Preliminary Analysis on The Induction of Communication Protocols

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Abstract

This paper describes our preliminary analysis on the induction of communication protocols. Our work has two goals: *(i)* to recognize rules (i.e. protocols) from the communicative behavior of people in daily activities and; (ii) to understand *how* a person *learns* to *infer communication protocols*. Our research aim is to conceive an effective Autonomous Agent and Human Agent communication. We record sequences of communication exchanges of computer scientists collaborating online as a benchmark for the analysis of *regularities* that emerge from the exchanges of those communications. We analyze their *conversation structures* and interaction. We found a particular event where *person A* had applied a similar manner of communicating as *person B* did in a *similar situation* (learning rules as a side effect of communicating). We demonstrate this analysis.

Keywords: Learning and Communication; Situated Cognition; Activity Theory; Agent Communication Language.

Introduction[1]

The foundation of our work is the investigation of problems of communication protocols encountered in real world scenarios as well as those emerging from the Multiagent Systems domain. In particular, we have considered the communication problems reviewed by (Clancey, 2001) of several scientists collaborating in a joint work carried out during the NASA Haughton-Mars Project. The focus of our work is to study the communication protocols among group members in a virtual joint work environment. We want to investigate *how* they *behave* in different contexts of communications. We focus on a particular scenario: computer scientists collaborating online to prepare a deliverable before a given deadline. We have kept track of the interaction among the collaborators with their tools and recorded about 40,000 word exchanges, including chat jargon and errors. These natural language conversations were converted into markup agent messages (having equivalent semantics) based on the formal model of the FIPA-ACL communicative acts[2] using the *activity states framework*. We have identified about 4,000 exchanges of communicative acts (i.e. performatives). These *translated conversations* were *analyzed* for identifying *regularities* that emerge from the exchanges; enabling us to identify how communication protocols may be induced. This paper is organized as follows: *(i)* motivation and related work; *(ii)* activity states; *(iii)* observing communications; *(iv)* preliminary results, and *(v)* conclusions.

Motivation and Related Work

We briefly review the motivation and related work in this section on (i) Learning and Communication (Bateson, 1972); and (ii) Situated Cognition and Activity Theory (Clancey, 1997; Leont'ev, 1977).

Learning and Communication

The basis of our work for understanding communication is rooted at the learning and communication theory of (Bateson, 1972). Bateson focused on how *learning* and *communication mutually influence* each other. Learning is categorized into a hierarchy structure following the laws of motion (i.e. rules for describing motion).

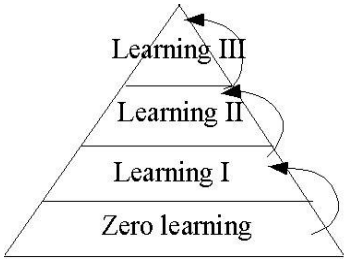

Figure 1: Hierarchy of learning types

Figure 1 illustrates the hierarchy of learning types. The zero learning is the basics of all learning; it is in some degrees stochastic and contains components of trial and error. The curved arrows represent that the one level up in the hierarchy of learning types is described by the motion of change of the level below it. In short, we can summarize it as: *(a)* zero learning: is described by deciding which response is right or wrong and is not subjected to correction; *(b)* learning I: is described by the change in the specificity of the response by correction of errors of choice within a set of alternatives; *(c)* learning II: is described as the change of process of learning I; either a corrective change in the set of alternatives from which choice is made, or a change in how the sequence of *experience* is punctuated (see explanation in

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[2] FIPA-ACL communicative acts specification provides a formalism for modeling agent messages. Agent communication languages (ACL) are specification languages for agents to communicate information and knowledge.
Link:http://www.fipa.org/specs/fipa00037/SC00037J.html

the next paragraph); *(d)* learning III: is described as the change of process in learning II, i.e.,: a corrective change in the system of sets of alternatives from which choice is made. We study only the learning type zero, I and II. (Bateson 1972) also discusses learning type IV; however we do not illustrate it here as it involves a higher level of learning that is tied to evolutionary processes.

