Construction and use of multimodal corpora of referring expressions in collaborative problem solving dialogues

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The 13th Korea-Japan Workshop on Linguistics and Language Processing
2012.12.1@Waseda University

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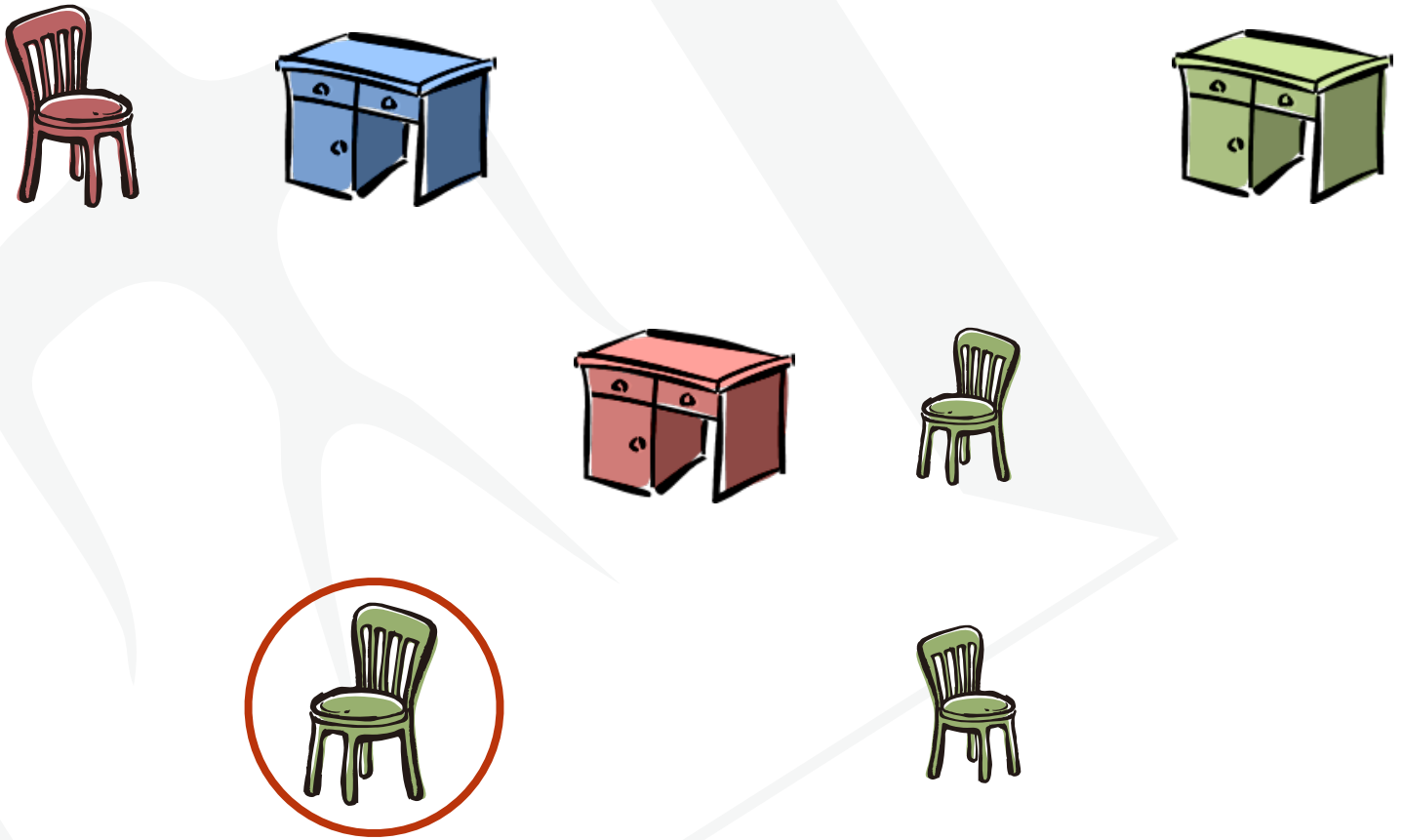
- Background
- Corpus construction & analysis
- Examples of corpus use
  - Referring expression generation
    Comparative study (English vs. Japanese)
  - Referring expression resolution

Referring expressions

- A linguistic device referring to the target object(s)
- Language analysis
  - Reference (Anaphora) resolution
  - target object = antecedent/entity in text
- Language generation
  - Generation of referring expression (GRE)
  - target object = entity in a world → situated

Referring expressions in a situation

"the green big chair"



