Nature's Inventive Mishmash of

Turntaking

Mechanisms & Stuff

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Definitions

- “Turntaking”
  - Observable phenomenon
  - People take turns speaking in any sustained dialog
    - as measured at particular timescales & modes
- “Mechanism”
  - A causal chain of some significance
    - Recursive definition

Overview

- Introduction
- YTTM - Ymir Turntaking Model
  - Contexts, contextual alignment, coupling
  - Evaluation, extension: Other models
- Conclusions

F2F Dialog: Biggest Constraint

- Cognitive apparatus
  - Made for incremental interpretation
- Cognitive constraints
  - Interference between usage of key for production and understanding
    - E.g. working memory

Turntaking: What it is Good For

- Nature's "workaround"
- Ensures alignment of content
  - By ensuring that understanding can progress incrementally
    - Without interference from e.g. planning and presentation processes
      - Taking advantage of various information-carrying systems like face, intonation, tone of voice

YTTM

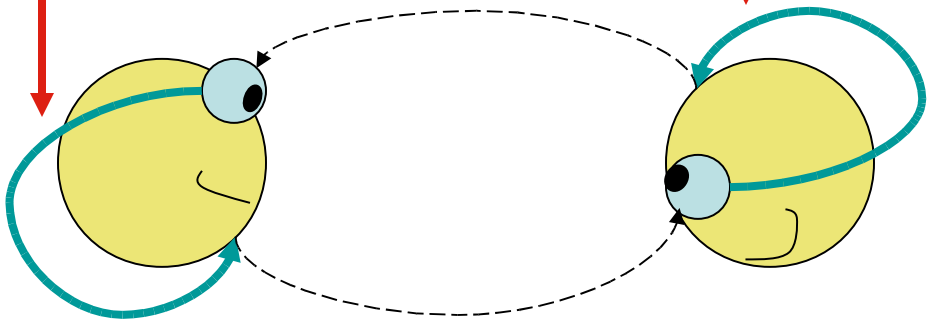
- Generative model
  - From perception to action (to fully generate, you have to include both)
- Runnable
- Multimodal
- Realtime

YTTM

- Separation of dialog behaviors into
  - Envelope processes
    - Those which control the *process* of communication
  - Content processes
    - Those responsible for the *topic* of discussion

YTTM: Participants

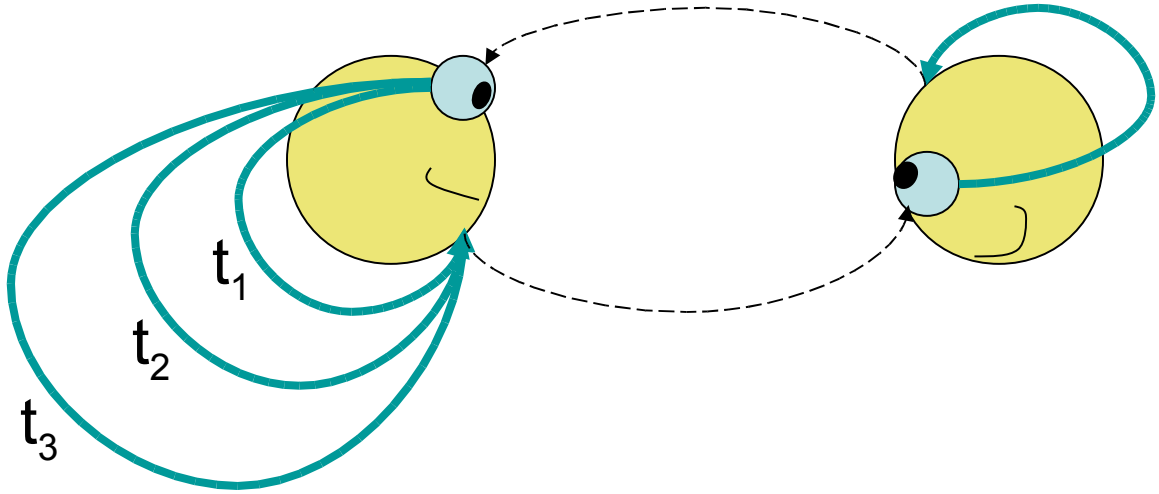
- Modeled as separate processes with independent perception-action loops



YTTM: Participants

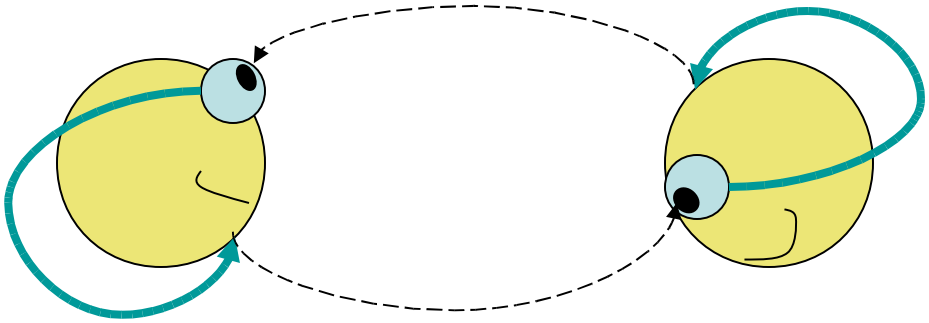
- Modeled as separate processes with independent perception-action loops
  - Multiple loops at different timescales

$t_3 \geq t_2 \geq t_1$



YTTM: Participant

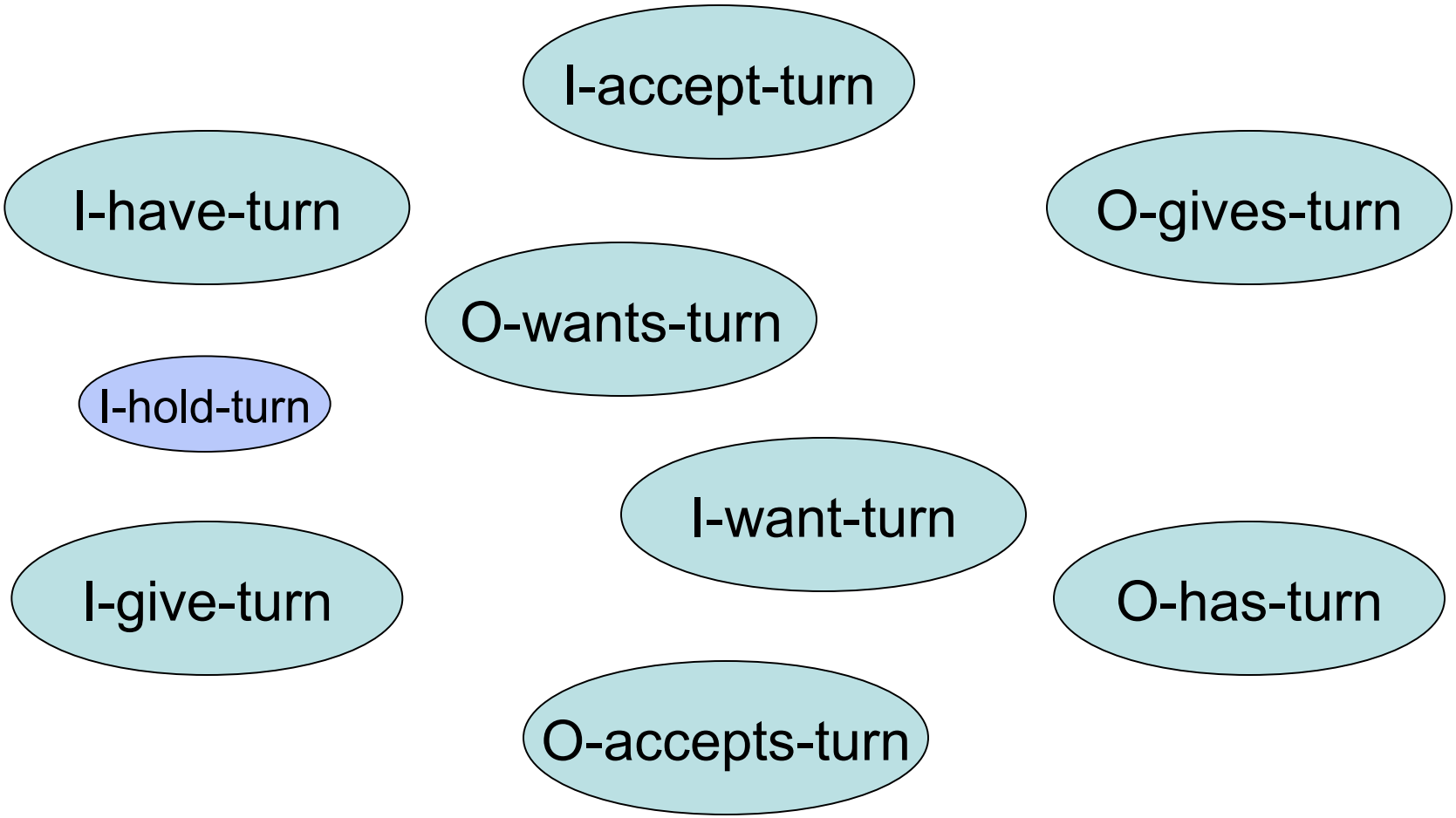
- Cognition = {P, D, C_u, C_g, B, G, P}
  - Set of perceptual feature processes, P
  - Set of decision-making processes, D
  - Content understanding mechanism, C_u
  - Content generation mechanism, C_g
  - Behavioral displays, B
  - Plans with goals, P, G
- P = {p_1 … p_n}
- D = {d_1 … d_n}
- B = {b_1 … b_n}
- G = {g_1 … g_n}
- P = {p_1 … p_n}



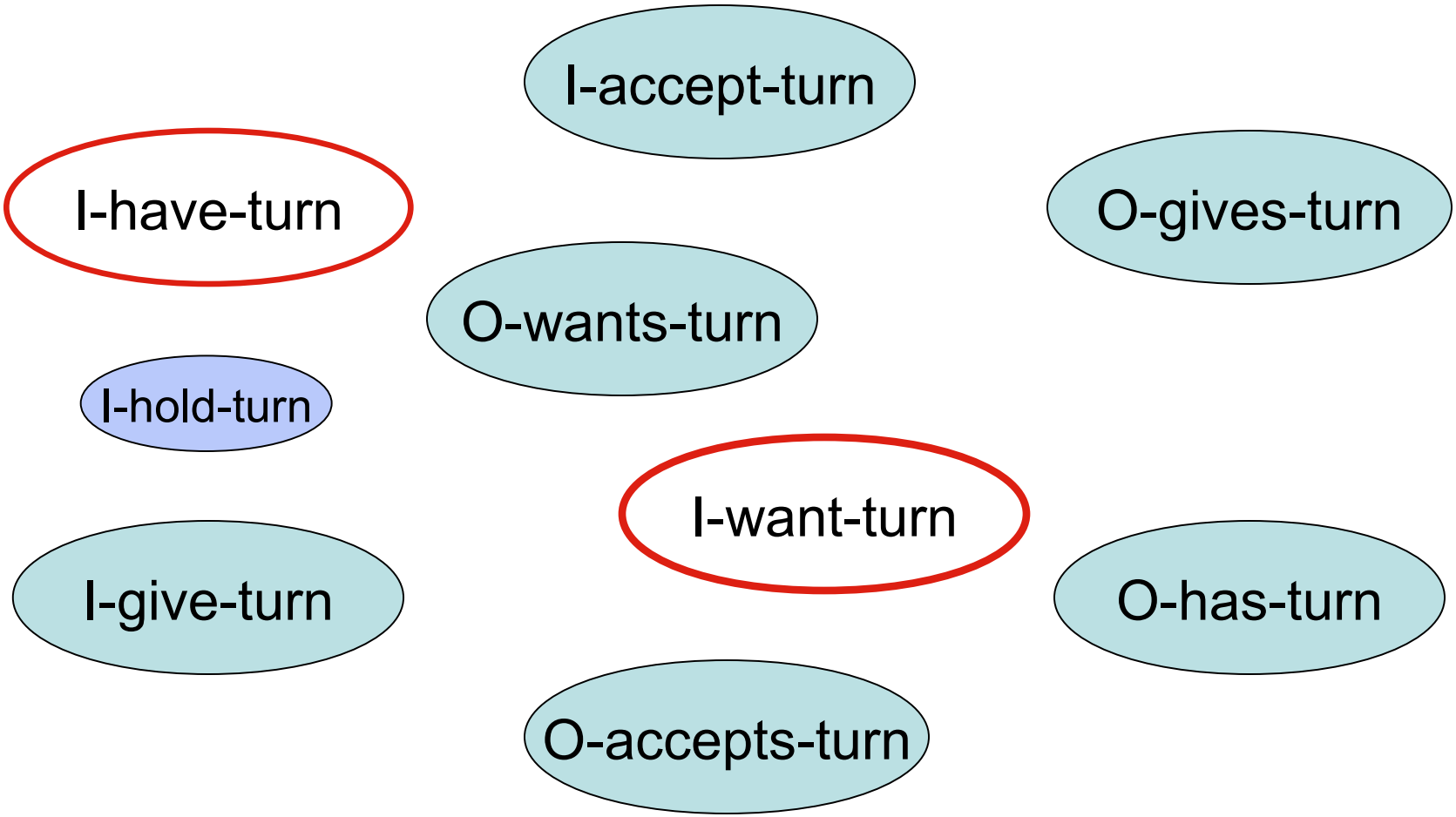
YTTM: Contexts

- Indirect control of anticipation and prediction
  - A form of attentional control
- Guide perception, planning, action realization