The basic *elements* that *distinguish* one *type* of *learning* from the other are characterized by *contexts*. These contexts are *repeatable* but may never be the same, and may have *related classes* of *how* a person may *respond* to it. For example, we may have a case in which a *person's response* at *Time 2* is different from the one of the same person at *Time 1* (Bateson, 1972). From here, Bateson uses the notion of *external event systems* that carry *signals* telling a person *how* to *respond* to *what* and *when*. They might tell the person: *(i)* from what set of alternatives she[3] should take as her next move (class); and *(ii)* which member of that set she should choose. Bateson suggests that these *streams* of *events* (sequences of experiences) are somehow *punctuated* into *contexts* which may be *equated* or *differentiated* by the person. The *learning hierarchy* holds a key to *how* those streams of *events* is *punctuated* in the *first place*. In a similar notion, (Dewey, 1925) spoke of *events* that "turn into objects turn into meanings". Here Dewey focused on the aspects of "transformation": what goes on in-and between the stimulus-action/response which had been discussed by Bateson as "*communication sequence*". Dewey looked into the aspects of how *meanings* are constructed in *communications* focusing on *events*. Events are replaced by how *each sequence* of *communication* go through some kind of transformation. Quoting from (Dewey, 1925): "*Events have meanings; recognizing communication becomes an act of merely perceiving them."* In other words, the ability to *recognize* a certain *communication protocol* goes *through* the *punctuation* of *context* (learning), *markers* that *mark* them as *events* with *experiences* (having meaning), which are classified as "classes." We extend the example given by (Bateson, 1972). Let us assume in a sequence of events, person A's behavior is perceived as a stimulus for person B's behavior and how person B responds to that behavior is by learning to select from her set of *contexts* (i.e. all the related events) the next alternatives she takes. In these sets of contexts, how does she learn how to know what to respond with and when?

Situated Cognition and Activity Theory

The definition of *situated cognition* is based on the idea that every human thought and action is adapted to the environment that is *situated*. Situated is then defined as consisting of 3 elements which are: *(a)* What people *perceive* (structural view); *(b) How* they *conceive* their *activity* (functional view) and *(c)* What they *physically do together* (behavioral view). It is also concerned with the "representation", that occurs in the brain like imagining a scene, or speaking to oneself. This process of formulating the representation, from the agent's perspective involves *intentionality*. Situated Cognition defines intentionality as being about *conceiving*: *(a)* a categorization as being a thought; *(b)* categorizations as being about something (referential); *(c)* the thinking process itself as being part of an activity (Clancey, 1997). The *Activity Theory* on the other hand, emphasizes on what an *organism* is *doing* in the world and that the *subjectivity* of that *activity* is realized *within* and *constructed* by *interaction* (Clancey, 2002). Situated Cognition serves as a complete research view for understanding the integrated mechanisms of how humans coordinate, and conceptualize their activities. The Activity Theory (Leont'ev, 1977) provides a platform to analyze daily activities of people; how consciousness (e.g., motives, intentions) arise within-and during the coordination and conceptualization of their daily activities. Since our aim is to understand and explain how humans induce communication protocols, it is necessary to relate: *(i)* Situated Cognition; *(ii)* Activity Theory; *(iii)* Learning, and *(iv)* Communication. So that we can explain how a person *coordinates* (i.e.(i)) as a whole by *conceptualizing* her *context* (i.e.(i),(iii)) of *what* her *activity* is (i.e. (i),(ii)) when communicating (i.e. (iv),(i)) structured by her *private rules*. (when we speak of *private rules*, we refer to the manner a person is structuring her learning and understanding).

