

The Effect of Familiarity on Knowledge Synchronisation

Andrew Lee*

*Department of Computer Science
University of Exeter, UK
Andrew.Lee@exeter.ac.uk

Abstract

Sequences of dialogue acts occur in conversational dialogues, for example explanations are normally followed by acknowledgements, and queries are usually followed by responses. In a co-operative goal-directed dialogue, these patterns of moves can be seen to represent the synchronisation of knowledge, indicating how participants maintain mental maps of their own knowledge and that of their partner. However, these sequences may be influenced by the familiarity of participants, for instance when sufficient communicative conventions have been established between participants to omit acknowledgements to previous dialogue acts through non-verbal signals or implicit communicative patterns.

This paper sets out to determine whether a correlation between dialogue acts and familiarity exists by investigating the distribution of dialogue acts in transcripts of goal-directed dialogues where participants are either familiar or unfamiliar with each other. Any correlation may then provide opportunities for an automated mind-minding agent to identify and simulate familiarity when interacting with a human mind-minding agent.

1 Introduction

In a conversational dialogue, two participants take turns exchanging information in order to establish shared knowledge (Power, 1979). Utterances made in the dialogue can be represented as dialogue acts (Traum, 2000) using a variety of coding schemes, which exemplify the structure of the discourse (Carletta, 1997). Using these dialogue acts, patterns can be identified within discourse to indicate how conversational goals are met (Carlson, 1983; Walker, 1990).

However, these sequences of dialogue acts cannot always be assumed to be complete due to metalinguistic information. With only verbal exchanges between participants who have no prior knowledge of each other, the structure of the discourse should exhibit complete patterns of dialogue acts in order to synchronise knowledge, since there are no other cues to provide responses. This is not always the case where participants in a conversation have prior familiarity with each other, where non-verbal communication conventions may have already been established to converse more efficiently. In addition, the psychological rapport developed between two familiar conversants introduces situations where sequences of dialogue acts are interrupted to engage

in unrelated sub-dialogues, for instance social communication or digressions to recall shared experiences and establish reference points.

The purpose of this paper is to identify whether significant differences exist between conversational dialogues between participants who are either familiar or unfamiliar with each other. If a simple metric to measure familiarity based on dialogue acts alone can be identified, automated mind minding agents can alter their responses to establish and maintain psychological rapport with human agents in order to develop a more natural interface.

1.1. The Map Task Corpus

To analyse the effect of familiarity on dialogue, the HCRC Map Task corpus (Anderson et al, 1991) was used. The Map Task corpus comprises of 128 transcripts of conversational dialogue between two participants engaged in a navigational task. The participants are given variations of a map where a common start point is marked on both maps but a number of landmarks may appear on one or both of the maps. One participant (the Giver) also has a route drawn on the map and an end point, and their task is to guide their partner (the Follower) along

this route, primarily by verbal communication only although a subset of the tasks allows eye contact as a non-verbal.

Sixty-four (50%) of the transcripts are recorded and coded between participants who have not had prior contact with each other. The remainder of the tasks are conducted with participants who are familiar with each other.

The MapTask data is coded with a rich set of annotations, the relevant data for this investigation being thirteen types of dialogue moves (figure 1), whether the Giver or Follower is making the utterance, and familiarity between participants.

The structure and coding of the tasks provide suitable data to investigate knowledge synchronisation in a co-operative goal-directed conversational dialogue since participants are engaged on a specific goal-oriented and knowledge based task. By engaging in the navigational task by verbal communication only, participants must synchronise their knowledge of their own mental state and that of their partner in order to navigate through the maps, and must therefore provide sufficient information to inform each other of their knowledge state.

Initiating Moves

- Instruct: command to perform an action.
- Explain: information not elicited by partner.
- Check: confirmation of information.
- Align: checking attention or agreement.
- Query-YN: question expecting a yes/no answer.
- Query-W: other types of question.

Response Moves:

- Acknowledge: shows previous move was heard.
- Reply-Y: yes response to yes/no question.
- Reply-N: no response to yes/no question.
- Reply-W: response to other type of question.
- Clarify: repetition of information.

Pre-initiating Move

- Ready: indicates start of dialogue game.

Other Moves:

- Uncodable: incomprehensible utterances.

Figure 1: Move annotations used in the Map Task corpus (Isard, 1995).