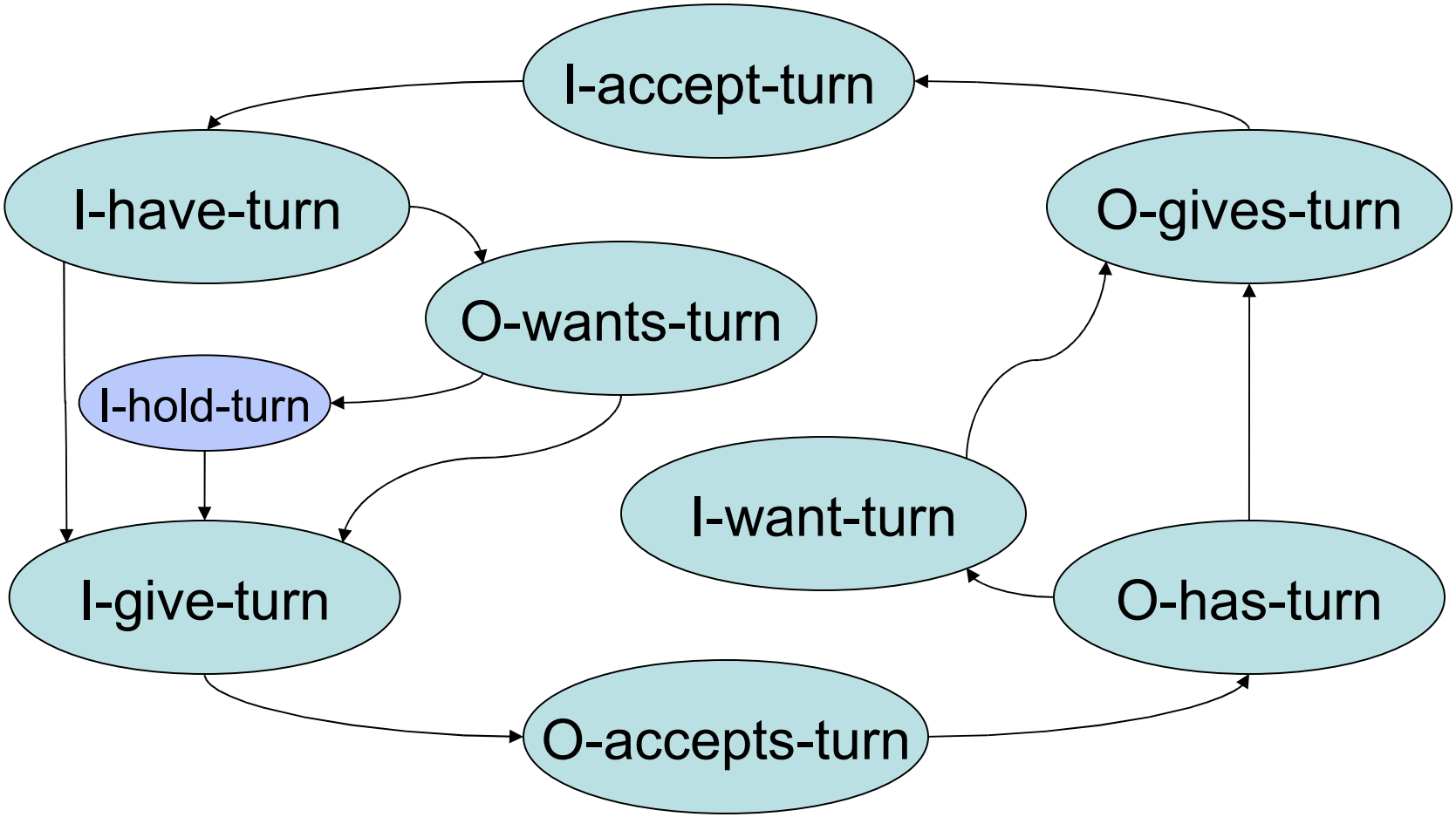
YTTM: Contexts



YTTM: Contexts



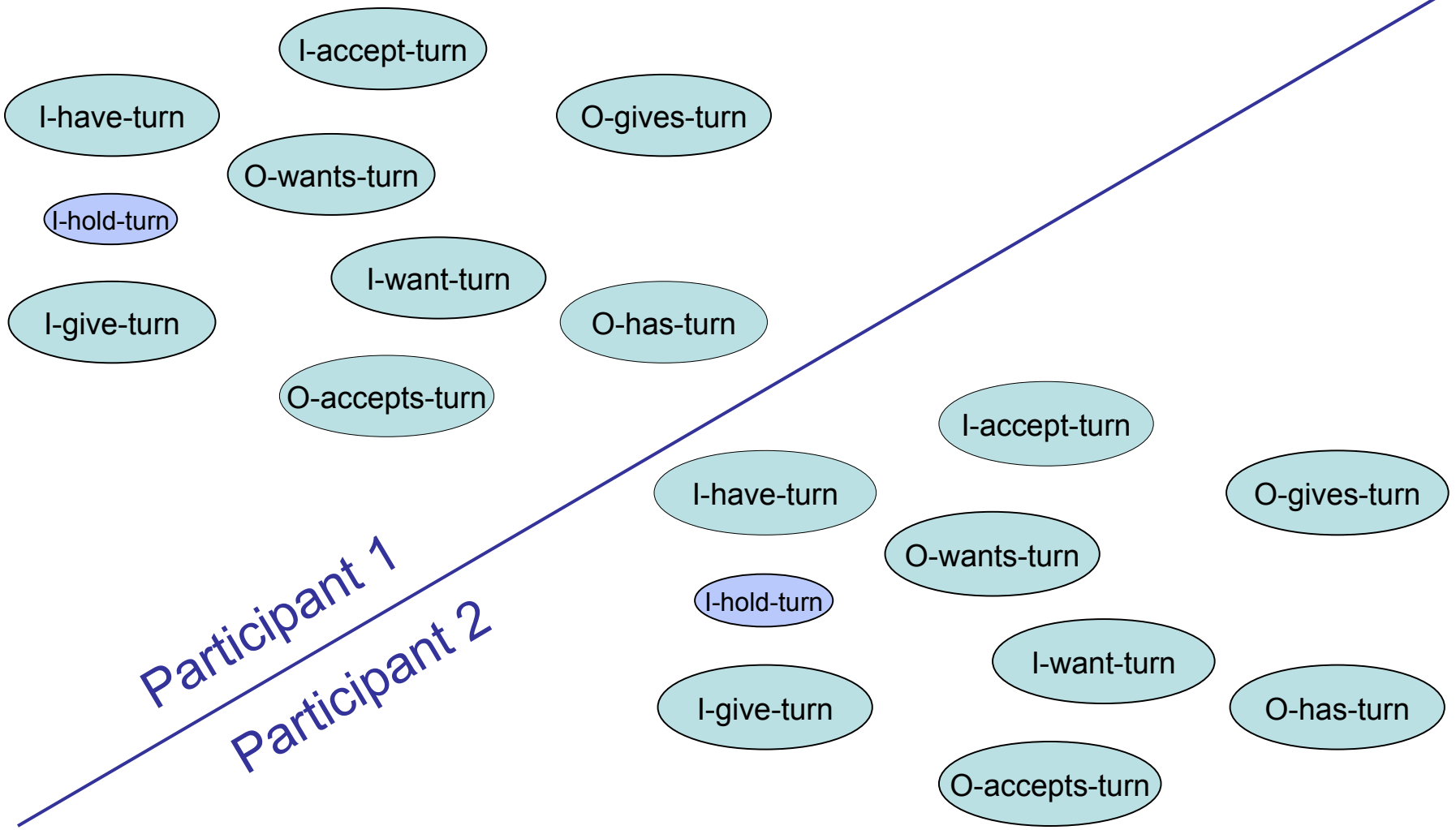
YTTM: Contexts



Contexts are:

- The basis for the coupling of communicating individuals
  - When the contexts of participants are aligned, envelope behaviors are synchronized
    - and content can be exchanged
- Cognitive processes related to content presentation and content interpretation can run efficiently
  - In all participants

Coupling


I-accept-turn
I-have-turn
O-gives-turn
O-wants-turn
I-hold-turn
I-want-turn
I-give-turn
O-has-turn
O-accepts-turn
Participant 1
Participant 2
I-accept-turn
I-have-turn
O-gives-turn
O-wants-turn
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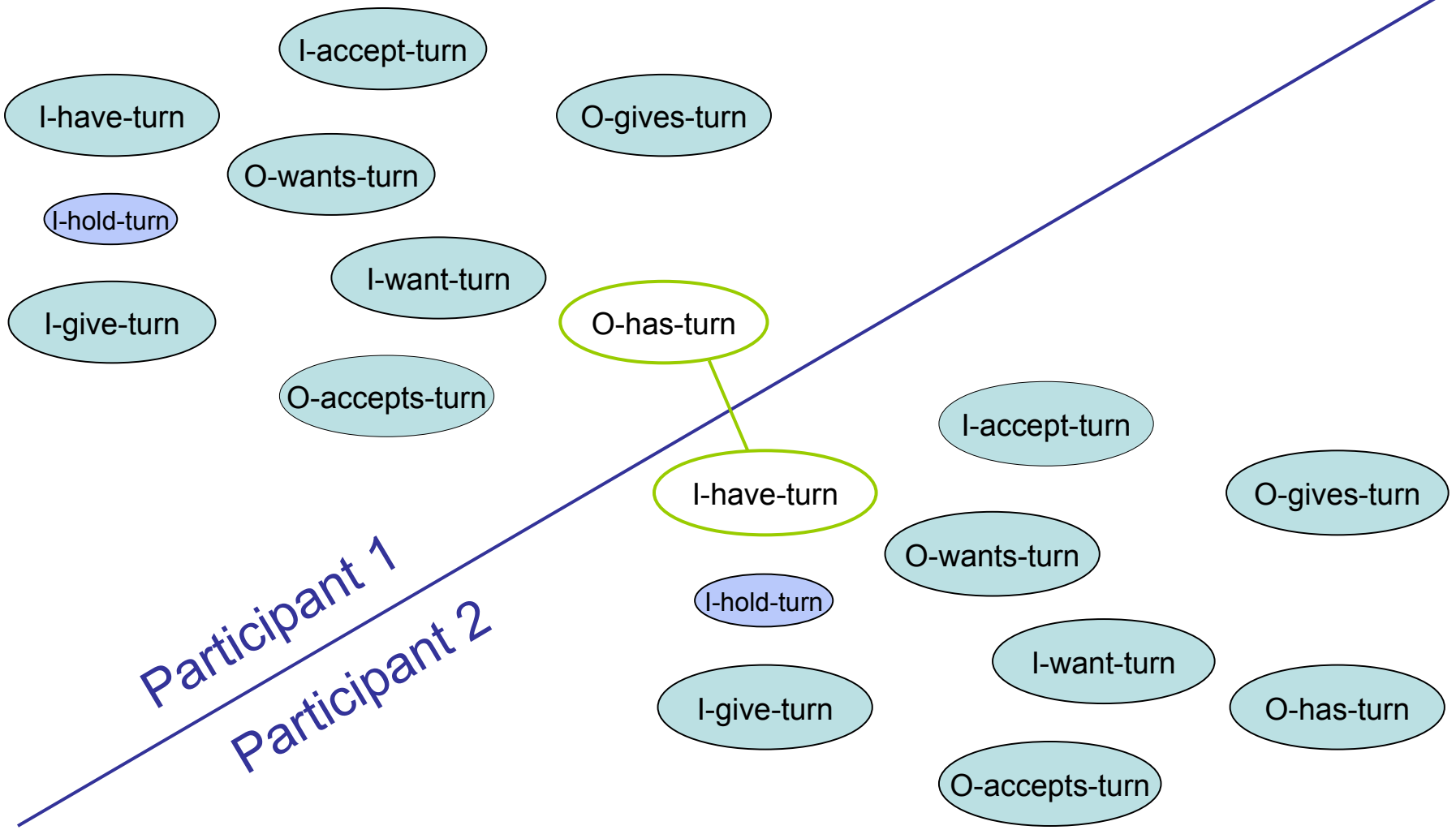
I-want-turn
I-give-turn
O-has-turn
O-accepts-turn