Activity States

We have briefly described in the previous sections the state of the art. Now we introduce our own framework: *activity states*, which is inspired by these studies: *(i)* Transactional Dynamics (i.e. Situated Cognition); *(ii)* Mental reflections on action and operation (i.e. activity theory); *(iii)* Mental states (i.e. Beliefs, Desires, Intentions); *(iv)* Transitional states and phases. The *activity states* framework (Binti Abdullah, 2005) main contribution is to provide for intermediary concepts that map natural language conversations onto an equivalent agent communication language (FIPA-ACL). FIPA-ACL is derived from Speech Acts which were developed as a theory for characterizing human conversations. Speech acts were later employed in Agent Communication. The conversion step is a sort of a full circle by then re-applying the agent language back to human conversations[4]. Therefore, our work is connected to the well-established framework of (Searle, 1983) at the same time extending the notion of *intentionality* of (Clancey, 1997; Leont'ev, 1977). If we separate the conversion steps from learning how the communication protocols are induced, we would not be able to understand how intentions arise in the first place within a person's activity. Then we would not achieve our aim to know *how* those *communication protocols* are *punctuated*. So, we must

[3] We use she for he/she.

[4] In (Searle, 1983), the author explores some connections between Intentional States and Speech Acts in order to answer the question "What is the relationship between the Intentional State and the object or state of affairs that it is in some sense directed at?".

begin by understanding *how intentions arise,* meanings and communications are formulated. The conversion steps specifically focus on that.

The center idea of activity states is that *what* a person *wishes* to communicate to others is influenced by her *current mental activity states*. Mental states[5] are generally concerning the beliefs, desires and intentions. We extend the notion to *mental activity states* inspired by the concept *of mental reflections* on action and operation (Leont'ev, 1977). We look into: *(i)* the current activity the people is engaged in (i.e. what is my current objective world); *(ii)* the flow of the conversations (i.e. what is my relationship with what I was doing previously, presently and what I would like to do in the future); and *(iii)* changes of context during conversations (i.e. my process is influenced by external factors that had triggered me to change direction) as guidelines for identifying *beliefs*, *desires* and *intention*. We also look at it from both views: (i) activity states of the speaker and (ii) activity states of the hearer.

A person's *beliefs* and *desires thus her intention* is a two way relationship with her: *(i)* inner processes and *(ii)* the activity that she is engaged in. They are always mutually *conceptualizing* the *context* of her action. Therefore, the *choice* of intention is more likely to be *activity directed* depending on the task that the person has to do. In some cases the activity direction can turn some task, into short term-goals or long-term goals (i.e. persistent goal). We give a scenario below to illustrate why we model the intentions as *activity-directed*:

I think I want to do C -(1) →I am going to do C -(2) → I will do C -(3) →I am doing C -(4) →I have done C -(5)

As an example, these are representations of some mental states of a person's activity that have been manipulated during time. What manipulates the "states" has direct relationship to the activity states implying what the person is actively conceptualizing. What happens when there is an impeachment to do C during step (3)?

C can't be done -(6) →I think I can't do C -(7) → I think maybe I won't do C -(8) →I think I really won't do C -(9)→ I won't do C- (10) → C won't be done by me -(11)

For this, we argue that not all communication is goal-directed. The way one communicates normally reflects her ongoing activities. These activities may influence the states of beliefs and/or desires and thus her intention. As a consequence, the current activity she is engaged in might make her to change directions during the course of communication. The next question is, how do we study these "*interruptions*" of states? We relate this to the *transactional dynamics* approach. Transactional dynamics is centered on the idea that treats "*events*" as the fundamentals unit of study. Events here are defined as a composition of psychological, temporal and environmental aspects. Although we relate our study to this approach, we do not use this term in our framework for the reason that we look at the different phases of behavior of the subject on the social tool (e.g. instant messaging). We need to know at which point the communication protocols had been induced by the subject, and at that point, what changes had occurred (i.e. interruption or pause). Therefore we replace the term "transactional dynamics" with *transitional states* as a consequence of the observation of the different states (i.e. phases) a person goes through. And also the sequences of events that had contributed to her change of behavior from one state to the other.

[5] Our definition of mental states is within the study of "activity".

Observing Communications

This section illustrates the daily communications scenarios among the collaborators. We have analyzed daily chats between two collaborators (period of 7 months) and minutes of meetings which were held twice a month among five collaborators (period of 2 months). In particular, we have kept track on two person's communicative behavior on the Web, Pete and Mathew. We show samples of the environments in figure 3 and 4 below.

