# Relating coordination in non-linguistic games and dialogue games


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## Abstract

We use TTR, a type theory with records, to characterize a non-linguistic game involving perception and coordination and then suggest that this same notion of game can be applied to conversational games (including conversational games which are multimodal). We will show that this notion of game has a natural connection to topoi as discussed by Breitholtz, and is based on the same kind of common sense reasoning. However, it has nothing to say about how to make choices between alternative moves in non-deterministic games. For this we suggest blending the TTR notion of game with standard Game Theory, taking inspiration from recent work by Heather Burnett.


It is a central idea in TTR (Cooper, 2012; Cooper and Ginzburg, 2015) that perception involves classifying an object or situation as being of a type, or in type theoretic terms making a judgement that an object or situation, $a$ is of some type $T$, $a : T$. The notion of game introduced by Cooper (2014); Breitholtz (2014a); Cooper (prep) builds on this idea. Games in the sense we will discuss also relate to the notion of genre or conversation types discussed by Ginzburg (2012) and communicative projects discussed by Linell (2009). This follows a long tradition of making a connection between linguistic and non-linguistic action, going back at least to Austin (1962); Lewis (1969); Searle (1969); Clark (1996); Barwise and Perry (1983). This work continues to be influential in a great deal of linguistic research including SDRT, dynamic syntax, applications of game theory to linguistic analysis, the philosophy of language and computational work on dialogue systems.

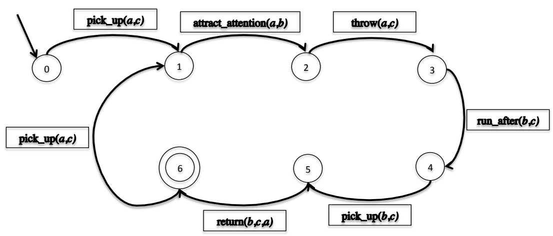
Another central idea in the TTR characterization of games is the idea that situations or events can be seen as strings of smaller situations or events. This is an adaptation to TTR of the finite state approach to events developed over many years by Tim Fernando. A recent account of Fernando's work can be found in Fernando (2015). In (1) we give an example of how we can characterize string types in TTR:

(1) a. if $T_1, T_2 \in$ **Type**, then $T_1 \frown T_2 \in$ **Type**
$a : T_1 \frown T_2$ iff $a = x \frown y$, $x : T_1$ and $y : T_2$

b. if $T \in$ **Type** then $T^+ \in$ **Type**.
$a : T^+$ iff $a = x_1^\frown \ldots ^\frown x_n$, $n > 0$ and for $i$, $1 \leq i \leq n$, $x_i : T$

Consider the non-linguistic game of "fetch", played by a human and a dog, where the human throws a stick which the dog is then supposed to run after and bring back to the human. We can think of a simple version of this as a finite-state machine as given in (2).

(2)




Here notations like 'pick_up($a$,$c$)' represent types of situations or events, in this case, the type of situation where $a$ (the human) picks up $c$ (the stick). We can think of the automaton as representing a type of events. Given the string types we introduced in 1 the type represented can be expressed as in (3).

(3) (pick_up($a$,$c$)$^\frown$attract_attention($a$,$b$)$^\frown$
throw($a$,$c$)$^\frown$run_after($b$,$c$)$^\frown$
pick_up($b$,$c$)$^\frown$return($b$,$c$,$a$))$^+$

In order to explain how two agents (a human and a dog) could coordinate on the production of an event of this type we use the notion of gameboard (Lewis, 1979; Ginzburg, 1994, 2012) or information state (Larsson, 2002) which enables the agents to keep track of where they are in the process of creating the event. Each agent has their own view of the state of the game and this plays a central role in coordination, especially when the two views of the state of the game are not in sync and repair must be carried out. We shall model information states as records in the TTR sense, that is, sets of fields consisting of labels and objects and gameboards as record types which are types of information states. For this relatively simple, non-linguistic game we shall characterize the type of information states as requiring one field for an agenda, as in (4).

(4) $\left[\text{ agenda } : \text{ list}(\textit{RecType}) \right]$

This means that any information state (a record) of this type must contain a field labelled by 'agenda' whose value is a list of record types, representing the types that the agent plans to realize (in order) at the current stage of the game. We say that an initial information state is one where the agenda is the empty list, that it, it is of the type in (5).

(5) $\left[\text{ agenda=[] } : \text{ list}(\textit{RecType}) \right]$

The *manifest field* in (5) expresses that an information state of this type must not only contain a field with the label 'agenda' whose value will be a list of record types but that in addition it determines which list of record types it will be, namely the empty list.

