of affiliation and control. The main difference with the dimensional representation is that laws try to make discrete prediction about the other behavior. For each behavior, complementarity and symmetry make discontinuous prediction about the the other interact behavior.

Finally, categorical representation make a discrete prediction on which kind of social relationship are well performed. In addition the categorical representation focus only on local prediction (prediction in a small region within a dimensional scheme).

Dimensions	Laws	Categories
Continuous Local	discontinuous Global	discontinuous Local

2.1 Dimensions of interpersonal relationship

The definition of dimensions was widely studied under different labels. However, we distinguish four dimensions that are always used for the representation of interpersonal relationship.

Dominance and power Scholars from different fields converge to define power as the ability to influence the other behavior [9]. Power may be latent (Komter, 1989), which is in contrast with the definition of dominance which is inevitably manifest (Dunber, 2004). It is an asymmetric variable in which one interactant's assertion of control is met by acquiescence from another (Rogers-Millar & Millar, 1979).

Familiarity In Svennevigs relational model [9], the definition of familiarity is based on social penetration theory (Berscheid and Reis, 1998) which describe the grades of relationship evolution through mutual exchange of information both in depth (superficial information to personal and intimate information) and breadth(from narrow to a broad range of personal topic).

Affect This dimension represent the degree of liking that have one interact for the other. This dimension allows interactants to create personal attachment and improve the relationship of interactants [4]

Solidarity The solidarity dimension is in the opposite of power dimension. It is a symmetrical dimension where two individuals share equal obligations and rights [9]. Is is identified as like-mindedness [1] where interactants have the same behaviors and share for example the same preferences.

2.2 Dialogue utterances

In this paper we are interested in modeling a collaborative negotiation on preferences in the context of social dialogue. The negotiation takes its values during the dialogue when messages are exchanged between interlocutors. In the following we present our model of dialogue.

Structure of messages The basis structure of dialogue is a message that contain all the information that interlocutors exchange. We thus define a message as triple $M = <\mathsf{i} \rightarrow \mathsf{j}, \mathsf{s}(\mathsf{cont}), \mathsf{F}>$, where i, $j \in$ {agent, user} are the agents participating in the dialogue,$s \in \wp$ is the utterance used to express a message. $\wp = \{\mathsf{Ask}, \mathsf{Propose}, \mathsf{Reject}, \mathsf{Accept}, \mathsf{State}\}$ represents the set of utterance types [8] that agents can express to exchange messages. $\mathsf{F} \in \mathfrak{I}$ where $\mathfrak{I} = \{\mathsf{Strongly}, \mathit{Weakly}, \mathit{Yelling}, \mathit{Withhesitation}...\}$ is a set of multimodal features that are applied to the utterance to express a personal linguistic style or

social move. These features affect the perception of interlocutors about their relationship. Therefore, we define a social relationship function SR: $2^{\mathfrak{F}} \times \mathtt{context} \rightarrow \mathtt{Relationship}$, that tells which feature say in term of social move. The context represents all the previous knowledge of the speaker. We focus on the relation of dominance in this paper. Thus $\mathtt{Relationship} = \mathtt{Dom}$ where $\mathtt{Dom} = \{+, -, =\}$ is a three values function. For example, two colleagues have a conversation, colleague A speaks *loudly with insurance*, while colleague A shows *hesitation* in his talking. Thus, based on the features used in their linguistic style, we can conclude that the colleague A dominates the colleague B (i.e $\mathtt{Dom}_{\mathsf{A,B}} = +$ and $\mathtt{Dom}_{\mathsf{B,A}} = -$)

Preferences Now, that the model of communication is defined, we introduce the notion of negotiation on preferences. First, lets define the domain of preferences. We assume that the agent expresses its preferences on a defined object based on one or multiple criteria.