Coupling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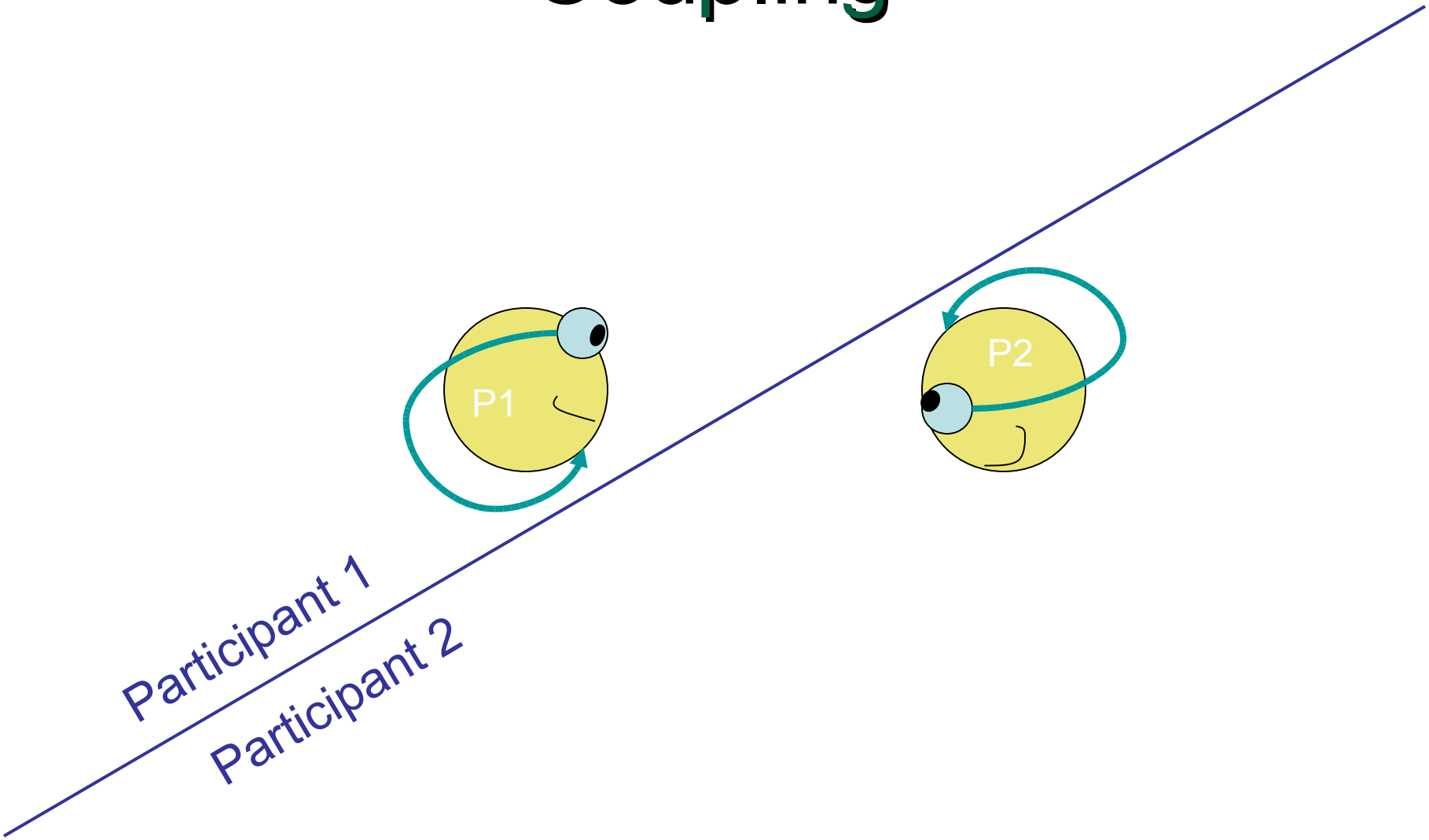
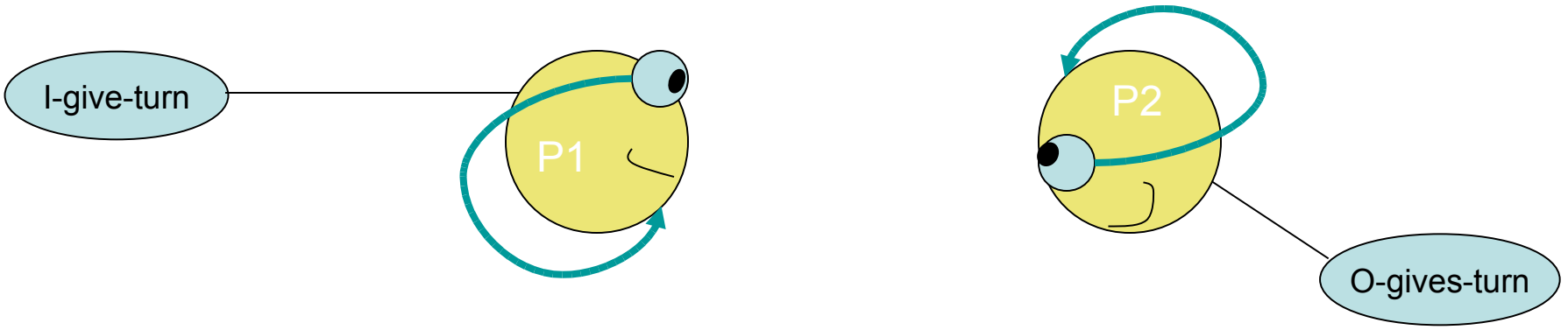
Coupling

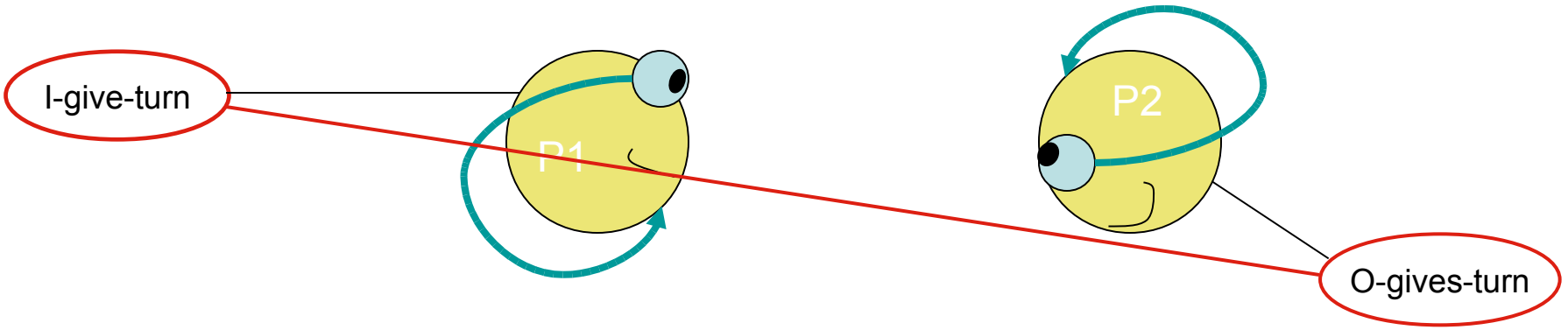


Coupling



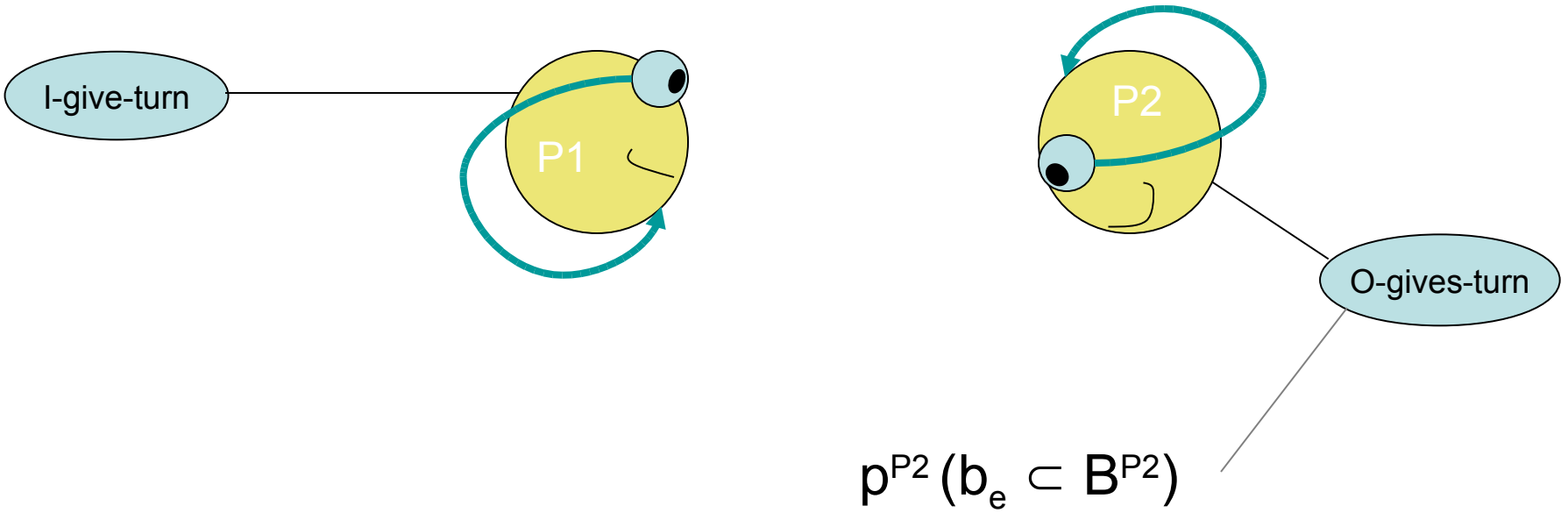
Coupling

Coupled contexts:



Associated with each context are perceptions and behaviors that the agents have learned over the years

Coupling



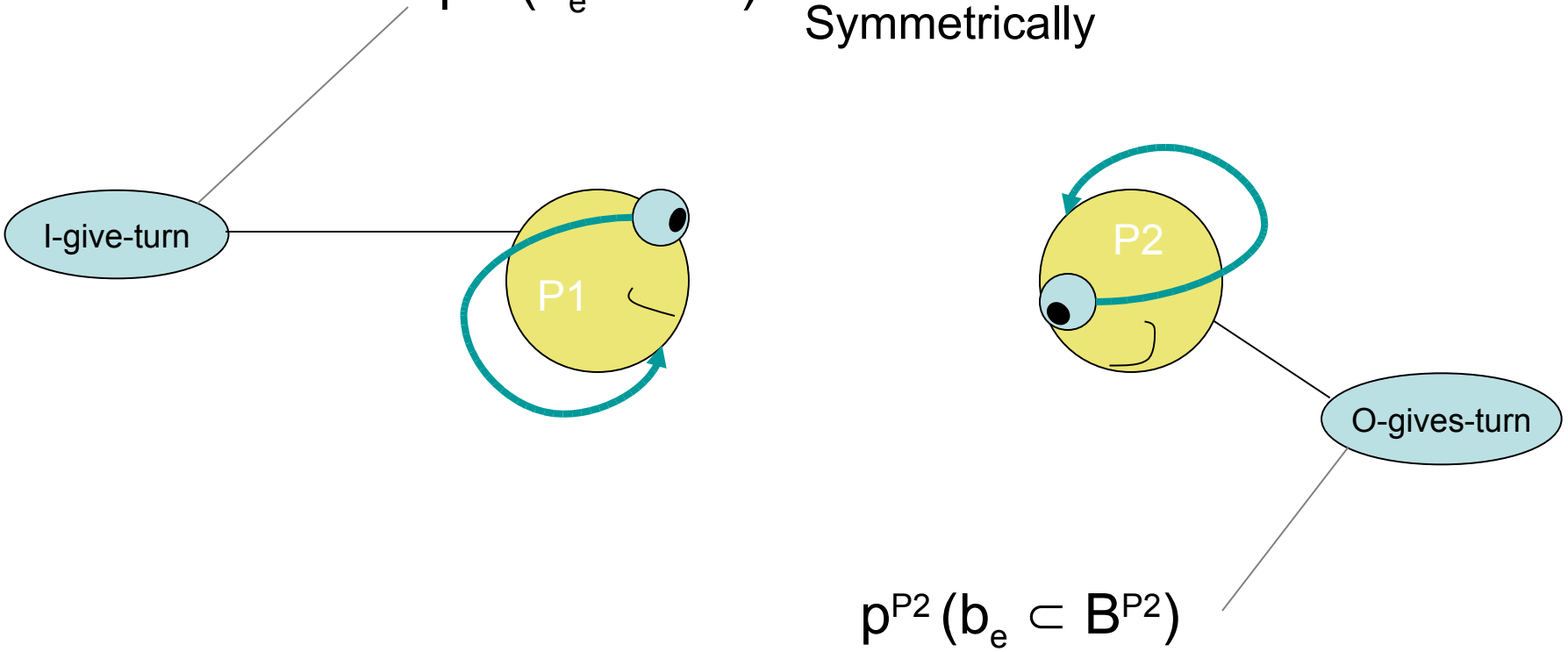
$p^{P2}(b_e \subset B^{P2})$

b_e is behavior P2 expects from P1 that P2 has learned to be useful for alignment with P2 in the O-gives-turn context