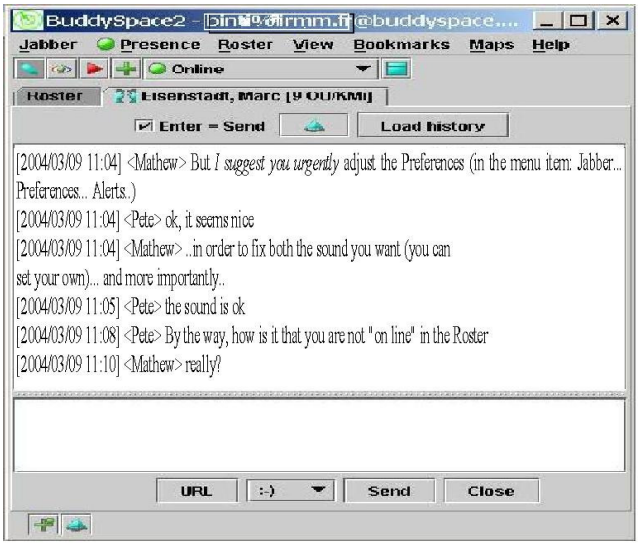

Figure 3: Daily chats between Mathew and Pete.

Figure 4: A typical virtual meeting, held at least once in two weeks among group members.

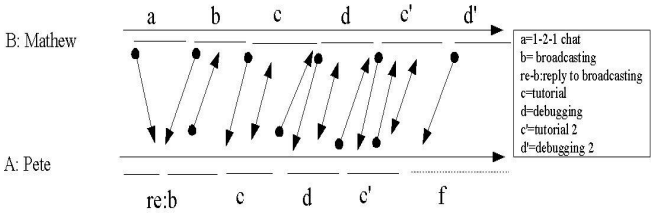

Figure 5: Observing transitional states of Mathew and Pete.

Figure 5 corresponds to figure 3. It is the representation of the transitional states to identify, *where*, and *how* Pete had applied different/new communication protocols. Activities are labeled as *a*, *b*, *c* and *d*. *c'* is a similar type of activity to *c* and so is *d'* to *d*. The arrow (●→) denotes who changed the context of communication. The double directed arrows denote the exchanges of communication. The horizontal line denotes the time of activity. Hereafter, we illustrate the steps for *identifying changes* that have occurred during the *transitional states*: *(i)* locate the point of changes of activities: *(ii)* look at what are the events that had caused the activity to take a change; *(iii)* locate at which event A's behavior had responded in a way similar to B's; *(iv)* compare the communication structures (e.g. conversations *or* conversations and interaction with tools) of A (e.g., Pete's) to B (e.g., Mathew's); *(v)* now, compare the communication structures of A to any of his previous set of related events (i.e. *contexts*); *(vi)* study the differences and then generalize the changes; *(vii)* continue for related behaviors of A.

Preliminary results

We illustrate the collaborating scenarios. Pete is the project manager for this joint project and he was new to this environment (i.e. instant messaging and video-conferencing). Mathew, on the other hand, is an experienced collaborator and has run many virtual collaborations. Everyday Mathew and Pete go online to chat about the project. Pete's job was to make sure everyone does his/her share of work, and respect the deadlines in order to achieve their shared goals together. So he had a tough job to make sure that everyone stays focused and that the meeting does not run over an hour. Before the FlashMeeting[6] reported hereafter, at the start of the collaboration, Mathew had taught privately Pete how to use the tool. During the first meeting held among some of the collaborating members, Pete carried out his role. We show the excerpted natural language conversations of the two meetings M_1, M_2:

M_1. Excerpted from FlashMeeting 1, Date: 17/09/2004. Duration of meeting: 1 hour 34 minutes 51 seconds
(1) Pete: Craig, can you hear me?
(2) Craig: Yes, we hear you but Mathew is not there. Oh we have Mathew and Justine. Hi Mathew.
(3) Mathew and Justine (M & J): Hi everybody, everybody ok?
(4) Pete: Yes, good afternoon to everybody. I could see somebody from X, not looking like Iris, maybe he can introduce himself to us.
(5) Unknown: Hello everybody. I am the colleague of Iris, she's just coming up, and in a few moments she's here.
(6) M & J: By the way, you all notice, there's a slightly new interface from what we used last time. So, now you notice, down below, if you click on the little chat tab, you should see it highlighted in green, actually makes it a little easier to have a simultaneous chat while others discussion is going on.
(7) Craig: Hi, Iris, how are you doing?
(8) M: Hello iris, welcome to FlashMeeting. Hope the technology is working well for you. You probably work out on the hand button to raise your hand or you click on the interrupt button if you have something urgent to say. It's a strictly push to talk model because that makes the audio simply work a lot more reliably and it also it makes the replay of the meeting well coz we know exactly who's talking at any moment. And you can stop broadcast anytime just by clicking on the…, in fact un-broadcasting or broadcasting again and someone will take the floor.

M_2. Excerpted from FlashMeeting 2, Date: 22/09/2004. Duration of meeting: 58 minutes
(1) Pete: Good afternoon everybody
(2) Craig: hi you
(3) Pete: Good afternoon Simon. Maybe it is your first time practicing this kind of meeting. So there is 1 button to start and to stop broadcasting and to join the queue. So you have to press to start and to ask for the queue and to stop broadcasting as well.

Two similar events took place during meeting M_1, M_2. Refer to M_1: at *(4)*, *(5)* and *(8)*. We can conclude that: (i) Pete knows Iris, but he does not know the colleague of Iris. (ii) On the other hand, Mathew does not know Iris. So, he immediately proceeds to give instructions to her on how to use the tool. Refer to M_2: Pete re-encountered, a "new face", Simon. However, this time he immediately proceeds to give instructions on how to use the tool which is in a way similar to how Mathew had done it, even if with modified structures. We demonstrate the results of our interpretation of that learned behavior below.

Table 1: Comparing the conversation structures of Mathew and Pete on a similar context.

Mathew's instruction to Iris on the 17/09/04, (context c_1). Agent Messages in this column correspond to M_1; sentence label (8) above.	**Pete's instruction to Sm on the 22/09/04, (context c_1'). Agent Messages in this column correspond to M_2; sentence label (3) above.**
[7]30 greet m[8], iris û	3 greet p[9], sm û
31 inform-if m,iris (tch)(wk)(wl) =	4informp,sm (prc)(mtg)(1stm)

[6] FlashMeeting is a video-conferencing tool developed by the team at kMi, Open University, The UK.

[7] The message format follows partly the FIPA-ACL format which is in this order: message number, communicative act (e.g. greet), sender (e.g. m), receiver (e.g. iris), content (e.g. *û*, which is an abbreviation used for the sentence or (wk) which abbreviates *work*). In this message, number 30, we denote the sentence simply as û because of the nature of greeting.
[8] m stands for Mathew.
[9] p stands for Pete and sm stands for Simon.

Mathew's instruction to Iris on the 17/09/04, (context c_1). Agent Messages in this column correspond to M_1; sentence label (8) above.	**Pete's instruction to Sm on the 22/09/04, (context c_1'). Agent Messages in this column correspond to M_2; sentence label (3) above.**
=true	^ (t-is) (1) (**bt**[10])
32 inform-ref m,iris (wk) (hnd)(**bt**)	5 inform-ref p,sm (**bt**)(str)(**brdc**[11])
33request whenever m,iris (rs)(hnd)(clk)(hnd)(**bt**)v	6 inform-ref p, sm (**bt**)(**stp**[12]) (**brdc**)
34 inform-ref m,iris (clk)(int)(**bt**) ^	7inform-refp,sm (**bt**)(to)(jn-q)
35 request whenever m,iris (nd-to) (sy)(smtg)(urg)	8 request whenever p, sm (str) (prs)(**bt**)
36 confirm m,iris (md)(fm)(psh-to)(tlk)	9 request whenever p, sm (as-q) (prs)(**bt**)
37 inform-ref m,iris (mk)(ad)(rlb)	10 request whenever p, sm (**stp**) (**brdc**)(prs)(**bt**)
38 inform-ref m,iris (mk)(repl) (wl)	
39 inform-ref m,iris (knw)(wh)(tlk)(pt)	
40inform-ref m,iris (cn)(**stp**)(**brdc**)(ayt)	
41 request whenever m,iris (clk)(**stp**)(ubrdc)(**stp**)(**brdc**) v	
42 request whenever m,iris (clk) (**brdc**)(ag)(**stp**)(**brdc**)	
43 inform m,iris fl (sm)(tk)	

Table 2: A comparison of Pete's conversation structures to his own in a similar context.