Now we can think of a game as a set of update functions corresponding the transitions in the finite state automaton (2). In (6) we give three examples of such functions.

(6) a. **initial update function**

$\lambda r{:}\left[\text{agenda=[]:list}(\textit{RecType})\right]\ .$
$\left[\text{agenda=[}\left[\text{e:pick\_up}(a,c)\right]\text{]:list}(\textit{RecType})\right]$

b. **non-initial, non-final update function**

$\lambda r{:}\left[\text{agenda=[}\left[\text{e:pick\_up}(a,c)\right]\text{]:list}(\textit{RecType})\right]$
$\lambda e{:}\left[\text{e:pick\_up}(a,c)\right]\ .$
$\left[\text{agenda=[}\left[\text{e:attract\_attention}(a,b)\right]\text{]:list}(\textit{RecType})\right]$

c. **final update function**

$\lambda r{:}\left[\text{agenda=[}\left[\text{e:return}(b,c,a)\right]\text{]:[}\textit{RecType}\text{]}\right]$
$\lambda e{:}\left[\text{e:return}(b,c,a)\right]\ .$
$\left[\text{agenda=[]:list}(\textit{RecType})\right]$

(6a) says that if the agenda is empty then the type of event where $a$ (the human) picks up $c$ (the stick) can be put on the agenda. (6b) says that if this type is on the agenda and there is in fact an event, $e$ of that type, then the type of event where $a$ attracts $b$'s (the dog's) attention can go on the agenda. (6c) is a final update function which returns an empty agenda after the dog has returned the stick. An empty agenda means that the agent exits the game successfully.

We have formulated this game as a game between three particular individuals $a, b$ and $c$. A version where we have abstracted over the roles is given in Figure 1. This maps a situation (modelled as a record) where there is a human, a dog and a stick to a set of update functions involving those participants.

Consider a dog, $d$, who perceives a human picking up a stick and attracts $d$'s attention with it, that is, $d$ has perceived an event of the type in (7).

(7)
$$\begin{bmatrix} \text{x:}\textit{Ind} \\ \text{c}_{\text{human}}\text{:human(x)} \\ \text{y:}\textit{Ind} \\ \text{c}_{\text{dog}}\text{:dog(y)} \\ \text{z:}\textit{Ind} \\ \text{c}_{\text{stick}}\text{:stick(z)} \\ \text{e:}\left[\text{e:pick\_up(x,z)}\right]^\frown\left[\text{e:attract\_attention(x,y)}\right] \end{bmatrix}$$

This is enough information for $d$ to come to the conclusion that she is involved in a type of event where she is playing fetch with the human. In fact, at this point, many dogs will start running in the direction in which the human appears to be about to throw the stick.

(8)
$$\lambda r{:}\begin{bmatrix} \text{x:}\textit{Ind} \\ \text{c}_{\text{human}}\text{:human(x)} \\ \text{y:}\textit{Ind} \\ \text{c}_{\text{dog}}\text{:dog(y)} \\ \text{z:}\textit{Ind} \\ \text{c}_{\text{stick}}\text{:stick(z)} \\ \text{e:}\left[\text{e:pick\_up(x,z)}\right]^\frown\left[\text{e:attract\_attention(x,y,)}\right] \end{bmatrix}.\ \left[\text{e:play\_fetch}(r.\text{x},r.\text{y},r.\text{z})\right]$$

Given a situation in which there is a human, a dog and a stick such that the human picks up the stick

$$\lambda r^*:\begin{bmatrix} \text{h} & : & \textit{Ind} \\ \text{c}_{\text{human}} & : & \text{human(h)} \\ \text{d} & : & \textit{Ind} \\ \text{c}_{\text{dog}} & : & \text{dog(d)} \\ \text{s} & : & \textit{Ind} \\ \text{c}_{\text{stick}} & : & \text{stick(s)} \end{bmatrix} .$$

$$\begin{array}{l}
\{\ \ \lambda r{:}\big[\text{agenda=[]:[}\textit{RecType}\text{]}\big]\ . \\
\quad\quad \big[\text{agenda=[}\big[\text{e:pick_up}(r^*\text{.h},r^*\text{.s})\big]\text{]:[}\textit{RecType}\text{]}\big], \\
\quad \lambda r{:}\big[\text{agenda=[}\big[\text{e:pick_up}(r^*\text{.h},r^*\text{.s})\big]\text{]:[}\textit{RecType}\text{]}\big] \\
\quad\quad \lambda e{:}\big[\text{e:pick_up}(r^*\text{.h},r^*\text{.s})\big]\ . \\
\quad\quad\quad \big[\text{agenda=[}\big[\text{e:attract_attention}(r^*\text{.h},r^*\text{.d})\big]\text{]:[}\textit{RecType}\text{]}\big], \\
\quad \ldots, \\
\quad\quad \lambda e{:}\big[\text{e:return}(r^*\text{.d},r^*\text{.s},r^*\text{.h})\big]\ . \\
\quad\quad\quad \big[\text{agenda=[]:[}\textit{RecType}\text{]}\big] \\
\hfill \}
\end{array}$$