Coupling

$p^{P1}(b_e \subset B^{P1})$

Symmetrically



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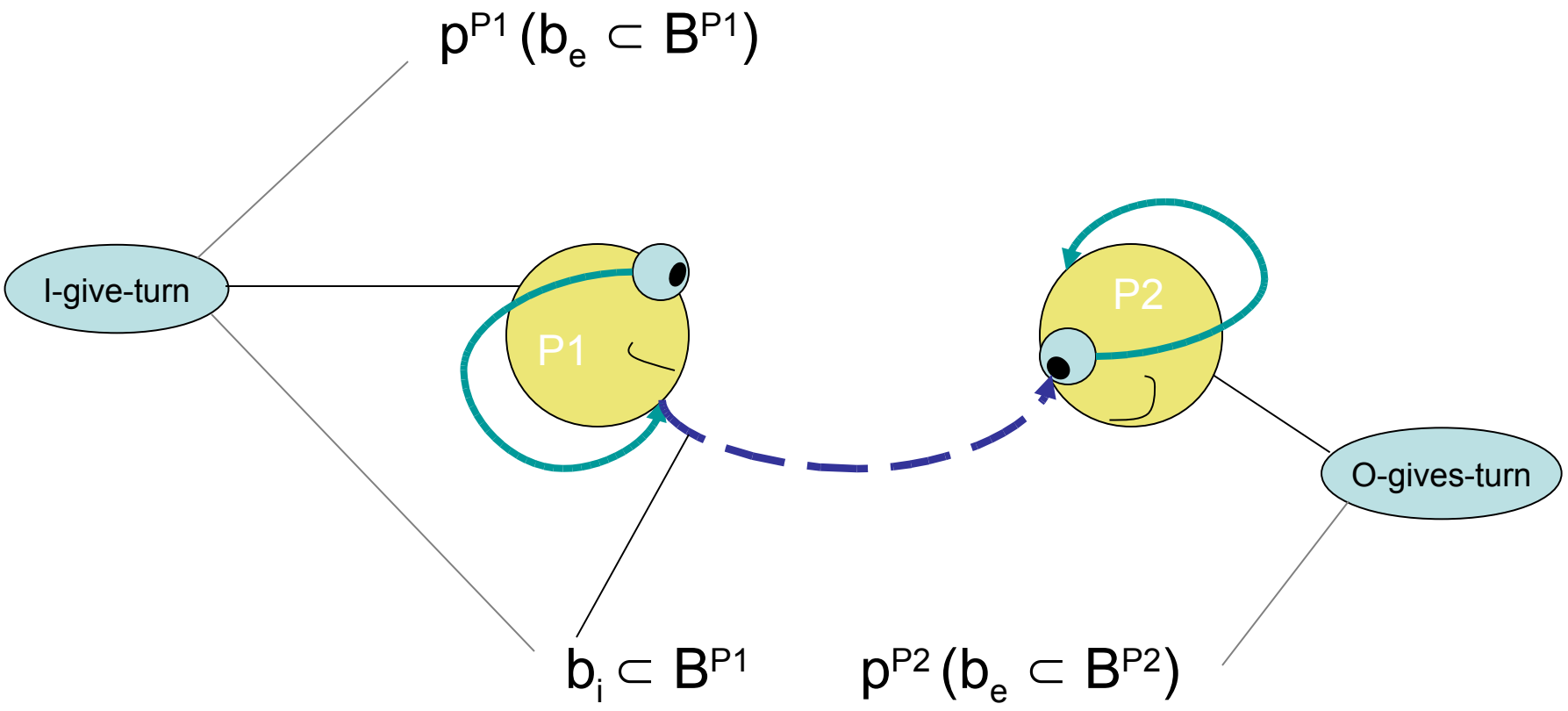
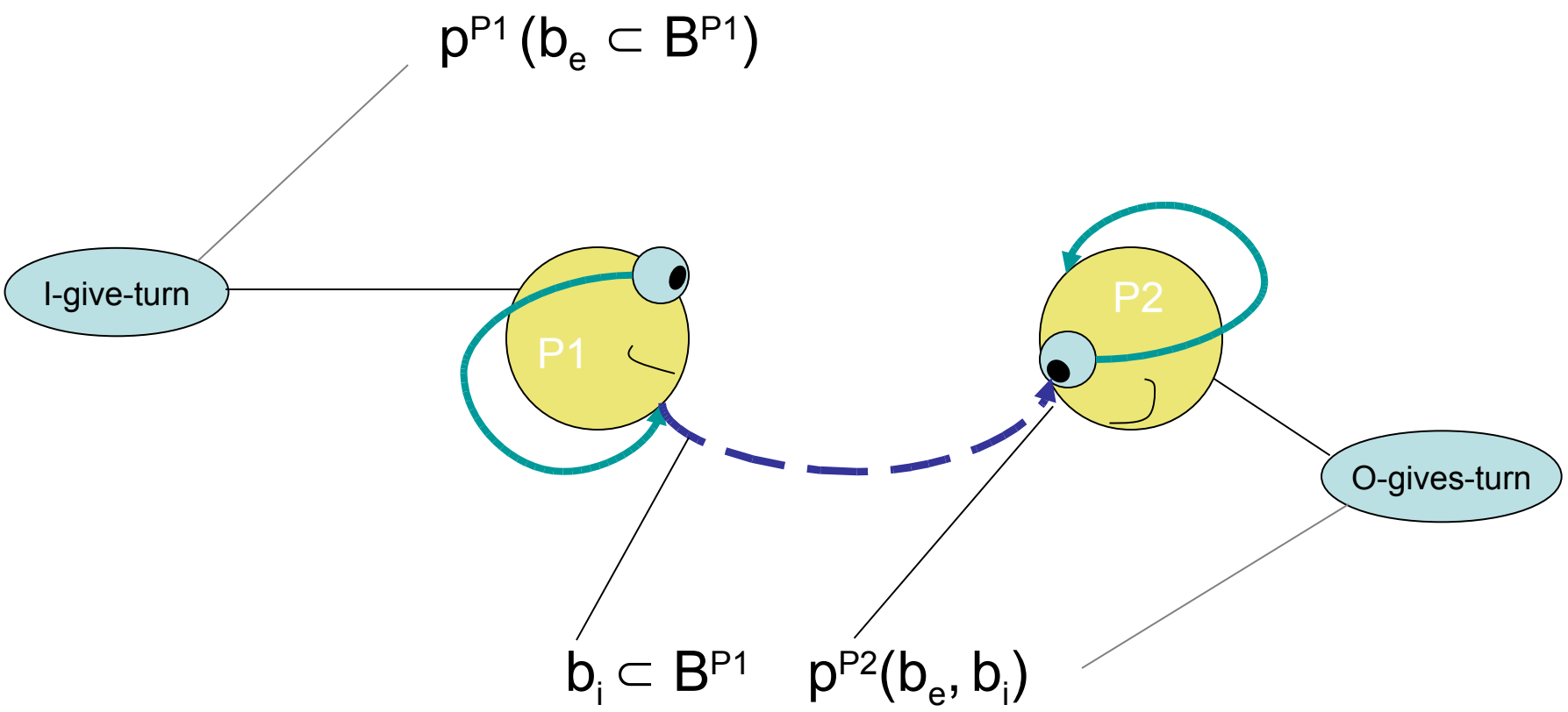
Coupling

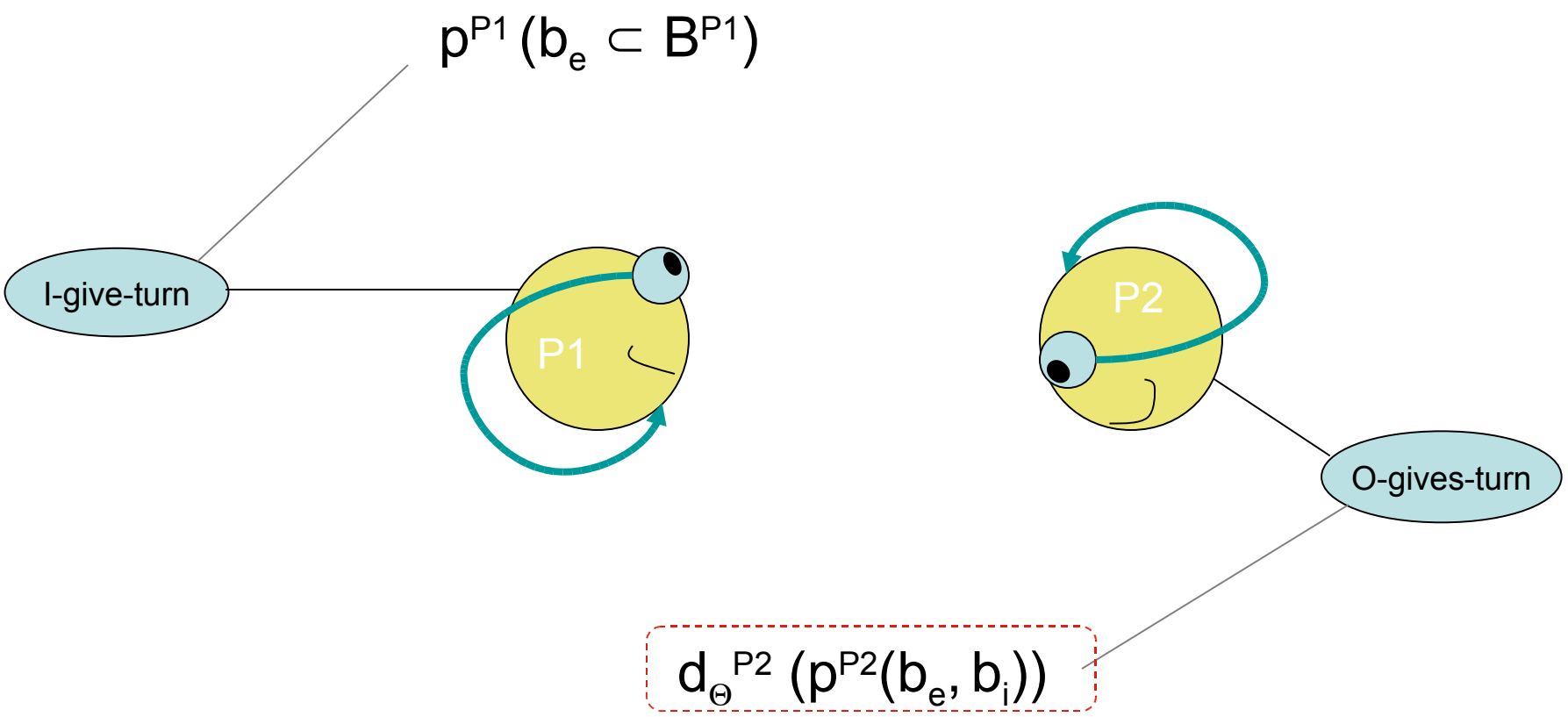


b_i has been learned
by P1 to be effective to align
the current contexts

Coupling


$p^{P1}(b_e \subset B^{P1})$
I-give-turn
P1
P2
O-gives-turn
$b_i \subset B^{P1}$
$p^{P2}(b_e, b_i)$

