How to play games with types

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UNIVERSITY OF GOTHENBURG

Outline

TTR Games in a theory of language as action

Social meaning games in GT

Relating the two notions of game

Argument games using topoi

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Argument games using topoi

Language as action

- Language as action (Austin, 1962; Lewis, 1969; Clark, 1996; Barwise and Perry, 1983)
- Agents need to coordinate action: coordination games (Lewis, 1969)

Two kinds of games

- Dialogue games build on techniques used in coordination games involving non-linguistic agents
- *Interaction games* in TTR, a type theory with records (Cooper, 2014; Breitholtz, 2014; Cooper, in prep)
- *Social meaning games* Burnett (fthc), drawing on techniques from Game Theory (GT) Lewis (1969)
- Combining these types of games in terms of a theory of dialogue involving *Information State Update*: Ginzburg's *KoS* (Ginzburg, 2012)

Potential contributions – KoS-TTR

- a framework for choosing which games to play
- an account of misunderstandings about which game is being played
- accommodation of games on the basis of interlocutor's behaviour
- explain how a single action can represent a move in more than one game — *What's cookin'?*

Potential contributions – GT

- an account of variation in probabilistic terms
- a variety of overall interactive strategies:
  - male rationalism – maximize own utility
  - collaborative – maximize utility (regardless of whose)
  - altruistic – maximize other's utility
- a theory of strategy in non-deterministic games
- a way of accounting for choice in dialogues where the opinion or world view of the receiver is important, such as argumentative dialogue

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Games in TTR

- Cooper (in prep), Ch. 1 (discussed here)
- Breitholtz (2014) in relation to enthymematic reasoning
- related to Ginzburg on genre and conversation types

Fetch – a game of interaction and coordination

Query – is this the beginning of an event of type *FetchGame*?

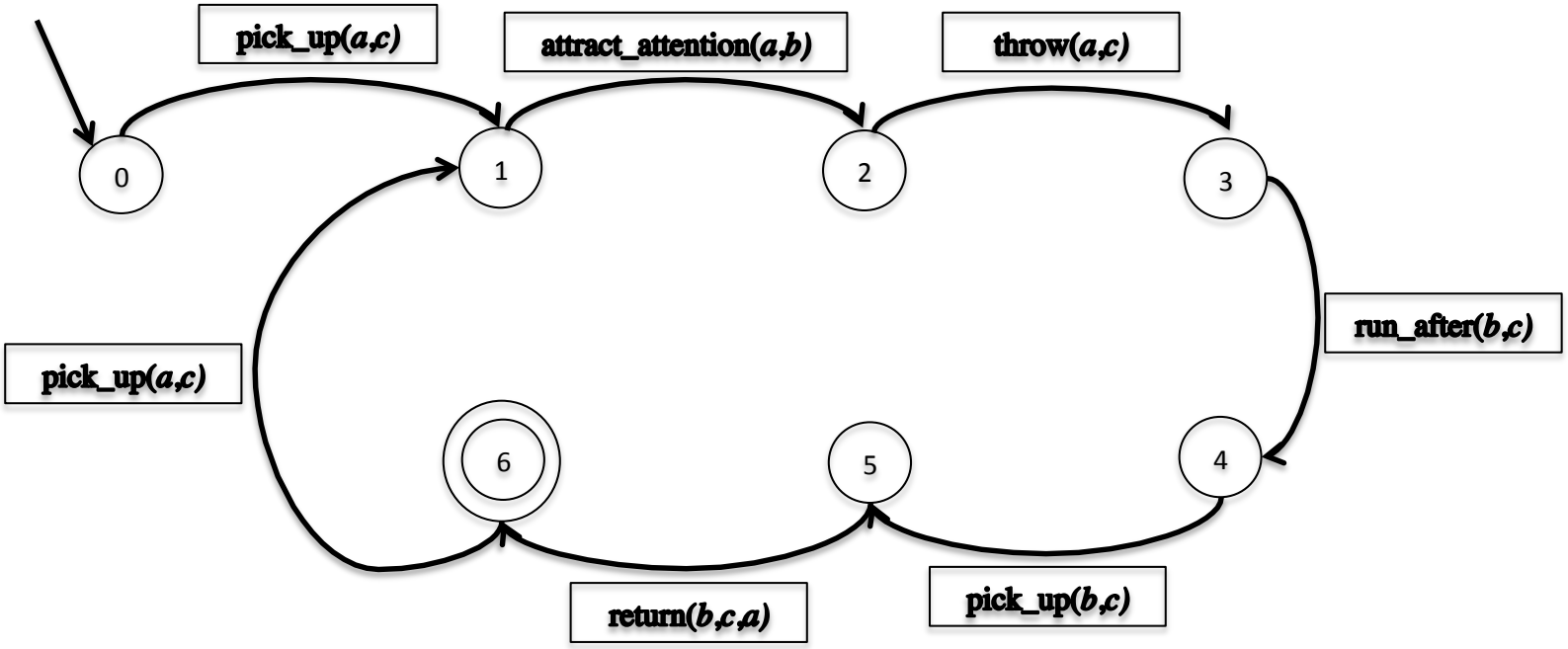
Creation – the dog must predict and carry out its contribution to an event of type *FetchGame*