Existing referring expression corpora

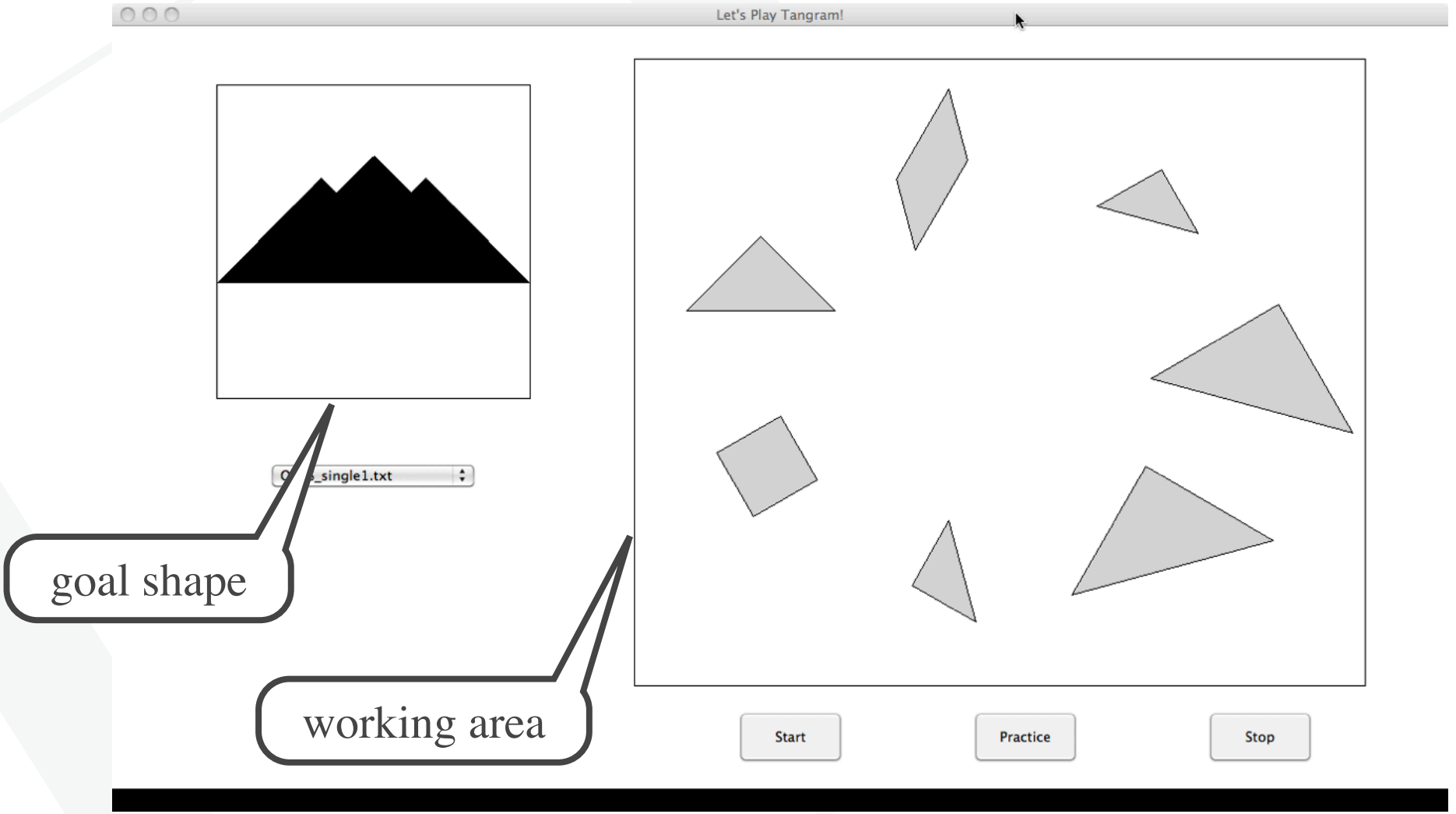
- TUNA corpus (van Deemter, 2007)
- COCONUT corpus (Di Eugenio et al. 2000)
- QUAKE corpus (Byron, 2003)
- JCT corpus (Foster et al. 2008)

Corpus construction

Corpus design

- Situated dialogue
- Collaborative task
- Extra-linguistic information (actions, gaze)
- Multi-lingual (Japanese, English, (Turkish))

Task (Geometrical puzzle: Tangram)