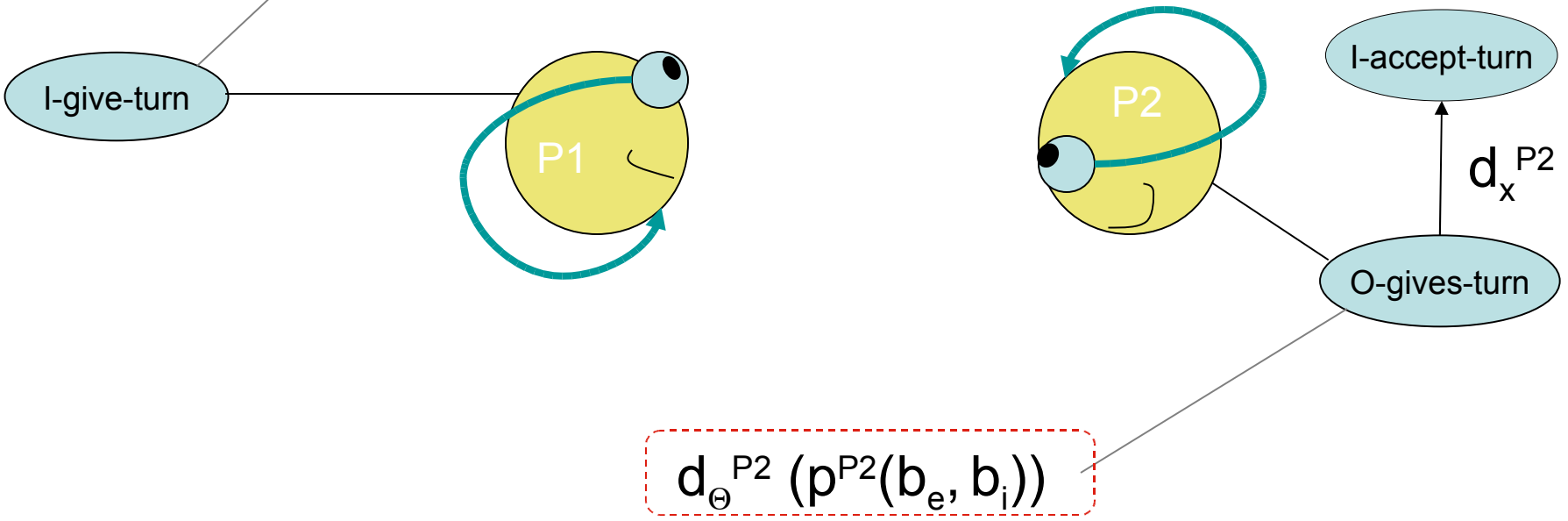
Coupling



P2's decision mechanisms decide that the output of p_{P2} provides sufficient evidence that b_e and b_i match

Coupling

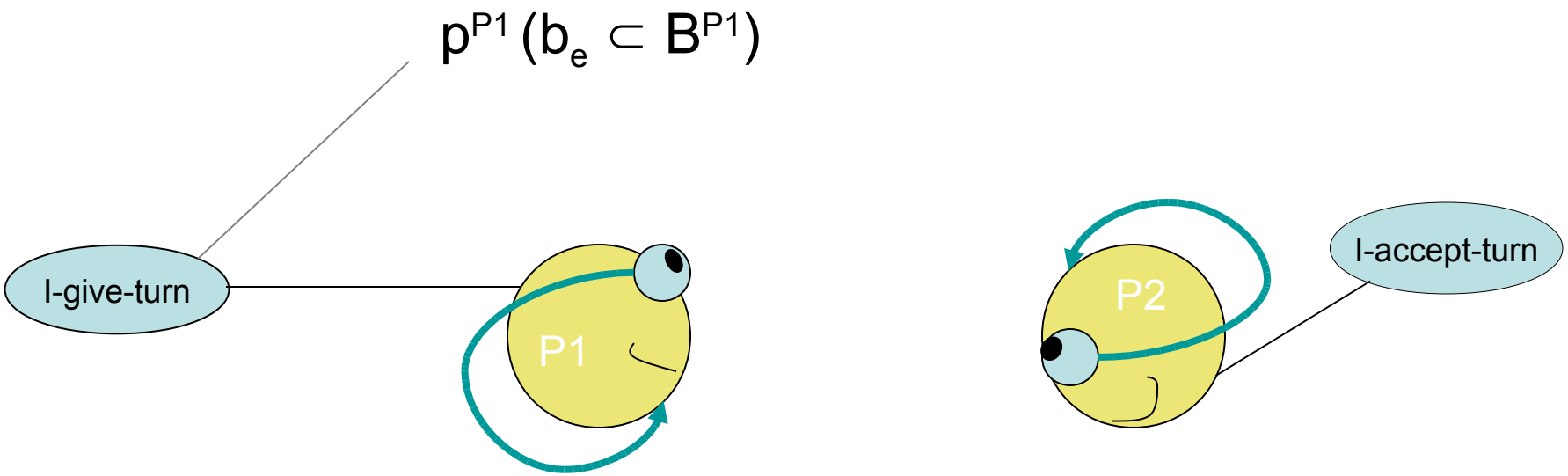
$p^{P1}(b_e \subset B^{P1})$



$d_\Theta^{P2}(p^{P2}(b_e, b_i))$

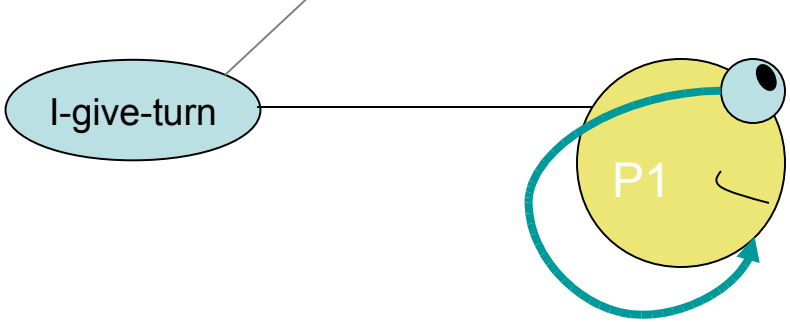
P2 decides that to be aligned with P1
the best context is should be I-accept-turn

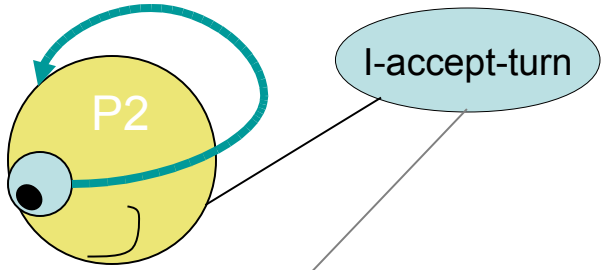
Coupling



Coupling

$p^{P1}(b_e \subset B^{P1})$

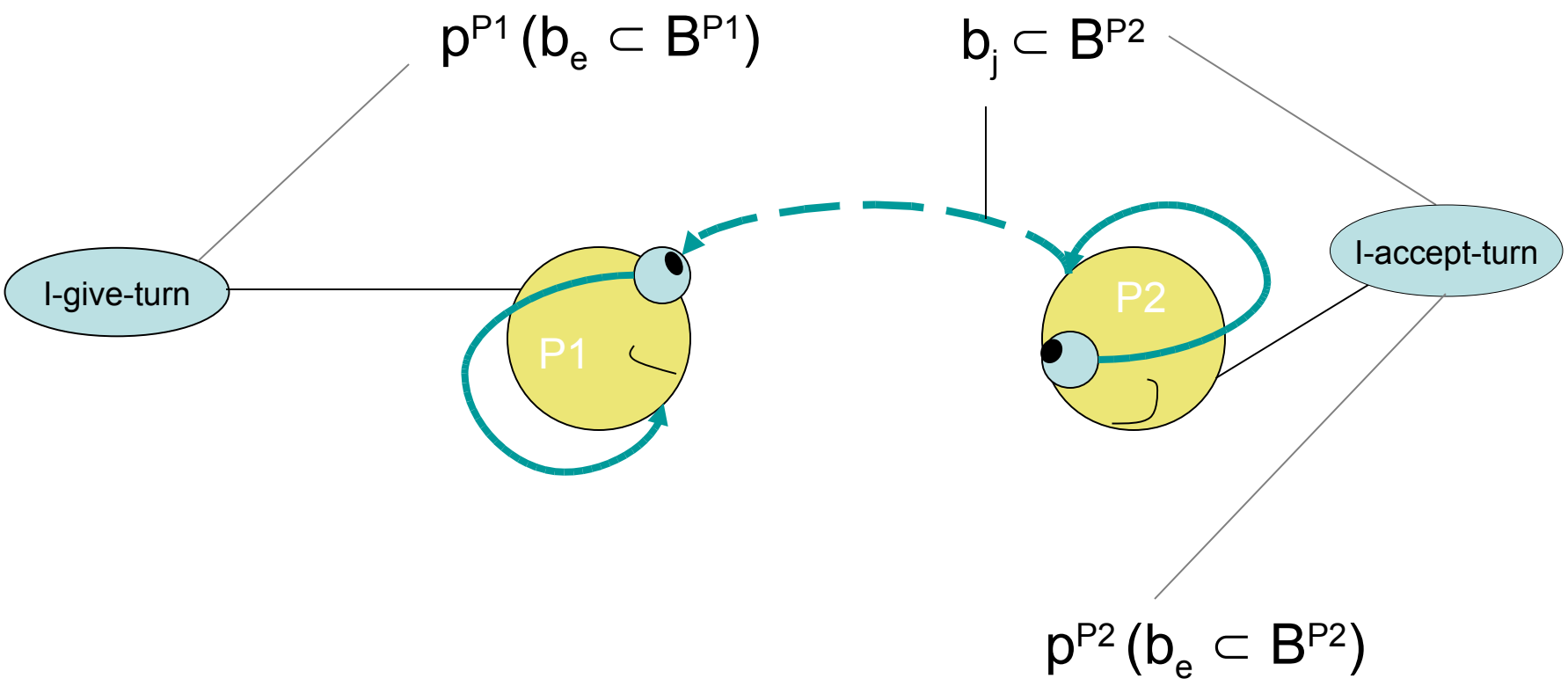




$p^{P2}(b_e \subset B^{P2})$

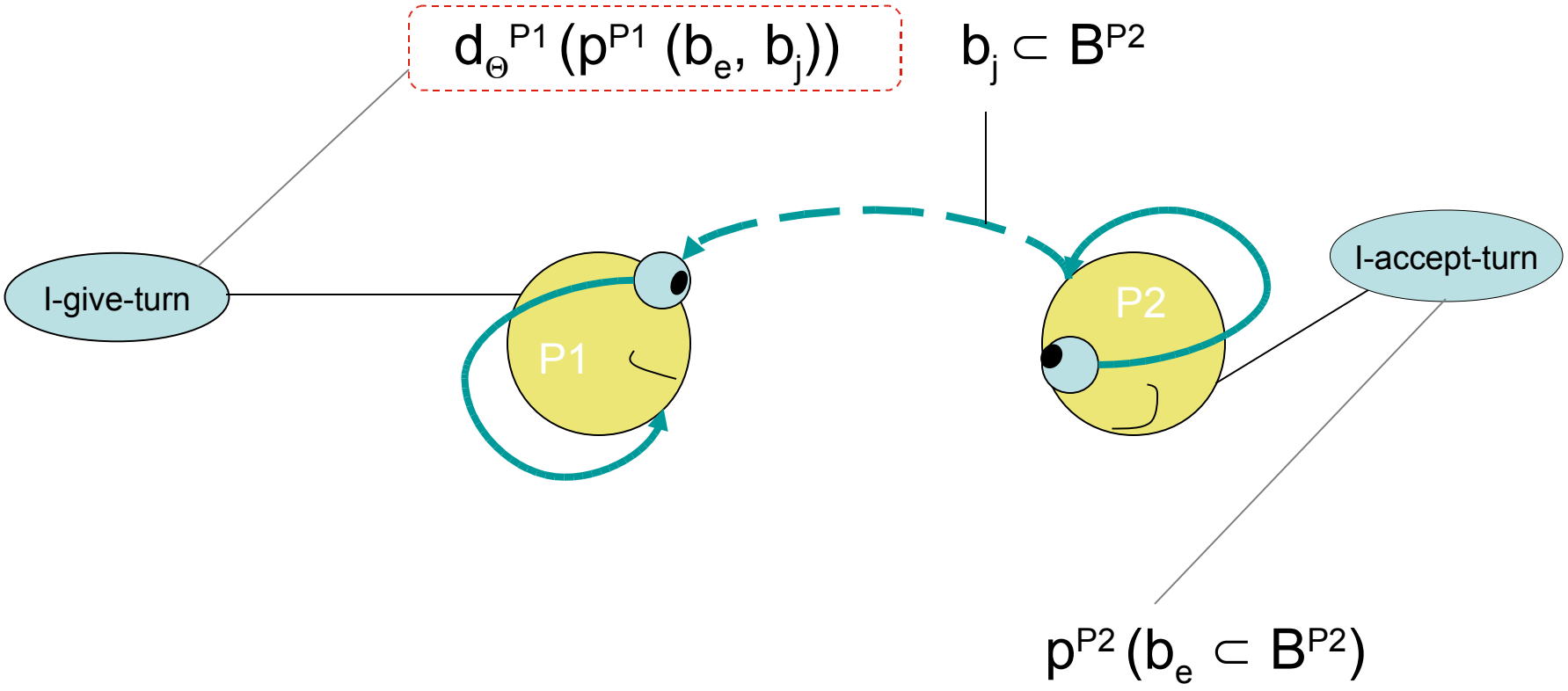
Associated with I-accept-turn
are cues b_e that P2 expects from P1
Indicating that P2 has turn