String types

cf. work by Tim Fernando, e.g. Fernando (2015)

1. 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 $y : T_2$
2. if $T \in$ **Type** then $T^+ \in$ **Type**.
   $a : T^+$ iff $a = x_1{}^\frown \ldots {}^\frown x_n$, $n > 0$ and for i, $1 \leq i \leq n$, $x_i : T$
   ...

A game of fetch



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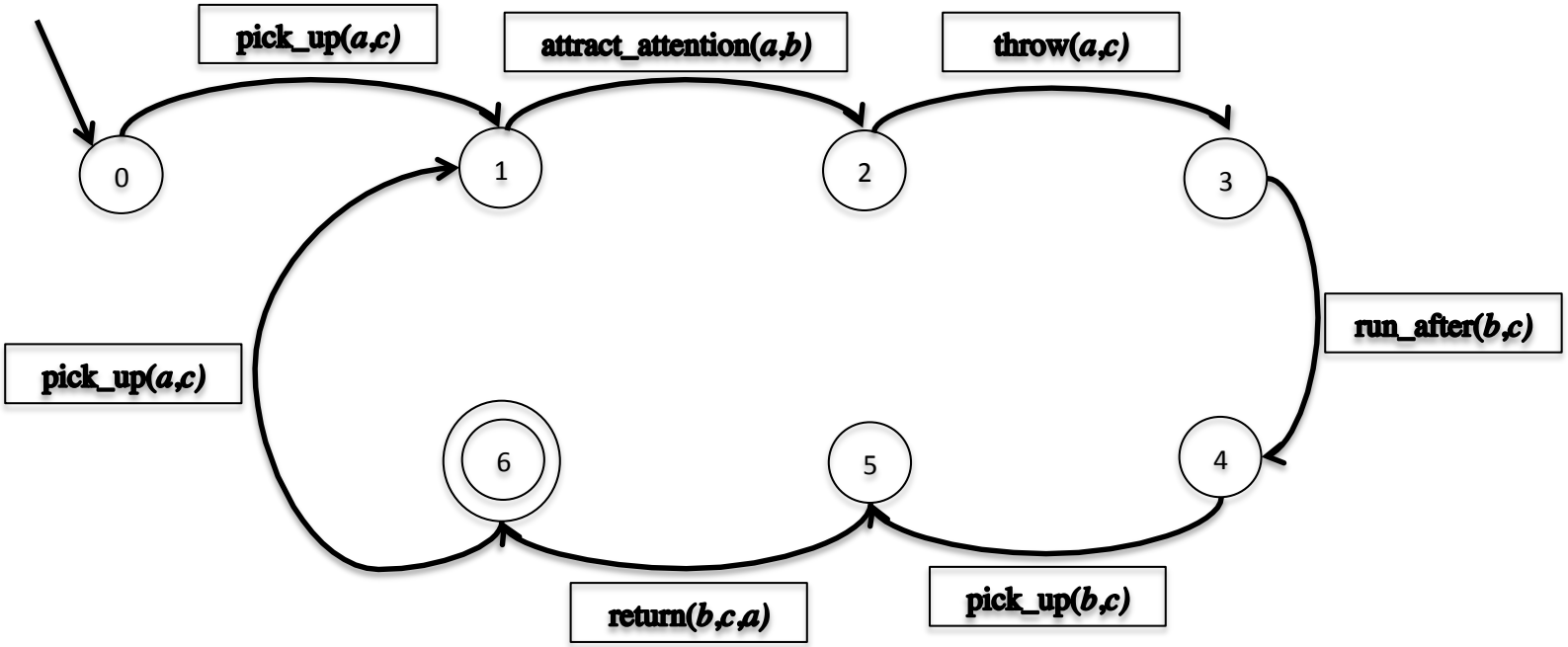