- Objects O : Set of all possible objects of negotiation. For example, negotiate to find at which restaurant have dinner.
- Criteria C: represents the criteria or features of preferences on a defined object. For example, we assume that we can choose a restaurant based on one or several of the following criteria = {cuisine, ambiance, quality of food, price, location}. Each criterion has its domain of values that we note: $\forall \mathsf{c} \in \mathsf{C}$, $\mathsf{D_c}$ is its domain. For example $\mathsf{D}_{\mathtt{cuisine}} = \{\mathtt{chineese}, \mathtt{italian}\}$.
- $\forall \mathsf{o} \in \mathsf{O}, \forall \mathsf{c} \in \mathsf{C}$, we define $\nu(\mathsf{c}, \mathsf{o}) \in \mathsf{D_c}$ as the objective value of preference attributed for the object o in the context of the criteria c. For example, Ginza is an expensive Japanese restaurant. Thus $\nu(\mathtt{price}, \mathtt{Ginza}) = \mathtt{exprensive}$ and $(\mathtt{cuisine}, \mathtt{Ginza}) = \mathtt{japanese}$.
- Lets now define interlocutor's preferences. $\forall \mathtt{agent_i}$ that has to define its preference for an object, for example a restaurant.
  - Preferences on crietria of quality related to the object: $\mathsf{Pref}_\mathsf{i}^\mathsf{C}(\mathsf{X}, \mathsf{Y})$ is a total ordered set of criteria. For example, $\mathsf{Pref}_\mathsf{i}^{\mathtt{restaurant}}(\mathtt{cuisine}, \mathtt{price})$ means that the criteria of cuisine is more important for the $\mathtt{agent_i}$ than the price to choose a restaurant. (To discuss: preferences are a total / partial oredred ?)
  - Once the criteria is defined, the $\mathtt{agent_i}$ defines his preferences on the domain of this criteria. Thus, $\forall \nu_1, \nu_2 \in \mathsf{D_C}$, the agent has a partially ordered preference on these values noted $\mathsf{Pref}_\mathsf{i}^\mathsf{C}(\nu_1, \nu_2)$ that can be represented as $\nu_1 >_\mathsf{C} \nu_2$. For example, $\mathtt{agent_i} : \mathsf{Pref}_\mathsf{i}^{\mathtt{cuisine}}(\mathtt{Japanese}, \mathtt{Chinese})$, means that $\mathtt{agent_i}$ prefers the Japanese cuisine over the Chinese. ν_1 and ν_2 can take other values as presented :
    - $\mathsf{Pref}_\mathsf{i}^\mathsf{C}(\nu_1, *)$ means that $\mathtt{agent_i}$ prefers the most ν_1.
    - $\mathsf{Pref}_\mathsf{i}^\mathsf{C}(*, \nu_2)$ means that $\mathtt{agent_i}$ doesn't like ν_2.
    - $\mathsf{Pref}_\mathsf{i}^\mathsf{C}(*, *)$ means that $\mathtt{agent_i}$ has no preference on C.
  - The last step consists in defining the agent preferences on the object "restaurant". Based on what we defined above, we conclude that defining a preference on an object is a multi criteria decision [2]. We denote a

function of decision Dec such that $\forall o_1, o_2 \in \mathsf{OxO}, \mathsf{Dec}$ define an order of preference on these objects where $\{o_1 \prec o_2, o_1 \succ o_2, o_1 \approx o_2\}$.

Belief base and intentions In this section we present the agent belief on his preferences. We situate our definition in the context of social conversation between two people. Suppose $i, j \in \{\mathtt{Interolocutors}\}$.

Following the BDI [5], we present the following definitions:

- $B_i\varphi$ the fact that $\mathtt{agent}_i$ believes that a proposition φ is true. For example, $\mathtt{Agent}_i$ likes Chinese cuisine is represented $B_j\mathtt{Pref}_i^{cuisine}(\mathtt{Chinese})$.
- $U_i\varphi = \neg B_i\varphi \wedge \neg B_i\neg\varphi$, means that the $\mathtt{agent}_i$ has no belief on φ. For example, the fact that $\mathtt{agent}_j$ ignores what type of cuisine the $\mathtt{agent}_i$ prefers is formalized : $U_j\mathtt{Pref}_i^{cuisine}(*,*)$.
- $I_i\varphi$ means that agent i has the intention that φ is true.
  In our work, we focus on communication of preferences. Therefore, $\varphi = \mathtt{Pref}_i^c(x,y)$ and we will consider formulas of the form: $B_j\mathtt{Pref}_i^c(x,y)$ (possibly, $i = j$ if we represent an agent belief about its own preferences, and $i \neq j$ when it represents the beliefs about the interlocutor's preferences).
  The dialogue is a negotiation about preferences. Therefore, we do not modify the preferences of the other (to be discussed with Chuck). We only have intentions of the form $I_iB_j\mathtt{Pref}_i^c(x,y)$: the agent has the intention to change a belief about a preference, with $i \neq j$, or $I_iB_i\mathtt{Pref}_j^c(x,y)$, with $i \neq j$.
  In our model, these $I_iB_j\varphi$ or $I_iB_i\varphi$ correspond to communications: the agent i has the intention to communicate a preference ($I_iB_j\varphi$) or to obtain the information about the interlocutor's preference ($I_iB_i\varphi$).
  Thus, we can write that $I_i\varphi$ means that agent i has the intention to communicate about φ (in one way or the other: obtain or transmit a preference).
  We define axioms of cooperation that allows an agent to respond to a communication. Thus, $B_i\varphi \wedge B_iU_j\varphi \wedge B_iI_jB_j\varphi \implies I_iB_j\varphi$.
  In our model, actions are not built automatically by a planer: the plan is described in an HTN following the DISCO paradigm... Theses actions are modeled using Disco [7] representation. The action selection is done reactively, where the next action is selected based on the user response on the previous action.