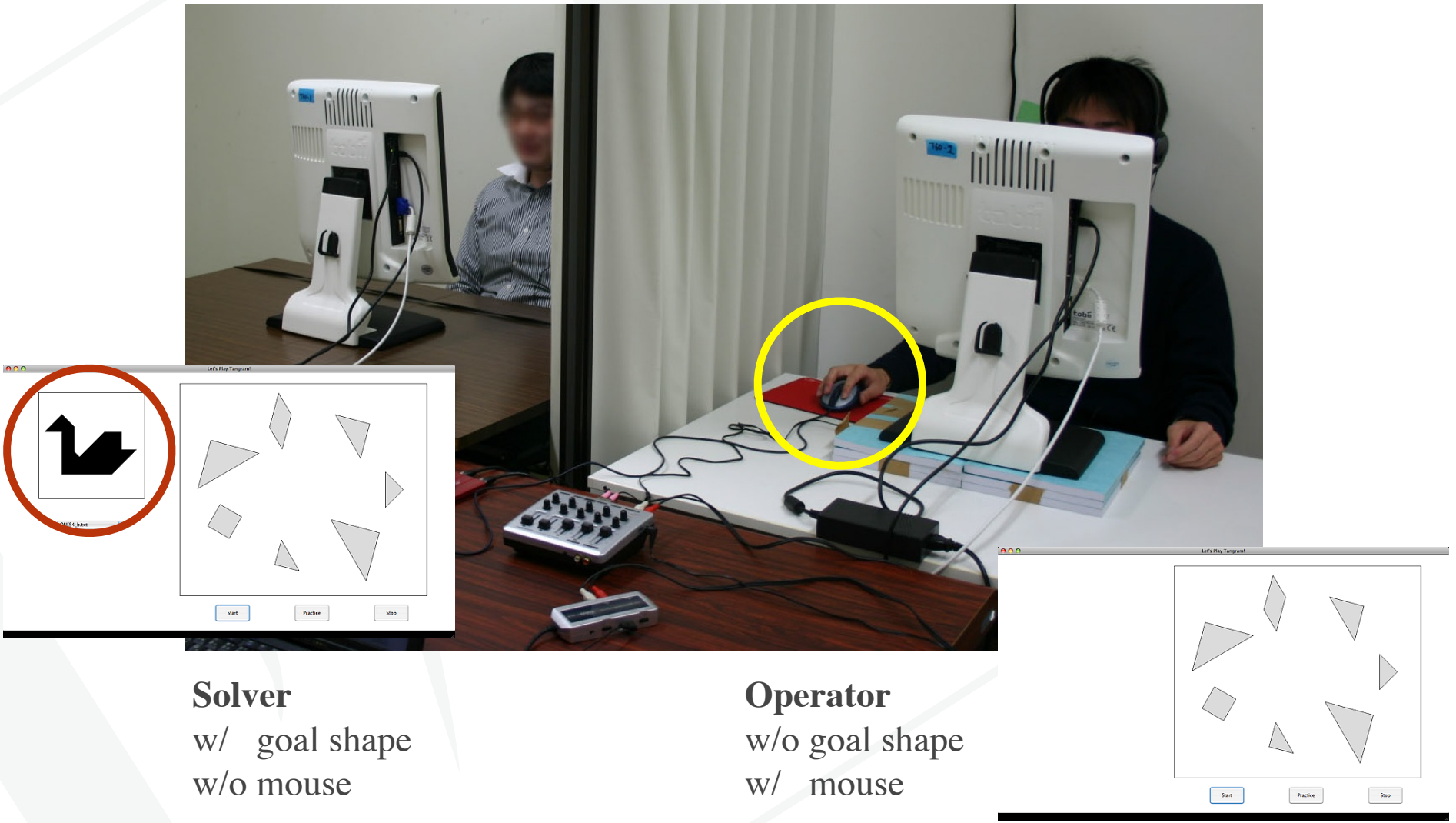
Experimental setting

- A pair of participants: two roles

role	goal shape	mouse
Solver	O	X
Operator	X	O

- 4-6 trials/pair
  - Exchange roles after half of the trials
- Time limit: 10-15 min.
- Optionally, hints (a correct piece position) at every 5 min. are provided

Experimental setting (snapshot)