$$(\text{pick\_up}(a,c)^\frown\text{attract\_attention}(a,b)^\frown\text{throw}(a,c)^\frown\text{run\_after}(b,c)^\frown \text{pick\_up}(b,c)^\frown\text{return}(b,c,a))^+$$

Information states and gameboards

- Information states (gameboards) are used by agents to keep track of where they are in the creation of an event belonging to a certain type
- each agent has their own view of the state of the game
- plays an essential role in coordination
- *information state* (Larsson, 2002) and *gameboard* (Ginzburg, 1994, 2012, originally Lewis, 1979) are adopted from the literature on dialogue
- we shall model information states as records and use 'gameboard' to refer to types of information states

The types *InfoState* and *InitInfoState*

$$\begin{array}{rl} \mathit{InfoState} & \left[\begin{array}{lcl} \text{agenda} & : & [\mathit{RecType}] \end{array}\right] \\ \mathit{InitInfoState} & \left[\begin{array}{lcl} \text{agenda}=[] & : & [\mathit{RecType}] \end{array}\right] \end{array}$$

Game of fetch (human, a, dog, b, and stick, c)

- game as a set of update functions corresponding to transitions in a finite state automaton
- an initial update function
  $\lambda r{:}\left[\text{agenda}{=}[]{:}[\mathit{RecType}]\right]\ .$
  $\quad\left[\text{agenda}{=}[\left[\text{e:pick\_up}(a,c)\right]]{:}[\mathit{RecType}]\right]$
- a non-initial, non-final update function
  $\lambda r{:}\left[\text{agenda}{=}[\left[\text{e:pick\_up}(a,c)\right]]{:}[\mathit{RecType}]\right]$
  $\quad\lambda e{:}\left[\text{e:pick\_up}(a,c)\right]\ .$
  $\quad\quad\left[\text{agenda}{=}[\left[\text{e:attract\_attention}(a,b)\right]]{:}[\mathit{RecType}]\right]$
- a final update function
  $\lambda r{:}\left[\text{agenda}{=}[\left[\text{e:return}(b,c,a)\right]]{:}[\mathit{RecType}]\right]$
  $\quad\lambda e{:}\left[\text{e:return}(b,c,a)\right]\ .$
  $\quad\quad\left[\text{agenda}{=}[]{:}[\mathit{RecType}]\right]$

Corresponding action rules

$$\frac{r :_A \left[\text{agenda}=[]:[RecType]\right]}{:_A \left[\text{agenda}=[\left[\text{e:pick\_up}(a,c)\right]]:[RecType]\right]!} \; r \text{ is } A\text{'s current info state}$$

If A judges the current information state to have an empty agenda then A is licensed to create an information state where an event type of a picking up c is on the agenda.

$$\frac{r :_A \left[\text{agenda}=[\left[\text{e:pick\_up}(a,c)\right]]:[RecType]\right] \qquad e :_A \left[\text{e:pick\_up}(a,c)\right]}{:_A \left[\text{agenda}=[\left[\text{e:attract\_attention}(a,b)\right]]:[RecType]\right]!}$$

Game of fetch (with roles abstracted)