Utterances semantic Agents communicates using utterances that encapsulate the message and after each communicated utterance, agents will update their beliefs about the preferences of the other agent. Therefore an utterance is communicated to a need to update a belief. In the following we suppose that $\mathtt{agent}_i$ is the speaker and $\mathtt{agent}_j$ is the hearer. As messages are actions, the are defined with precondition and effects on the belief. The preconditions are all optional, because the message selection depends first on the agent strategy. However, defining preconditions allow us to do inferences in order to know the reasons that make the agent choose the action. For example, If the agent changes the subject of discussion and talk about Chinese food, it allows us to conclude

that the agent is dominant enough to lead the dialogue and change the subject of discussion. In addition, the effects are symmetric, we only represent the belief of the agent about its preferences and user preferences. We cannot represent the user belief, we can only represent the user perception of the user belief. For example, we situate our perception form the agent point of view, thus if the agent states that he likes Chinese food, thus, the agent believes that the user doesn't know the agent preference and the agent also has the intention to inform the user about its preferences. The effect of the statement is that now the agent believes that the user knows that the agent likes chinese food.

In the following, we will be presenting the utterances of dialogue, and we present the effect of this utterences on the agent belief in the case where the agent is either the hearer (*i.e* Agent = $\mathsf{agent_i}$) or the listener(*i.e* Agent = $\mathsf{agent_j}$)

- State.Preference($\mathsf{Pref_i}(P_1, P_2)$) : I prefer P_1 over P_2.
  - Preconditions(i): $\mathsf{B_i U_j Pref_i}(P_1, P_2), \mathsf{I_i B_j Pref_i}(P_1, P_2)$
  - Effects(j): $\mathsf{B_j Pref_i}(P_1, P_2)$
  - Effects(i): $\mathsf{B_i Effect}(j)$

  We define two variant valuations on stating preferences as follows:
  - State.Preference($P_i, *$): I prefer the most P_i.
  - State.Preference($*, P_i$): I don't like /hate P_i.
  - Example: State.Preference($\mathsf{Pref_i^{cuisine}}(\mathsf{Japanese}, \mathsf{Chinese})$) : I prefer japanese cuisine over chinese.
- Ask.Preference($\mathsf{Pref_j}(P_1, P_2)$) : Do you prefer P_1 to P_2 ?.
  - Preconditions: $\mathsf{U_i Pref_j}(P_1, P_2)$, $\mathsf{I_i B_i Pref_j}(P_1, P_2)$
  - Effects (j): $\mathsf{B_j U_i Pref_j}(P_1, P_2)$, $\mathsf{B_j I_i B_i Pref_j}(P_1, P_2)$
  - Effects(i): $\mathsf{B_i Effect}(j)$ (Remark it can be redundant ?)