Coupling

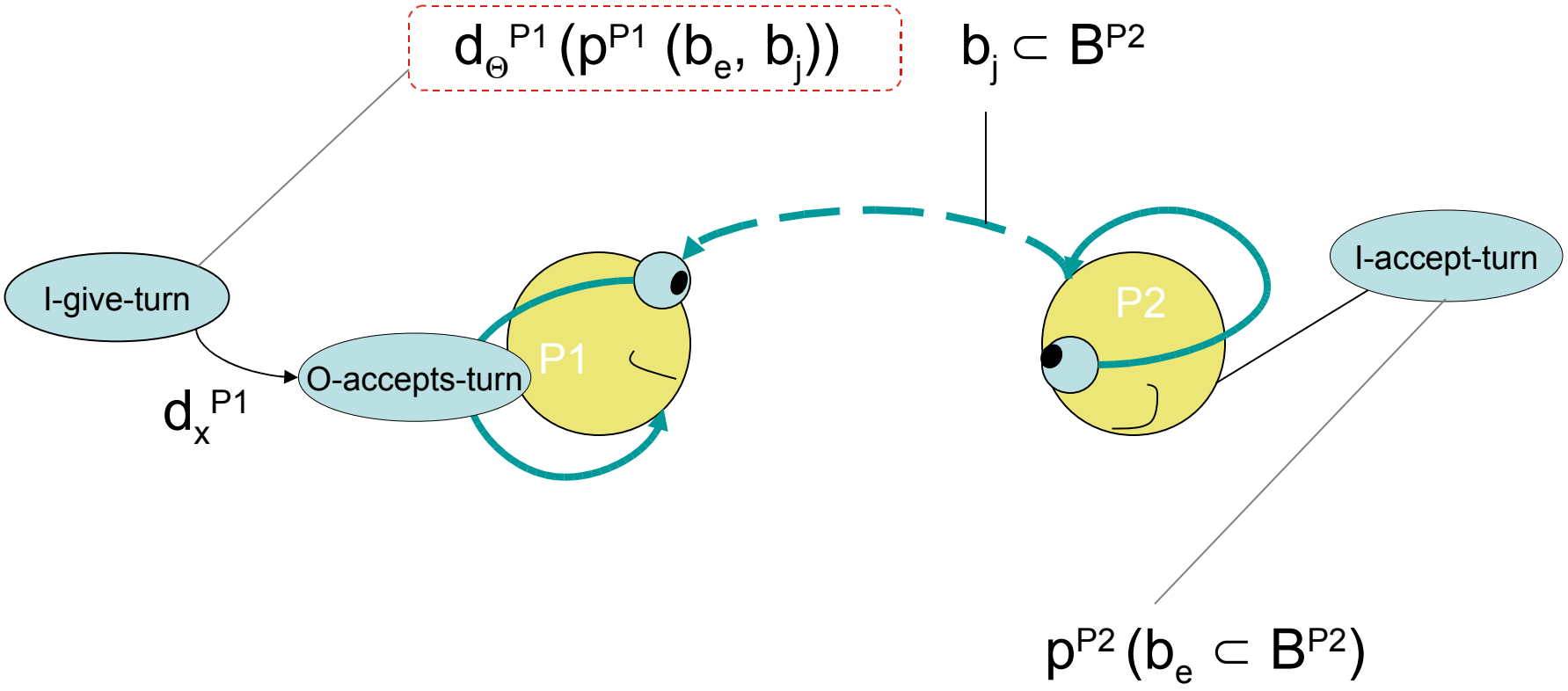


As a new contexts becomes
active, certain behaviors b_j are exhibited

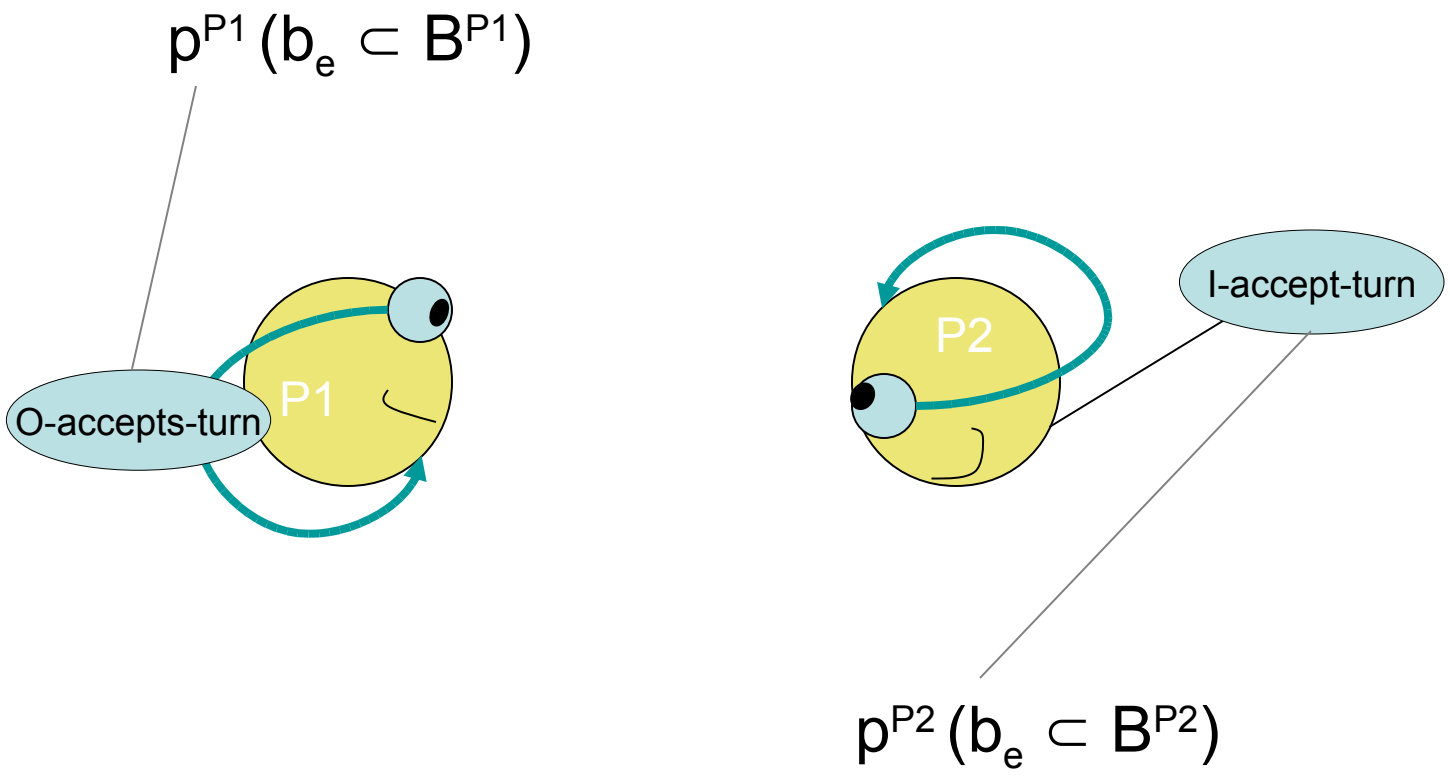
Coupling


$d_{\Theta}^{P1}(p^{P1}(b_e, b_j))$
$b_j \subset B^{P2}$
I-give-turn
P1
P2
I-accept-turn
$p^{P2}(b_e \subset B^{P2})$

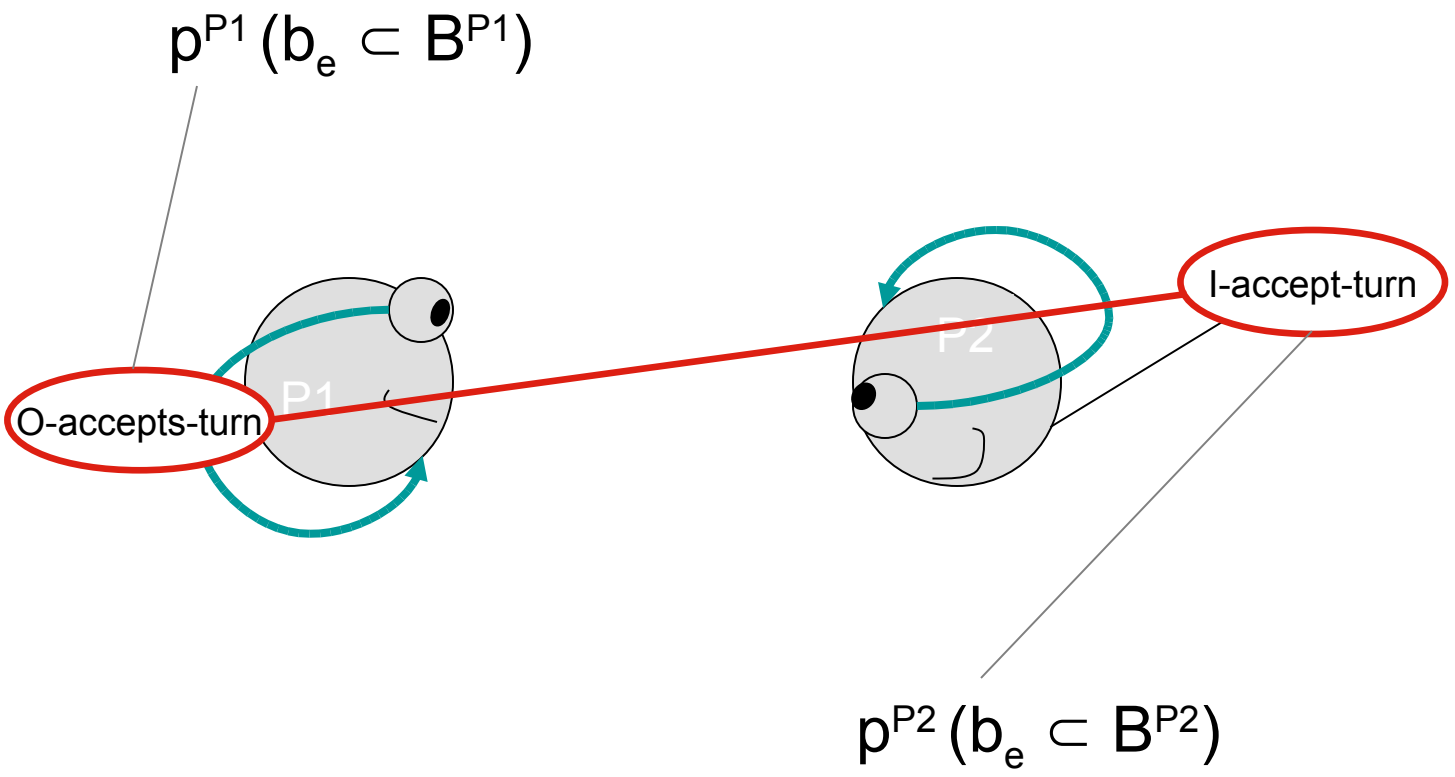
Coupling


$d_{\Theta}^{P1}(p^{P1}(b_e, b_j))$
$b_j \subset B^{P2}$
I-give-turn
d_x^{P1}
O-accepts-turn
P1
P2
I-accept-turn
$p^{P2}(b_e \subset B^{P2})$

Coupling

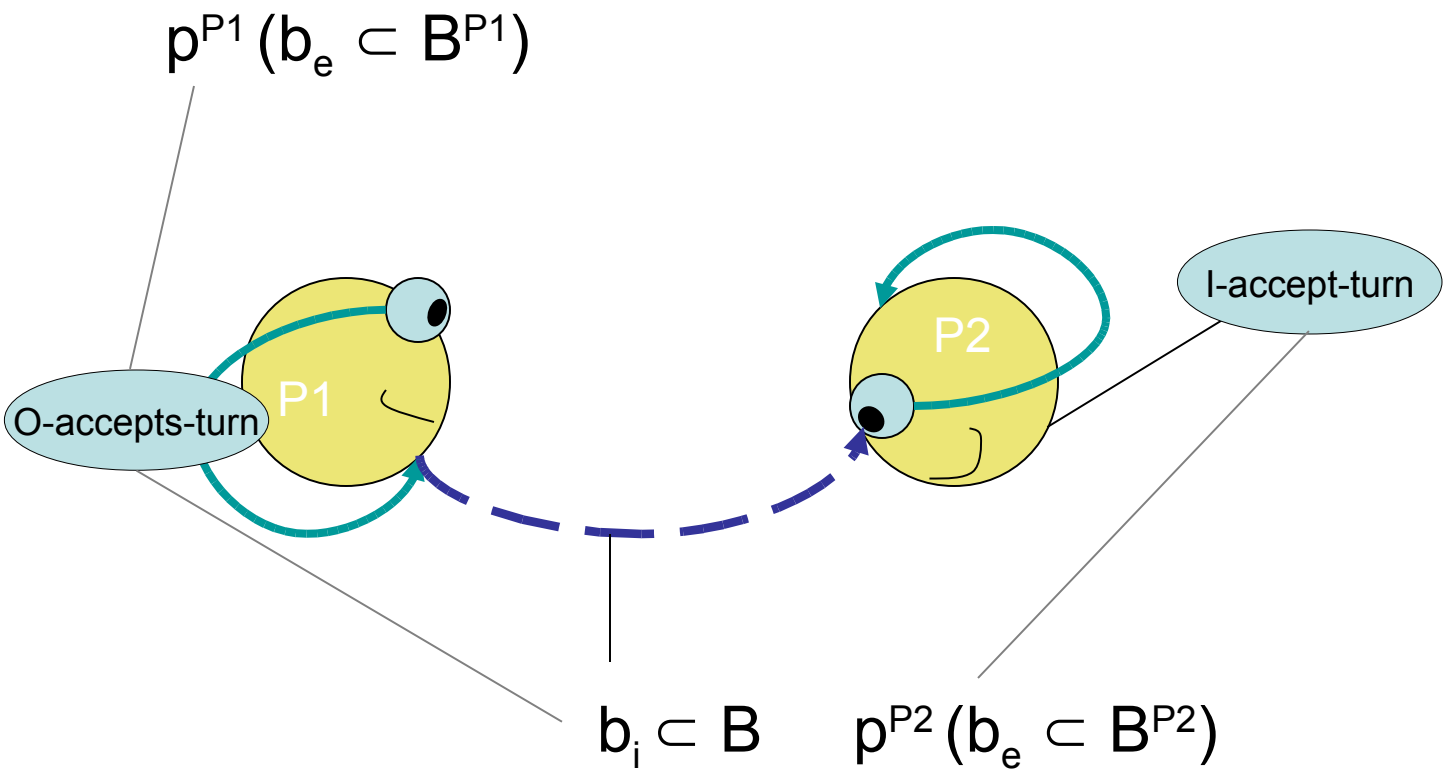

$p^{P1}(b_e \subset B^{P1})$
O-accepts-turn
P1
P2
I-accept-turn
$p^{P2}(b_e \subset B^{P2})$