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

$$\begin{aligned}
\{\quad & \lambda r\!:\!\big[\mathsf{agenda}{=}[]\!:\![\mathit{RecType}]\big]\ . \\
& \quad \big[\mathsf{agenda}{=}[\big[\mathsf{e}\!:\!\mathsf{pick_up}(r^*.\mathsf{h},r^*.\mathsf{s})\big]]\!:\![\mathit{RecType}]\big], \\
& \lambda r\!:\!\big[\mathsf{agenda}{=}[\big[\mathsf{e}\!:\!\mathsf{pick_up}(r^*.\mathsf{h},r^*.\mathsf{s})\big]]\!:\![\mathit{RecType}]\big] \\
& \quad \lambda e\!:\!\big[\mathsf{e}\!:\!\mathsf{pick_up}(r^*.\mathsf{h},r^*.\mathsf{s})\big]\ . \\
& \qquad \big[\mathsf{agenda}{=}[\big[\mathsf{e}\!:\!\mathsf{attract_attention}(r^*.\mathsf{h},r^*.\mathsf{d})\big]]\!:\![\mathit{RecType}]\big], \\
& \ldots, \\
& \quad \lambda e\!:\!\big[\mathsf{e}\!:\!\mathsf{return}(r^*.\mathsf{d},r^*.\mathsf{s},r^*.\mathsf{h})\big]\ . \\
& \qquad \big[\mathsf{agenda}{=}[]\!:\![\mathit{RecType}]\big] \\
& \}
\end{aligned}$$

A problem

- There is no mechanism for deciding which strategy to choose in non-deterministic games. (More than one update function that can be applied.)
- **Solution:** Use GT game similar to Burnett's social meaning games associated with variation.

Outline

Obama

- Use of *-ing/-in'* verbal morphology (Labov, 2012, p. 22, cited by Burnett and Smith)
- at a barbeque — 72% *-in'*
- meeting press after barbecue — 33% *-in'*
- acceptance speech at Democratic National Convention — 3% *-in'*

Social meaning

- *-in'* — less educated, lower class
- *-ing* — more educated, higher class
- *-in'* indicates 'friendly', but also possibly 'incompetent'
- *-ing* indicates 'competent', but also possibly 'aloof'

Social meaning games

forthcoming work by Burnett

Definition 4.1. *A* ***Social Meaning Game*** *is a tuple* $\langle \{S, L\}, \langle \mathbb{P}, > \rangle, M, C, [\cdot], Pr \rangle$ *where:*

1. *S and L are the players.* Two players
2. *$\langle \mathbb{P}, > \rangle$ is the* ***universe*** *(a relational structure), where*
   - *$\mathbb{P} = \{p_1, \ldots, p_n\}$ is a finite set of properties.* Properties such as 'friendly'
   - *$>$ is a relation on $\mathbb{P}$ that is irreflexive.*
3. *M is a finite set of* ***messages****.* ing/'in'
4. *C is a measure function on M describing the* ***cost*** *of each message.*
5. *$[\cdot]$ is the* ***indexation*** *relation (to be described below).* e.g. 'in' is friendly
6. *Pr is a probability distribution over sets of properties describing L's* ***prior beliefs*** *about S.* e.g. to what extent does L think Obama is friendly

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TTR properties (a kind of dependent type): friendly, aloof, competent, incompetent

Properties such as 'friendly'

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Properties such as 'friendly'

preclude relation on types: friendly ⊥ aloof, competent ⊥ incompetent

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   - *$>$ is a relation on $\mathbb{P}$ that is irreflexive.* preclude relation on types: friendly $\perp$ aloof, competent $\perp$ incompetent
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TTR properties (a kind of dependent type): friendly, aloof, competent, incompetent

utterance types

Personae

- a notion from third wave sociolinguistics (Eckert, 2012)
- personae — maximal consistent subsets of properties in P
  - {competent, aloof} — "stern leader"
  - {competent, friendly} — "cool guy"
  - {incompetent, aloof} — "asshole"
  - {incompetent, friendly} — "doofus"
- *-ing* indicates either competent or aloof
  -in' indicates either friendly or incompetent
- the speaker chooses a message in order to increase the likelihood that the listener will associate a certain persona with the speaker
- friendliness of most importance at the barbecue
  both friendliness and competence important at the press conference
  competence most important at the Democratic convention