  We define two variant valuations as follows:
  - Ask.Preference($\mathsf{Pref_j}(P_1, *)$): Do you like P_1?
  - Ask.Preference($*$): What do you like ?. This case appear when the speaker has no belief on the hear preferences.
  - Example: Ask.Preference($\mathsf{Pref_i^{cuisine}}(\mathsf{Japanese}, \mathsf{Chinese})$) : Do you prefer japanese cuisine or chinese?
- Propose.Preference(*V(criteria, value)*): I think that *value* would be great.
  - Preconditions: $\mathsf{I_i Pref_j}(\mathsf{V}(\mathsf{criteria}, \mathsf{value}))$
  - Effects: $\mathsf{B_j I_i Pref_j}(\mathsf{V}(\mathsf{criteria}, \mathsf{value}))$, $\mathsf{B_j Pref_i}(\mathsf{V}(\mathsf{criteria}, \mathsf{value}))$
  - Example: Propose.Preference($\mathsf{V}(\mathsf{cuisine}, \mathsf{Japanese})$: I want to taste japanese food.
- Accept.Preference(*V(criteria, value)*): Okay, let's choose *value*. After receiving a propose utterance from the $\mathsf{agent_j}$, $\mathsf{agent_i}$ might accept the proposal.
  - Effects: $\mathsf{B_{i,j} Pref_{i,j}}(\mathsf{V}(\mathsf{criteria}, \mathsf{value}))$
- Reject.Preference(*V(criteria, value)*): Sorry, I would choice something else.
  - Effects: $\mathsf{B_i} \neg \mathsf{Pref_j}(\mathsf{V}(\mathsf{criteria}, \mathsf{value}))$
- Propose.Object(*V(object, value)*): I think that *object value* would be great.
  - Preconditions: $\mathsf{I_i Pref_j}(\mathsf{V}(\mathsf{object}, \mathsf{value}))$
  - Effects: $\mathsf{B_j I_i Pref_j}(\mathsf{V}(\mathsf{object}, \mathsf{value}))$, $\mathsf{B_j Pref_i}(\mathsf{V}(\mathsf{object}, \mathsf{value}))$

– Accept.Object(V(object, value)): Okay, let's choose *value*.
  – Effects: $B_{i,j}Pref_{i,j}(V(object, value))$
– Reject.Object(V(object, value)): Sorry, I would choice something else.
  – Effects: $B_i \neg Pref_j(V(object, value))$

2.3 Find utterances in dialogs

In the following I represented the utterances in the hand made dialogues. When analyzing the recorded dialogues, the utterances appears in a more implicit manner. For example, when Lauriane says: " Sinon j'aime bien japonais". here its a State.preference(Lauriane, leonor,japonais).Loenor perceives it as a propose and make a reject by saying : "Je n'aime pas du tout le japonais." Dialogue Utterance

2.4 Synthetic dialogue with utterances

In this section, I present a synthetic dialogue to illustrate the language definition.Yhe goal of the agent is to invite the user to a restaurant. The Agent has a predefined list of preferences of types of food (AgentPreferences = { +Indian, +Italian, -Japanese}) and the agent has no information on user preferences (UserPreferences = {}). In this example the Agent is peer with the user.

1. A: Would like to have dinner with me ?	1. Propose.Preference(A,U,dinner).
2. U: Yes, that would be great.	2. Accept.Preference(U,A,dinner).
3. A: What kind of food do you prefer ?	3. Ask.Preferences(A,U,UserPreferences)
4. U: I like Japanese food	4. State.Preference(U,Japanese)
5. A: Oh, I really don't like japanese food.	5. RejectStrongly.Preference(A,U,Japaneese)
6. U: Ok. What do you prefer ?	6. Ask.Preferences(U,A,AgentPreferences)
7. A: I like italian food	7. State.Preference(A,italian).
8. U: Yeah, I like italian food too.	8. State.Preference(U,italian).
9. A: So let's have dinner at an italian restaurant.	9. Propose.Preference(A,U,Italian).
10. U: perfect for me!	10. Accept.Preference(U,A,Italian).

References

1. Timothy W Bickmore and Rosalind W Picard. Establishing and maintaining long-term human-computer relationships. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 12(2):293–327, 2005.
2. José Figueira, Salvatore Greco, and Matthias Ehrgott. *Multiple criteria decision analysis: state of the art surveys*, volume 78. Springer Science & Business Media, 2005.
3. Nick Haslam. Mental representation of social relationships: Dimensions, laws, or categories? *Journal of Personality and Social Psychology*, 67(4):575, 1994.
4. Carolyn Y Nicholson, Larry D Compeau, and Rajesh Sethi. The role of interpersonal liking in building trust in long-term channel relationships. *Journal of the Academy of Marketing Science*, 29(1):3–15, 2001.

5. Anand S Rao and Michael P Georgeff. Modeling rational agents within a bdi-architecture. *KR*, 91:473–484, 1991.
6. Harry T Reis, W Andrew Collins, and Ellen Berscheid. The relationship context of human behavior and development. *Psychological bulletin*, 126(6):844, 2000.
7. Charles Rich. Building task-based user interfaces with ansi/cea-2018. *Computer*, (8):20–27, 2009.
8. John R Searle. *Speech acts: An essay in the philosophy of language*, volume 626. Cambridge university press, 1969.
9. Jan Svennevig. *Getting acquainted in conversation: a study of initial interactions*, volume 64. John Benjamins Publishing, 2000.