Pete giving instruction *t* to several people on the 17/09/04 (i.e. context c_2)	**Pete giving instruction *t* to Sm on the 22/09/04 (i.e. context c_1') .**
54 cfp p,all (ag) (str)(ans-q)	4 inform p,sm (prc)(mtg)(1stm) ^ (t-is) (1)(bt)
55 cfp p,all (tk)(us)(csd)	5 inform-ref p,sm (bt)(str) (brdc)
56 inform-ref p,all (qst1)(wht)(t-dv)	6 inform-ref p, sm (bt) (stp) (brdc)
57 inform-ref p,all (qst2) (wht) (is) (av-crt)	7 inform-ref p,sm (bt) (stp) (jn-q)
58 inform-ref p,all (qst3) (cn-be)(dn)(14dys)	8 request whenever p, sm (str) (prs) (bt)
59 inform-ref p,all (qst1) (us)(nclr)	9 request whenever p, sm (as-q) (prs) (bt)
	10 request whenever p, sm (stp) (brdc) (prs) (bt)

We show in table 1, the converted conversations of Mathew and Pete. This is a particular case, where the memory of Pete has allowed him to act in a way similar to how Mathew has acted before by *re-sequencing* and *re-enacting* learned situations (Clancey, 1997). The words in bold *(stp),(brdc),(stp)* are the *parameters* that had both appeared in Mathew and Pete's conversation structures. In table 2, we show the comparison of the conversation structures of Pete to his other conversation structures in a *similar context*; where Pete had given instructions to several people on what to start with for the meeting. We had done this in order to locate if there were any changes in the *private rules* of Pete after he had observed and learned from Mathew during that particular event. To show clearly how the *communicative acts* along with the *parameters* had been re-sequenced, we re-translate column 1 and 2 of table 1 into figure 6 and 7 respectively. Therefore, we now have e=greet; inform-if=h; inform-ref=b; request whenever=f; confirm=q; inform=g; Ls = listener (i.e. sm); x*n*=parameters and y*n* = parameters.

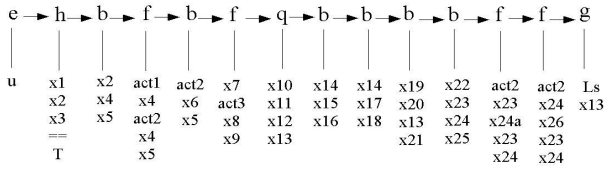

Figure 6: Communication protocol of Mathew at context c_1.

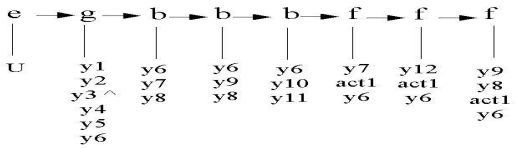

Figure 7: Communication protocol of Pete at c_1'.

Refer to figure 6: (i) from sequence *h-b-f-b* and look at *q* and the sequence *b-f-f;* had been re-sequenced into *g-b-b-b-f-f-f* which is shown in figure 7. The parameters: *x5= y6* (i.e. button); *x23=y9* (i.e. stop) and *x24=y8* (i.e. broadcast) are the ones that had re-appeared in Pete's structures; (ii) now we look at the interrelationships between the conversation structures of Mathew's and Pete's. We denote m_p*:* the message number of Pete's and m_m: the message number of Mathew's. The *Lhs* and *Rhs* respectively are to denote the causality relationship of messages.

Table 3: Causality relationships between Mathew's and Pete's messages (i.e. context c_1 and context c_1').