A problem

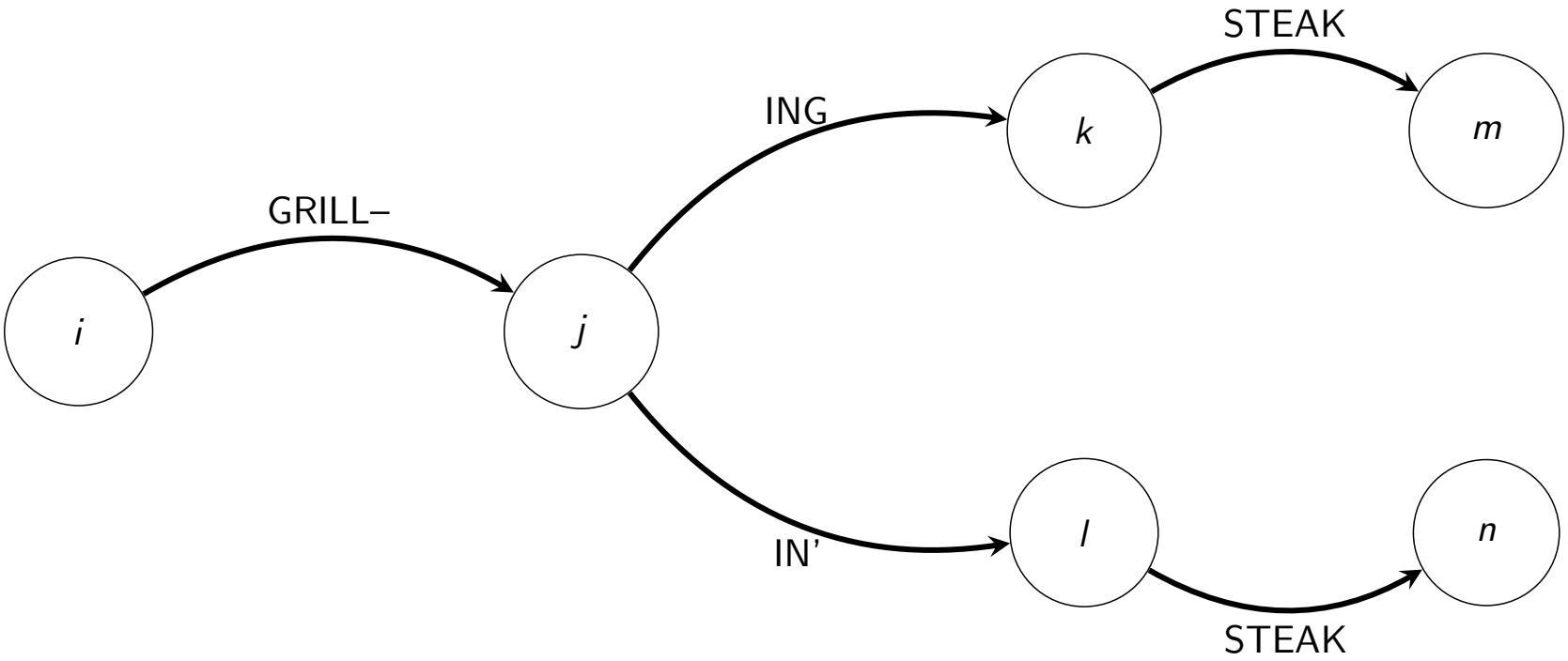
- Not immediately obvious how such games should be integrated into a general theory of dialogue.
- **Solution:** Embed the games in the kind of information state update approach associated with TTR

Outline

One way of putting TTR and GT together

- For each non-deterministic transition in a TTR game there is a Burnett game to help you make the choice
- That is, if you have more than one update function defined for the current state of the game you need a GT game to choose between them
- The probabilities associated with the different options are computed by a game referring to the mental states of the speaker and addressee as discussed by Burnett.
- Congenial with an information state update (gameboard) approach to dialogue
- *cf.* also HMMs