2. Experimental Support

2.1. Knowledge Synchronisation

To model knowledge synchronisation, a representation of the mental states of the participants is generated with regards to new information, and rules describing how the mental states are updated based on a dialogue move are applied to the MapTask data. The goal of the mental representation and knowledge synchronisation rules is to model mental states at the end of each dialogue game coded in the MapTask data. The mental states are represented by maintaining whether each participant definitely

knows or only believes that they or their partner has knowledge of objects and relationships described in a sentence (figure 2.)

	Giver		Follower	
	Self	Other	Self	Other
Objects				
Relationships				

Figure 2. Mental State Representation for Knowledge Synchronisation.

In general, the rules for knowledge synchronisation are as follows:

1) When an utterance is made by one of the participants, the information contained in that utterance is separated into objects (references to environmental landmarks on the maps) and relationships (interactions with the objects in the environment.) This separation allows the modelling of situations where an utterance made in response to a previous move demonstrates that the relationship is understood but the object referred to is not, for example when the Giver mentions a landmark that is on their map but not on the Follower's map and it is the object reference that is being queried, not the relationship to the object.

2) The mental state of the speaker is updated to register whether the objects or relationships are definitely known (K) or are believed to be known (B), both by themselves and by their conversational partner. The mental state of the other participant is not updated since they have not made an utterance confirming their knowledge or beliefs.

3) As subsequent dialogue moves are recorded, the knowledge and belief of the speaker is updated accordingly.

4) The mental state of both participants at the end of a dialogue game should all show Definitely Known for all fields to be considered a complete knowledge synchronisation.

As an example, an Instruct dialogue move, such as the utterance "go past the picket fence" made by the Giver demonstrates that the Giver knows about a picket fence object and a relationship of going around it. The Giver can only believe that the Follower knows either or both of these pieces of information until proven otherwise through subsequent exchanges, however the mental state of the follower cannot be updated at this point (figure 3).

	Giver		Follower	
	Self	Other	Self	Other
G: Go past the fence				
Fence	K	B		
Go past the fence	K	B		

Figure 3. Knowledge Synchronisation after an Instruct move.

If the follower responds an Acknowledgement move, the Follower has demonstrated that they know what information the Giver referred to and that their own mental state includes the referenced information (figure 4).

	Giver		Follower	
	Self	Other	Self	Other
G: Go past the fence (instruct)				
Fence	K	B		
Go past the fence	K	B		
F: Okay (acknowledge)				
Fence	K	B	K	K
Go past the fence	K	B	K	K

Figure 4. Knowledge Synchronisation after an Acknowledge move.

The Giver does not update their belief that the Follower is aware of information until they align their knowledge (figure 5.)

	Giver		Follower	
	Self	Other	Self	Other
G: Go past the fence (instruct)				
Fence	K	B		
Go past the fence	K	B		
F: Okay (acknowledge)				
Fence	K	B	K	K
Go past the fence	K	B	K	K
F: Okay (acknowledge)				
Fence	K	B	K	K
Go past the fence	K	B	K	K
G: You should be at the hill (align)				
Fence	K	K	K	K
Go past the fence	K	K	K	K
Hill	K	B		
Should be at the hill		K	B	

Figure 5. Knowledge Synchronisation after an Align move.

The sequence of dialogue Moves recorded in Map Task transcripts exhibit the process of synchronising knowledge between participants in order to complete the navigational task and this is reflected in Map Task annotations for dialogue Games where sub-goals of the main task are completed.

In an actual conversation, a dialogue game may have been considered complete but not explicitly demonstrated through the dialogue itself, for example an instruction from the Giver may be followed by a Query-YN move, where the acknowledgement is inferred by asking a subsequent question. In the case of a task conducted with no eye contact and no prior contact between participants, this represents an assumption made about a partner's mental state. In other cases, the incomplete knowledge synchronisa-

tion may be due to non-verbal communication such as eye contact (Boyle, 1994) or communicative conventions previously established due to familiarity between participants.

2.2. Exploring the Role of Familiarity

To investigate the role of familiarity on the sequences of dialogue Moves, the frequency of Move pairs in each of the 128 transcripts was counted so that the distribution in familiar and unfamiliar transcripts could be compared. Since the Move annotations had already been determined, no further processing of the utterances made by participants was required.

Any Move pair combinations which included the Uncodable move were also counted to determine whether any significant differences could be identified between the familiarity of conversants, either because the participants generated more uncodable utterances due to their unfamiliarity with each other, or the uncodable utterances occurred because the participants were familiar enough to feel comfortable communicating in such a manner.

An example of how the Move frequency was calculated is shown in figure 6.