Coupling

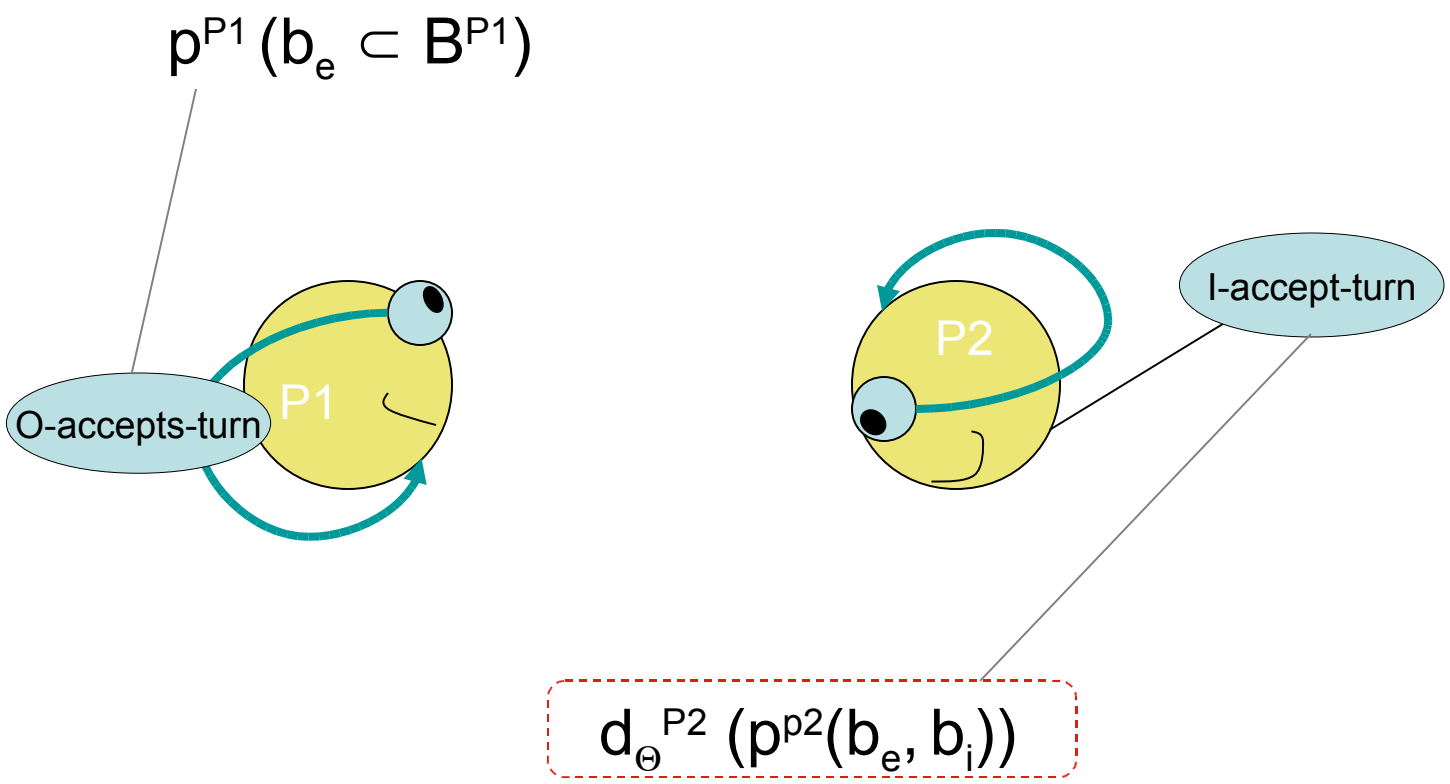


The agents have aligned their new contexts again

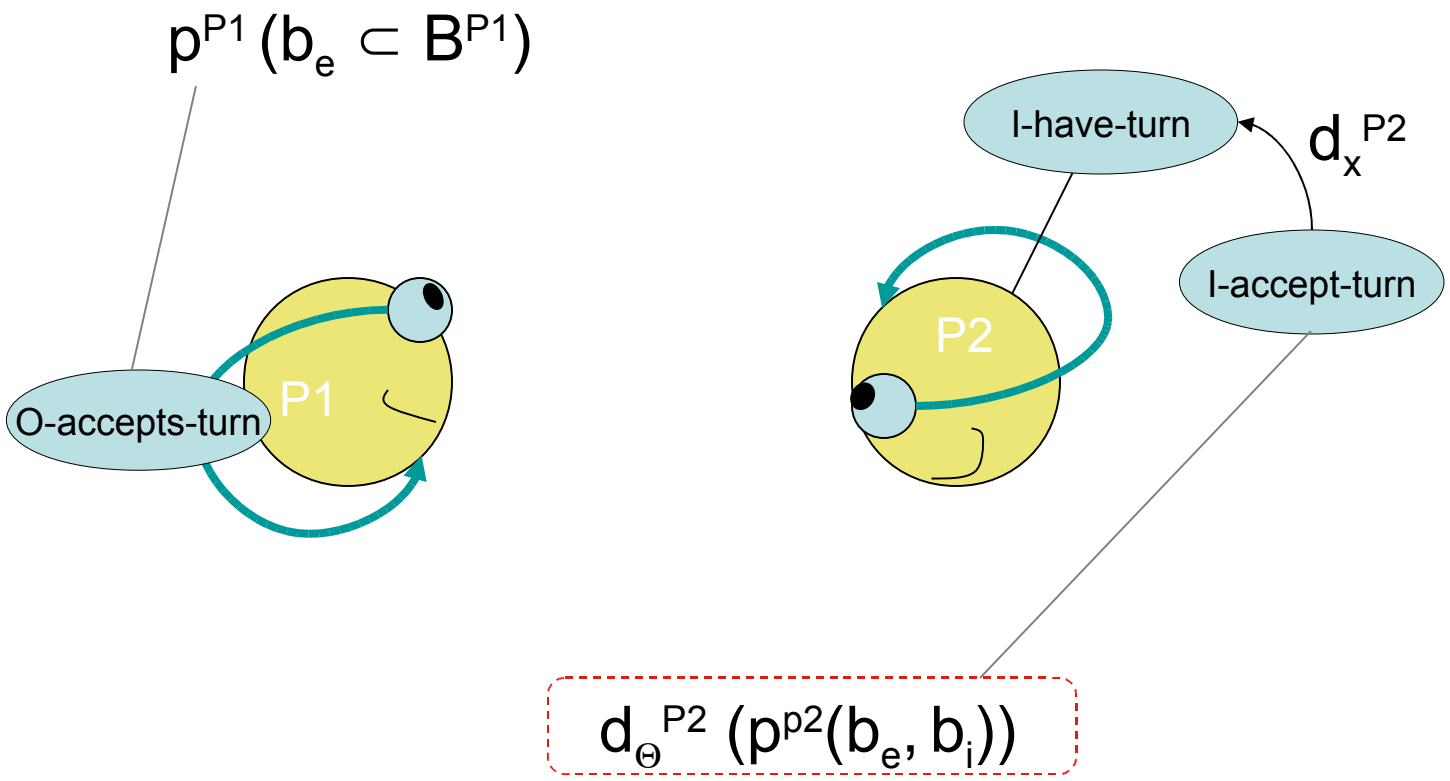
Coupling


$p^{P1}(b_e \subset B^{P1})$
O-accepts-turn
P1
P2
I-accept-turn
$b_i \subset B$
$p^{P2}(b_e \subset B^{P2})$

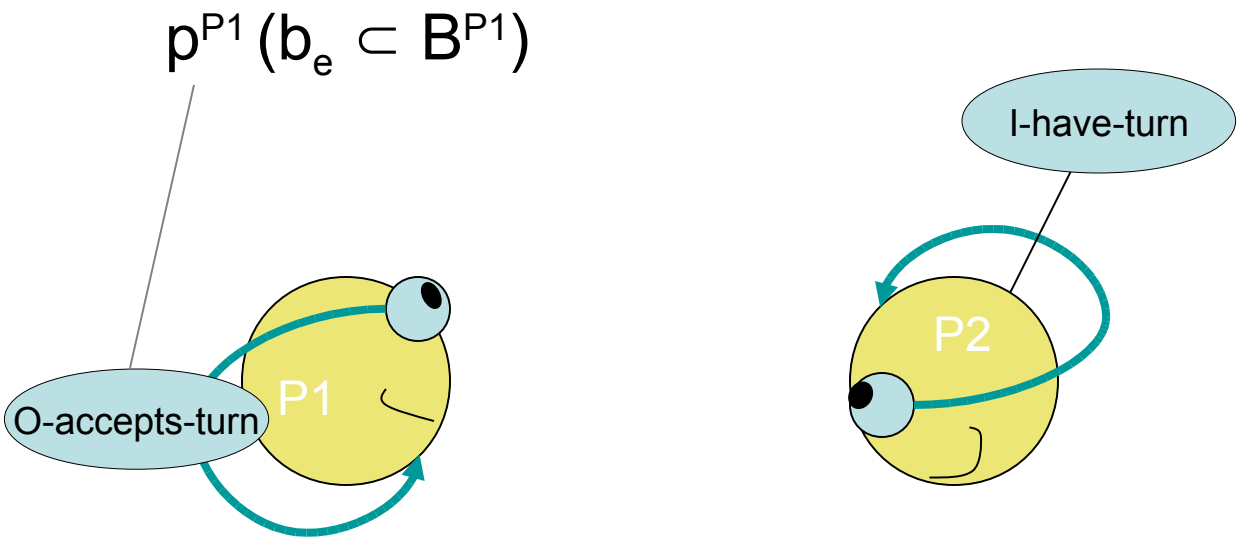
Coupling


$p^{P1}(b_e \subset B^{P1})$
O-accepts-turn
P1
P2
I-accept-turn
$d_\Theta^{P2}(p^{p2}(b_e, b_i))$

Coupling


$p^{P1}(b_e \subset B^{P1})$
O-accepts-turn
P1
P2
I-have-turn
d_x^{P2}
I-accept-turn
$d_\Theta^{P2}(p^{p2}(b_e, b_i))$