A simple example: Grilling steak



Outline

Argumentation in dialogue

- Estimating attitudes of addressee when choosing how to make an argument
- Involves estimating prior likelihood of addressee being convinced by a given argument

Our Corpus

- 40 triadic dialogues where participants have been asked to discuss a moral dilemma (Lavelle *et al.*, 2012)
- 20 of these conversations involves a patient diagnosed with schizophrenia

The balloon task

- Subjects asked to discuss a moral dilemma: Four people in a hot air balloon about to crash killing all four unless one of the four is thrown out
- pilot, pregnant woman (his wife), doctor (about to find a cure for cancer) and a child prodigy (new Mozart)

Two arguments

- if you throw out the pregnant woman, you are killing two people
- if the pregnant woman is thrown out, the pilot (her husband) may not be able to operate the balloon

Two topoi

- there is a choice between sacrificing n and sacrificing $n+1$ people $\rightarrow$ sacrifice n people
- someone is upset $\rightarrow$ they are not able to perform demanding tasks

Topoi and *Enthymemes*

- Enthymemes = (logically) incomplete arguments
  - lacks at least one premise
  - relies on what is "in the mind" of the listener
- The speaker expects the listener to have access to (and to acknowledge) a particular topos that underpins the argumentation.
- The topoi chosen affects whether the listener will be persuaded or not.

Part of a dialogue

- 42 A So I mean the person it seems like the person with least value is the pregnant woman.
- 48 B [she's] pregnant.
- 51 B [So you're] killing two people instead of one.
- 52 C Yhh and another thing is would he be able to pilot the balloon if his wife is overboard?

Argument game

- A TTR game (*cf.* suggestion games in Breitholtz (2014))
- Main moves: speaker makes an argument, listener accepts or rejects it
- In order to make an argument you have to first choose an appropriate topos
- Need a GT game

Argument game: choose topos

A tuple $\langle \{S, L\}, T_{cg}, \mathbb{T}, C, \mathfrak{I}, Pr \rangle$ where:

1. S and L are the *players* Two players
2. T_{cg} is a record type representing the *common ground* (*universe*) Type of the balloon situation
3. $\mathbb{T}$ is a finite set of *topoi* which S regards as relevant to the common ground Topoi on which arguments may be based
4. C_S is a measure function on $\mathbb{T}$ Cost of presenting topoi for S
   C_L is a measure function on $\mathbb{T}$ Cost of accepting topoi for L
5. $\mathfrak{I}$ is a relation between members of $\mathbb{T}$ and enthymemes *instantiating* them based on objects introduced in T_{cg}
6. Pr is probability distribution over $\mathbb{T}$ What S regards as topoi most likely to be accepted by L

Calculating the potential utility of using a topos

For $\tau \in \mathbb{T}$, S estimates potential utility of τ

$$utility_S(\tau) = \max(0, Pr(\tau) - C_S(\tau))$$

Payoffs: Actual payoff of τ for both players depending on whether L accepts or rejects

	Accept		Reject	
τ	$1 - C_S(\tau)$	$1 - C_L(\tau)$	0	$C_L(\tau)$

Updating expected probability of L being convinced

Let $\alpha \geq 2$ Temperature constant regulating learning rate

L accepts τ:

$$Pr(\tau) := Pr(\tau) + \frac{1-Pr(\tau)}{\alpha}$$

Increase probability that τ is convincing

$$\forall \tau' \neq \tau \; Pr(\tau') := Pr(\tau') - \frac{1-Pr(\tau)}{\alpha(|\mathbb{T}|-1)}$$

Decrease probability on other topoi

L rejects τ:

$$Pr(\tau) := Pr(\tau) - \frac{Pr(\tau)}{\alpha}$$

Decrease probability that τ is convincing

$$\forall \tau' \neq \tau \; Pr(\tau') := Pr(\tau') + \frac{Pr(\tau)}{\alpha(|\mathbb{T}|-1)}$$