Lhs	**Rhs**
4_p	$\leftarrow 31_m$-43_m
5_p	$\leftarrow 36_m$-40_m-41_m-42_m
6_p	$\leftarrow 40_m$
7_p	$\leftarrow 32_m$-33_m
8_p	$\leftarrow 5_p$
9_p	$\leftarrow 6_p$
10_p	$\leftarrow 7_p$

Referring to table 3, at the beginning of Pete's instructions, he had generalized all the instructions previously given by Mathew starting from message 31 until

[10] **bt** stands for button.
[11] **brdc** stands for broadcasting.
[12] **stp** stands for stop.

43, then specialized the functions of the features from message 5 to 7. Whereas from message 8 to 10, he had related the functions with its actions by indexing his messages in reference to his previous messages 5, 6 and 7. Now we compare these findings to table (2). We found what still remains as his private rules: *(i)* whenever the context is *to only explain*; start communication with the object (i.e. inform-ref) and follow by the description in a pre-order relationship. Now, *what* had taken place during this event? We notice that: (*i*) the protocol of Mathew has been *re-sequenced* by Pete and improvised by induction; generalizing and then conceptualizing the description and functions of object *w (*i.e. *w* is button) to the context; and (*ii*) the learned rules are then adapted to his own experience, (Pete remembered that he had seen how Mathew had encountered that context and had handled in a way similar to the one of Mathew). The communication protocol of Mathew was an efficient one as Pete had remembered well the functions of the objects and what to execute in order to make use of those functions. Pete had re-sequenced them to the way his *private rules* remember them best. When there are *changes*, we know that there are *differences*. The differences trigger the interaction between parts in the mind. By recognizing those differences in *private rules,* we can recognize the *learning operators* that have been responsible for those alterations in the private rules that had enabled Pete to induce communication protocols. We need to consider other aspects. Firstly, when Mathew was giving the instructions, what did he "perceive" from the user interface? (See figure 4). We make an assumption that most probably *that moment* when he begun by describing the *hand button,* corresponds to the current state of the user interface. On the other hand, Pete had not mentioned the hand button but the *broadcasting button* because the current state of the user interface was not similar to Mathew's. Secondly, *how* did Pete recognize a *similar context* of situation (is the "new face" a part of the stimulus/signal in the *external event system* as mentioned by (Bateson, 1972))? How did he *recognize* the "instructions" of Mathew as a set of communication protocols? Is "giving instruction to use the tool" a member of the class context of "instructions"? How was the communication protocol *punctuated*? Did he *induce* the *sameness* of *context;* then recognize that *particular way* as a set of communication protocols? In other words, are we correct to a-priori assuming this: Pete had *induced* a *sameness* of *context* (Mathew said "Welcome to FlashMeeting". Later, Pete said "Hi Simon, maybe this is your first time using") and looking that the *context* was about "using the tool for the first time" for new users, Pete had remembered how Mathew had handled that situation.

Conclusions

Our overall analysis has been based on the conversation structures of five people. In this particular example, we show the analysis of two person's conversation structures. We generalize for now that humans: *(i)* have *private* rules; *(ii) learn* from experience; *(iii)* private rules and learning may be monitored, modelled and used in real contexts (Learning Agents in Multiagent System). We outline several points from our observations and work. Firstly, people learn from their experiences by observations. Secondly, they remember and adapt the communication protocols as how they remember them best. This is then influenced by their private rules. Thirdly, when they re-encounter similar situations, they remember to how they have observed others handle the situations, and proceed to handle them in a similar way. They had merged and adapted the communication protocols of others into their very own. Fourthly, observing transitional states of human activities allows us to trace *where* changes in communication protocol takes place. Fifthly, allowing the conversations to be in a more or less formalized framework has enabled us to know *how* the changes had taken place by looking into the *re-sequencing* and the *re-enacting* of the communicative acts and parameters. The *re-sequencing* and *re-enacting* had happened by *learning* through *experience*. In summary, the activity of learning and communicating has faculties such as imagination, conceptualization, reasoning, comparing, remembering, confirming and conviction. Our next stage consists in further analyzing more corpuses. From these findings, it can help us to understand how to design effective communication among Autonomous Agents and Human Agents that are able to infer each other's communicative behaviour.

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