- Move 1 : Giver - ready
- Move 2 : Giver - instruct
- Move 3 : Follower - acknowledge
- Move 4 : Giver - align
- Move 5 : Giver - instruct
- Move 6 : Follower - acknowledge

Move Pair	Occurrences	Distribution
Ready/Instruct	1	0.2
Instruct/Acknowledge	2	0.4
Acknowledge/Align	1	0.2
Align/Instruct	1	0.2

Figure 6. Example of Move Pair frequency Distribution counting

The results were generated using a utility program and tabulated in a spreadsheet for analysis, with the distributions of move pair frequency calculated for all familiar and all unfamiliar transcripts.

3 Results and analysis

The frequency distributions of Move pair combinations were analysed with the following three criteria:

- Whether there were any significant differences in the proportion of Move types between Familiar and Unfamiliar transcripts.
- Whether the distribution of Move pairs indicated a trend towards Familiar or Unfamiliar transcripts.
- Whether significant differences could be identified in occurrences of individual Move pairs

3.1 Proportion of Moves

The frequency of Move types listed in figure 1 were counted and calculated as a percentage of the total number of moves listed throughout the 128 transcripts. The proportion of Moves in both Familiar and Unfamiliar transcripts were found to have a similar distribution pattern with a difference of less than 3% (table 1)

Table 1. Percentage of moves occurring in Map Task transcripts

	Familiar	Unfamiliar	Difference
Acknowledge	19.34	22.17	-2.83
Align	7.17	5.82	+1.35
Check	8.15	7.61	+0.54
Clarify	4.90	3.82	+1.08
Explain	8.16	7.49	+0.67
Instruct	15.15	16.66	-1.51
Query-W	3.29	2.33	+0.96
Query-YN	5.60	6.97	-1.37
Ready	7.62	7.72	-0.10
Reply-N	3.33	3.20	+0.13
Reply-W	3.60	3.07	+0.53
Reply-Y	12.06	11.82	+0.2
Uncodable	1.05	1.32	-0.27

The differences in Move type distributions between familiar and unfamiliar transcripts were consistent with expected results; the higher number of Acknowledgements and Instructions for participants unfamiliar with each other reinforced the need for explicit feedback between conversants since they had not yet established any other patterns of communication with each other. The higher number of Moves involving more implicit knowledge synchronisation, as seen in the Align, Check and Clarify moves found in familiar transcripts, was reasonable since the familiarity and communicative confidence between participants reduced the need for explicit feedback.

However, the low values of differences between familiar and unfamiliar transcripts were slightly surprising since it was anticipated that differences between Move Pair distributions would be more pronounced.

3.2 Move Pair Distribution

The ratio of transcripts in which Move pairs contained specific Move Types was tabulated to determine the distribution of between sets of Familiar and Unfamiliar data (table 2.)

Overall, the distribution of Move pair combinations occurred more frequently in transcripts where the participants were familiar with each other. Wh-questions had an overwhelming majority in Familiar transcripts suggesting a higher level of interaction

between participants which required a wider range of complex queries. Clarifications, Alignments and Explanations were also significantly higher in Familiar transcripts, again suggesting more complex interactions. This was in contrast to Unfamiliar transcripts in which the majority of Move type occurred for Acknowledgements and Yes/No questions representing a minimal exchange of information.

These results were expected since unfamiliar participants were not expected to have sufficiently developed a model of their conversational partner's communication patterns which would have allowed them to engage in more complex interactions, instead restricting their dialogue to common initiation-response patterns with minimal additional information in order to fulfil their given task.

Table 2. Distribution of Move pair combinations in the Map Task corpus.

Move Pair	Majority Familiar (out of 13)	Majority Unfamiliar (out of 13)
Query-W	13	0
Clarify	12	1
Align	10	3
Explain	10	3
Reply-W	10	3
Check	8	5
Instruct	8	5
Ready	8	5
Reply-N	8	5
Reply-Y	6	7
Acknowledge	5	8
Uncodable	4	9
Query-YN	3	10

The significant majority of Uncodable Move types for Unfamiliar transcripts reflected a lack of confidence between participants which was consistent with the lack of familiarity, for instance an increased number of uncodable utterances would be expected if one participant was unsure of how to express themselves due to a lack of familiarity with their partner.

3.3 Significant Individual Differences

In many cases, the proportional difference of moves between Familiar and Unfamiliar transcripts suggested a large variation; however the number of occurrences of that move combination skewed the results. For example the frequency of the Reply-N:Reply-Y combination in Familiar transcripts was 333% higher than in Unfamiliar transcripts, but occurred in 0.02% of the Familiar transcripts (2 occurrences out of a total 11992 samples.)