Increase probability on other topoi

An example

$\mathbb{T} = \{\tau_1, \tau_2\}, \alpha = 2$
$C_S(\tau_1) = 0, C_S(\tau_2) = .2;\ C_L(\tau_1) = .8, C_L(\tau_2) = .3$
$Pr(\tau_1) = .75, Pr(\tau_2) = .25$

	Accept		Reject	
τ_1	$1 - C_S(\tau_1) = 1$	$1 - C_L(\tau_1) = .2$	0	$C_L(\tau_1) = .8$
τ_2	$1 - C_S(\tau_2) = .8$	$1 - C_L(\tau_2) = .7$	0	$C_L(\tau_2) = .3$

$\text{Utility}_S(\tau_1) = Pr(\tau_1) - C_S(\tau_1) = .75$
$\text{Utility}_S(\tau_2) = Pr(\tau_2) - C_S(\tau_2) = .05$
S chooses τ_1 based on estimated utility, L rejects based on actual payoff.
Update: $Pr(\tau_1) = .75 - \frac{.75}{2} = .375, Pr(\tau_2) = .25 + \frac{.75}{2\times 1} = .625$
$\text{Utility}_S(\tau_1) = Pr(\tau_1) - C_S(\tau_1) = .375$
$\text{Utility}_S(\tau_2) = Pr(\tau_2) - C_S(\tau_2) = .425$
S chooses τ_2 based on new estimated utilities, L accepts based on actual payoff.

What happened to the personae?

- Combining GT with pragmatics and variational sociolinguistics enables us to predict linguistic choices having to do with social meaning.
  - using a native, rural dialect rather than a standard variant
  - using a grammatical form associated with a particular persona
  - using an argument based on a particular topos in order to appeal to the perceived audience

Topoi and personae

- "Defining a culture is defining its topoi" Rosengren (2008)
- We suggest: "defining a persona in terms of the topoi that are associated with it"
- Different arguments to the same conclusion if you are talking to an investment banker or a yoga teacher
- *Let's take Walnut Street. It's shorter/It'll take us through the park*
- personae could be used to make an initial estimation of which topos might be most convincing to your interlocutor

Potential applications of topoi in personae – patients *vs* non-patients

- a way of characterizing patients/non-patients in our balloon task corpus
- a way of characterizing interaction between patients and non-patients
  - do non-patients present different personae when interacting with patients?
  - are patients or non-patients more likely to adjust personae in an interaction?
  - are patients or non-patients more likely/quicker to learn in the manner our "choose topos"-game suggests? (A dialogue participant who does not learn might repeatedly use the same topos despite lack of success.)

Potential applications of topoi in personae – dogwhistles I

- "Dogwhistles can be defined as terms that send one message to an outgroup while at the same time sending a second (often taboo, controversial, or inflammatory) message to an ingroup." (Henderson and McCready, 2018)
- Paul Ryan (quoted in Henderson and McCready, 2018): "We have got this tailspin of culture, in our inner cities in particular, of men not working and just generations of men not even thinking about working or learning the value and the culture of work."
- Criticized by Representative Barbara Lee as a "thinly veiled racial attack"

Potential applications of topoi in personae – dogwhistles II

- Henderson and McCready's analysis in terms of Burnett's social meaning games and personae linked to the inference (not their formulation):

  inner_city ⇒ urban_Afro-American_neighbourhood

- H&McC's analysis seems closely related to our idea of characterizing personae in terms of sets of topoi.
- For us the persona may be associated with other topoi relevant to this example, such as:

  Afro-American ⇒ poor
  poor ⇒ lazy

Conclusions

- we have suggested a way of combining a type theoretical approach to dialogue with game theory
- a way of relating GT to work on information state update in dialogue
- one way of putting probability and strategy into our work on dialogue
- some potential advantages:
  - dialogue strategies like accommodation and repair may involve choice of games
  - strategies for playing non-deterministic games
- we sketched an example of game involved in choosing a topos when making an argument
- suggested that a set of topoi (among other things) can be used to characterize a persona

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