Coupling



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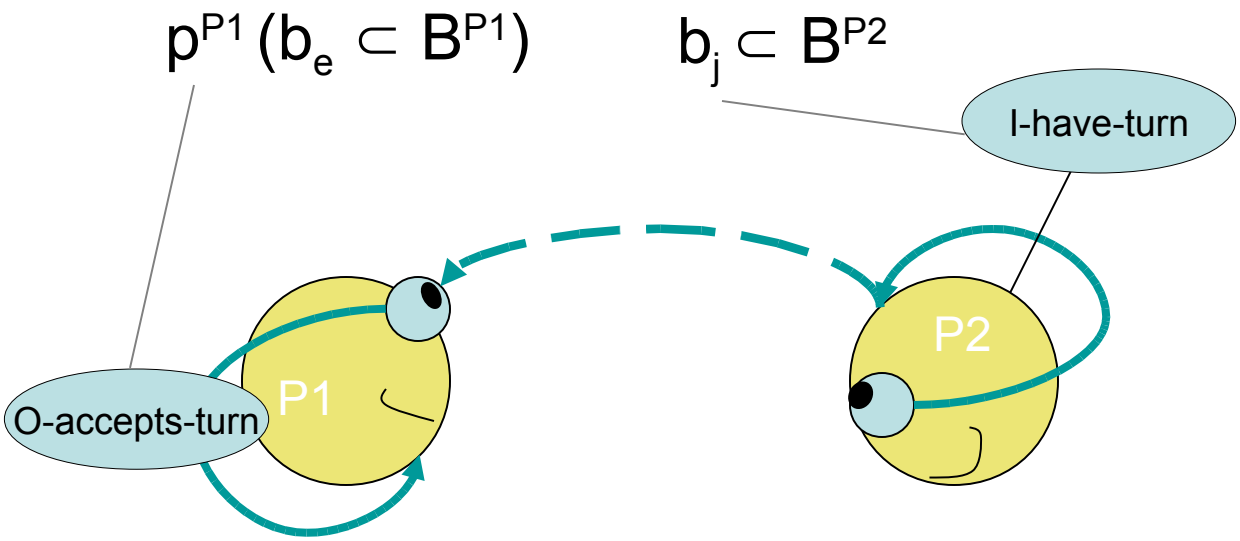
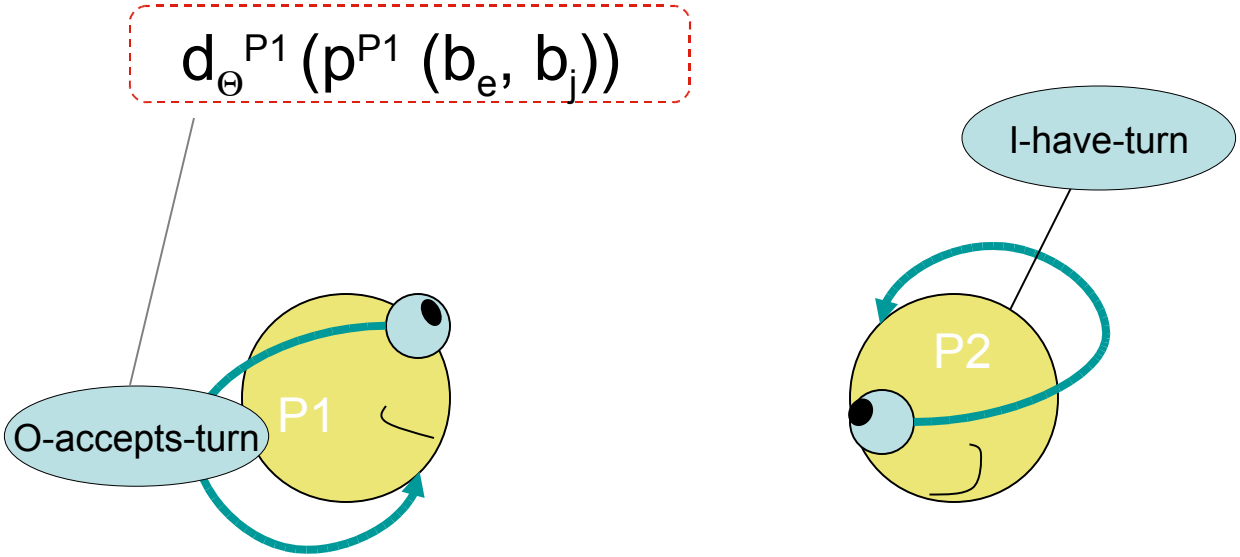

$p^{P1}(b_e \subset B^{P1})$
$b_j \subset B^{P2}$
I-have-turn
O-accepts-turn
P1
P2

Coupling



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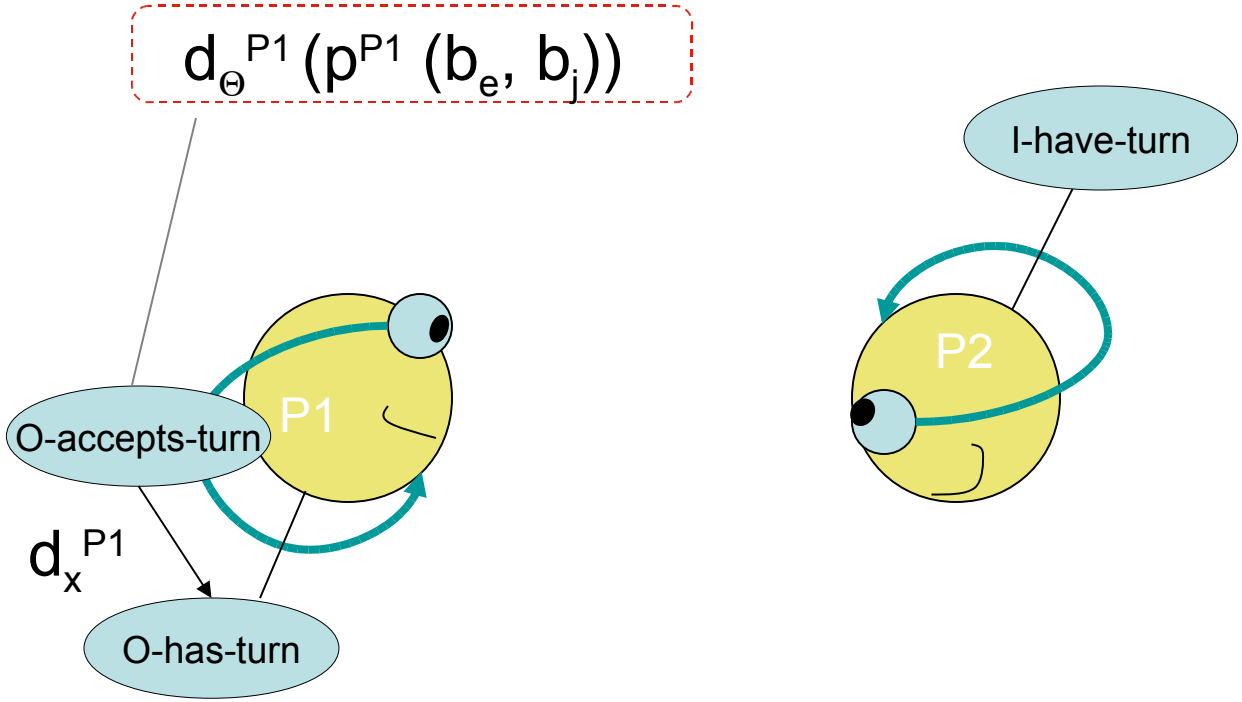
$d_{\Theta}^{P1}(p^{P1}(b_e, b_j))$
I-have-turn
P2
P1
O-accepts-turn
d_x^{P1}
O-has-turn

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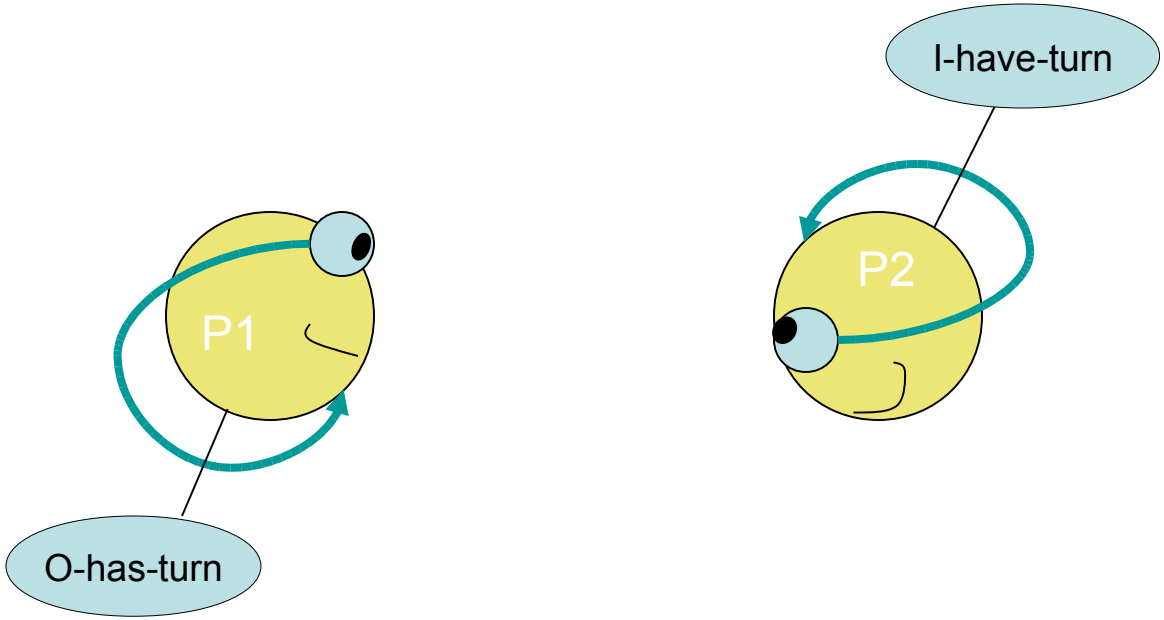

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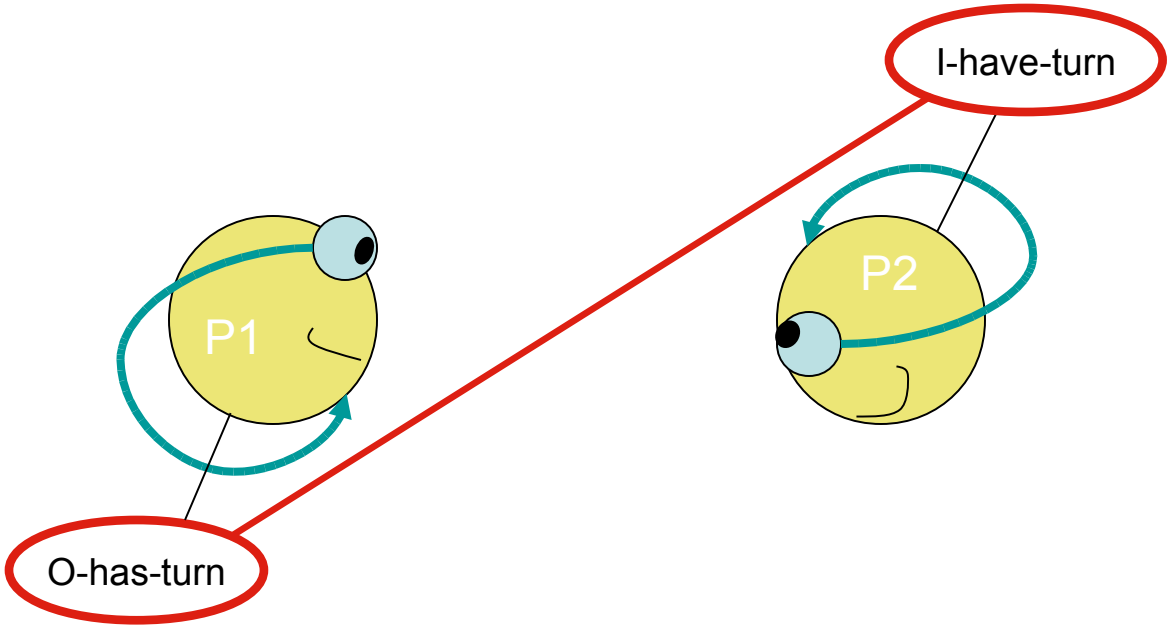

Coupling in Turntaking

- Happens as a
  - continuous alignment of predicted contexts
  - using predicted behavior displays
  - at multiple levels of detail and
  - multiple timescales
- Coupling ensures
  - Synchronized perceptual and planning mechanisms

YTTM Resulting Hypotheses

- Content production and interpretation can be separated from turntaking control
  - via a simple set of primitives
    - Topic-Knowledge-System-Received-Speech-Data
    - Speech-Data-Available-For-Analysis
    - Topic-Knowledge-System-Parsing-Speech-Data
    - Topic-Knowledge-System-Successful-Parse
    - Content-Layer-Action-Available
    - I-Have-Reply-Ready
    - Topic-Knowledge-System-Real-World-Action-Available
    - Im-Executing-Topic-Speech-Task
    - Im-Executing-Topic-Realworld-Task
    - Im-Executing-Topic-Multimodal-Act
    - Im-Executing-Topic-Communicative-Act
    - Im-Executing-Communicative-Act

YTTM Resulting Hypotheses

- Features perceived during dialog are logically combined to determine appropriate behaviors at any point in time
- Decisions about multimodal behaviors are based on boolean combinations of perceptual data

Summary

- YTTM
  - accounts for many macro phenomena in realtime multimodal dialog
  - explains coupling between participants in multimodal dialog, as observed in turntaking
  - ready to be merged with related theories
- Theories from different levels of detail
  - Constrain and extend each other
  - Producing better theories