Figure 1: Game of fetch with roles abstracted

and attracts the attention of the dog, this function returns the type of situations where the human and the dog play fetch with the stick. Note that it is important that it returns the type, not a particular situation of the type. The situation does not yet exist. The type indicates what kind of situation might be realized given the initial part the has been perceived. The dog can use this to guide its future actions in collaborating with the human to realize the type.

Note that characterizing a game in the way we have does not actually explain how anything actually happens. The update functions when given appropriate arguments will return a type. What an agent does with that type needs to be specified in a superordinate theory of action of the kind discussed in Cooper (2014, prep). The type theory as such enables us to provide a rich theory of the kind of objects that can be manipulated by the actions.

The function in (8) is exactly the kind of function employed by Breitholtz (2014a) to model enthymemes and topoi. Originally a rhetorical concept, an enthymeme is an argument where one or more premises necessary for the argument to be logical are suppressed. A topos in the same tradition, refers to an implicit inference rule that can be drawn on to underpin enthymematic arguments. Like topoi, the game modelled in the function above can be drawn on to underpin an act of reasoning. However, an observation by an agent of a move of the type where someone holds up a stick does not logically or necessarily entail that there will be a game of fetch. Rather the relation between the different types of moves or events in a conversational game (or a topos), is associative. Thus, in the example in (8) it could be that the human had a different intention or it might be that the human intended for there to be a game of fetch but just at this point fell and sprained her ankle, thus forcing the abandonment of the game. Nevertheless, despite the unreliability of the inference, it is an example of the kind of inference which agents live by in order to be able to interact with the world and with other agents. Breitholtz (2014b) gives a number of examples of how this kind of reasoning plays a role in dialogical interactions. On this account a conversational game is a strategy available to an interlocutor engaged in a particular activity who is to carry out a particular communicative project. Different games may be employed to perform the same kind of project – for example establishing which joint action to take in a given situation. One way of carrying out this project is by playing the suggestion game, as seen in 2. The suggestion game is of a type where the first move is made by one of the dialogue participants (who thereafter assumes the role of player 1 in the game) to the other. After the suggestion move follows an optional move by player one to motivate the suggestion, followed by an accept- or a reject move by player 2.

When engaging in dialogue, the participants of a conversational game have at their disposal sets of topoi – some of which are general, some associated with the activity or game – which can be drawn on to produce and interpret dialogue moves.

$$T_{G_S}\!:\big[\text{e:suggest(player1, player2 )}\big]^\frown\big[\text{e:motivate(player1, player2 )}\big]^{\leqslant 1\frown}\big(\big[\text{e:accept(player2, player1)}\big]\vee\big[\text{e:reject(player2, player1)}\big]\big)$$

$$\}$$

Figure 2: Suggestion game

There are, however, two important things missing in the current proposals for analyzing this kind of reasoning in TTR. One is that there is no indication of the *perceived degree of reliability* of the inference. The other is that there is no mechanism for dealing with *choices of action* in a non-deterministic game. We are currently exploring how a synthesis of the TTR approach to games with a more standard game theory (GT) as employed, for example, by Burnett (fthc) for the analysis of social meaning, could fill this gap and also place GT within a general theory of dialogue.

We illustrate this with a scenario where two agents, $A$ and $B$, are trying to agree on what to do in a particular situation. This could be done by means of various conversational games, and which one is chosen depends on several factors. Assume that $A$ tells $B$ "We are doing $P$!". In ordering $B$, $A$ limits $B$'s choices if $B$ wants to accept her role in an ordering game. On the other hand, choosing this strategy might decrease the likelihood that $B$ will keep playing the game. If $A$ chooses a strategy where he leaves $B$ the possibility of rejecting the suggestion, $B$ is more likely to accept the role assigned to her. If $A$ also adds a reason for doing $P$, the chances of success in actually getting $B$ to agree increases, as long as the reason chosen can be identified by $B$ as drawing on a topos which $B$ accepts and ranks as important.

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