To filter out the skewed results, any results where the distribution of Move pairs was less than 1% and the ratio of Move pairs between Familiar

and Unfamiliar transcripts was less than 25% were removed, giving the results in table 3.

In general, these results reflected the increased level of explicit feedback and checking for knowledge synchronisation between unfamiliar partners, compared to a more complex level of interaction between familiar partners. For example, the Instruct:Acknowledge and Acknowledge:Instruct pairs in unfamiliar transcripts indicate a basic pattern of initiating and responding to commands to explicitly synchronise knowledge. The Acknowledge:Query-YN and Instruct:Query-YN pairs demonstrate immediate simple queries to establish that both participants share common knowledge.

In contrast, the higher frequency of Move pairs such as Instruct:Align and clarifications suggest that the explicit feedback is omitted in transcripts where participants are familiar with each other.

Table 3. Significant individual differences in Move Pairs between Familiar and Unfamiliar transcripts in the Map Task corpus. Maj indicates whether move pairs in Familiar transcripts had a majority over Unfamiliar transcripts (F) or vice-versa (U). %Trans indicates the proportion of transcripts in which the move pair combination occurred. %Inc indicates the percentage majority of Move pairs in the majority transcript.

Move pair	Maj	% Trans	% Inc
Instruct:Align	F	1.49	41.85
Instruct:Acknowledge	U	8.58	35.50
Query-W:Reply-W	F	1.69	35.33
Acknowledge:Query-YN	U	1.67	33.67
Ready:Explain	F	1.21	31.60
Acknowledge:Clarify	F	1.05	29.23
Instruct:Query-YN	U	1.73	28.60
Check:Clarify	F	1.02	28.55
Acknowledge:Ready	U	2.8	25.90
Align:Reply-Y	F	3.83	25.85
Acknowledge:Instruct	U	7.56	25.17

3.4 Interpretation

Although the distribution of dialogue moves throughout all transcripts is generally similar, the majorities of different move pairs in Familiar transcripts suggest a higher number of varied and more complex interactions. The patterns of dialogue in transcripts where participants are unfamiliar with each other tend to exhibit patterns of initiation and response which conform to a more functional dialogue.

This result is reinforced by the difference between specific move pairs, for example where Unfamiliar transcripts demonstrate 35.5% more In-

struct:Acknowledge pairs, which is consistent with the exchange of explicit feedback with an unfamiliar partner.

In terms of automated mind-minding agents, two uses for these results can be identified:

-Detecting familiarity between participants. By examining the distribution of dialogue moves between two participants, an automated mind-minding agent could measure the level of familiarity between conversants and adapt its own communication accordingly. Additionally, the changes in dialogue move distribution over time may indicate an increasing or decreasing familiarity between participants to which the automated agent can adapt.

-Exhibiting familiarity in order to promote psychological rapport with a human agent. By matching dialogue output from an automated mind-minding agent to model distributions of dialogue moves corresponding to a higher level of familiarity, an automated agent may simulate the development of a more natural interaction that develops over extended contact time.

The results from this study show distributions of dialogue moves specific to the Map Task corpus where the taxonomy of dialogue moves is specific to a co-operative goal-directed task. Other dialogue act taxonomies exist to cover a wider range of dialogue types (Hovy 95) and further studies are required to determine whether a measure of familiarity based on dialogue move distributions identified in this paper are applicable to other co-operative goal-directed conversations and whether this approach can be generalised to a wider range of dialogue types.

4 Conclusions

This study set out to establish whether any significant differences in the distribution of dialogue Moves could be identified throughout the Map Task corpus for transcripts between conversational participants who were either familiar or unfamiliar with each other. The co-operative goal directed nature of the source transcripts served to focus the conversational exchange and thereby limit the variation in dialogue to a restricted range of dialogue moves.

Some notable variations were found between Familiar and Unfamiliar transcripts, suggesting that conversational participants who were familiar with each other used a wider range of exchanges with a higher level of complexity. Transcripts in which participants were unfamiliar with each other tended to use a more restricted range of moves, conforming to a direct initiation-response type exchange with more explicit feedback.

The results obtained were specific to the Map Task corpus transcripts and may not necessarily apply to other conversational dialogues where a

distinction between familiar and unfamiliar participants is given. However, the approach used does suggest some general principles to distinguish the familiarity of participants in a goal-directed task by measuring the level of explicit feedback and the complexity of exchanges.

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