Solver
w/ goal shape
w/o mouse

Operator
w/o goal shape
w/ mouse

Recorded data

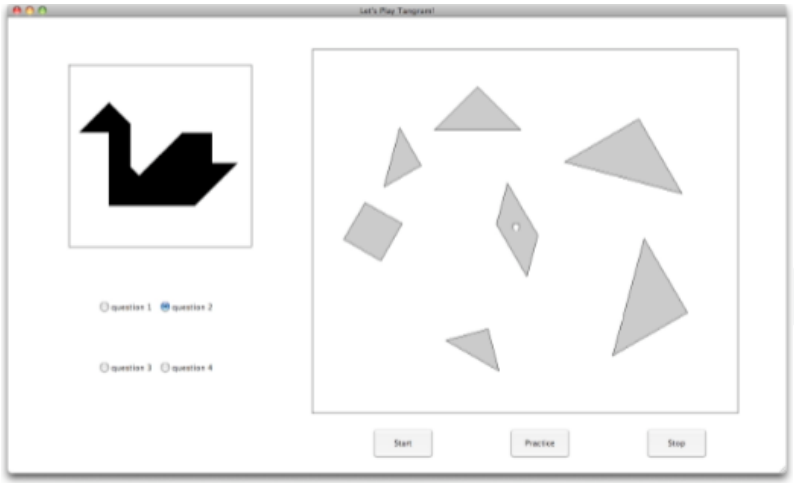
- Speech (channel separated in stereo)
- Mouse cursor position (1/65 sec)
- Mouse action (1/65 sec)
- Piece position (at each settlement)
- Eye-gaze position (1,280 x 1,024, 1/60 sec)
  (eye-tracker: Tobii T60 x 2)

Notable features of the corpora

- Time-aligned extra-linguistic information (actions, mouse positions, eye-gaze)
- Various configurations for collecting dialogues
  - Puzzle type (Tangram, Polyomino, 2-Tangram)
  - Hinting (with, without)
  - Language (Japanese, English)

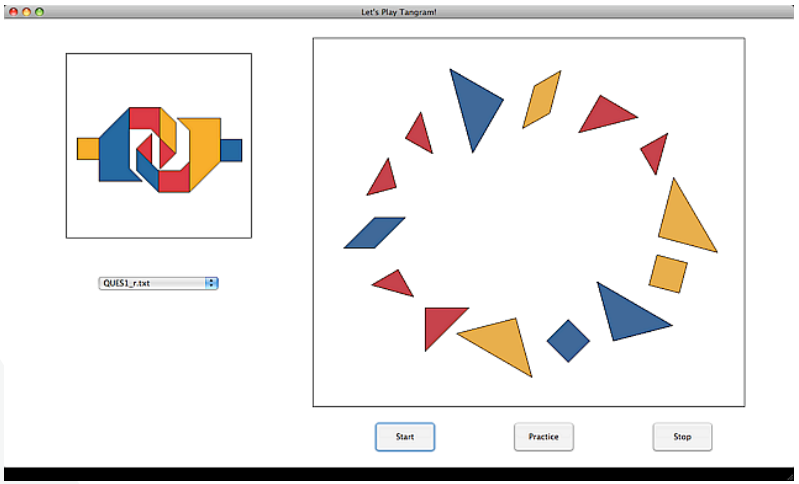
Puzzle type

Tangram



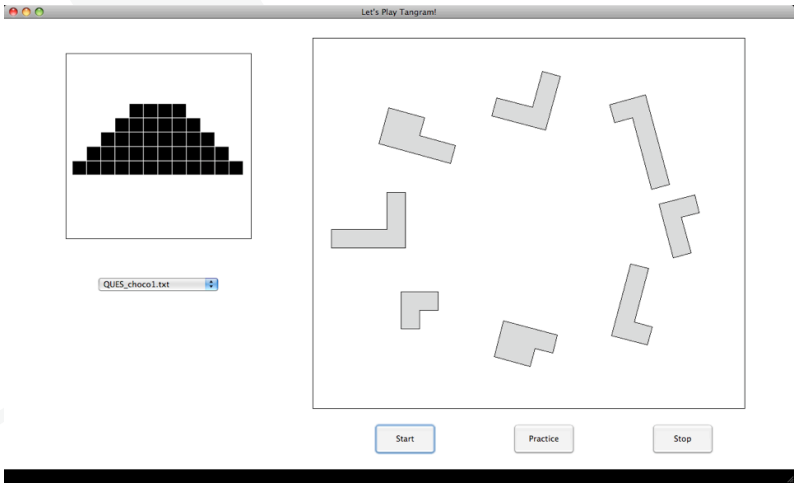
+attribute, ambiguity

Double Tangram

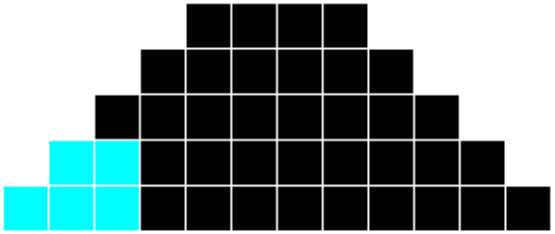


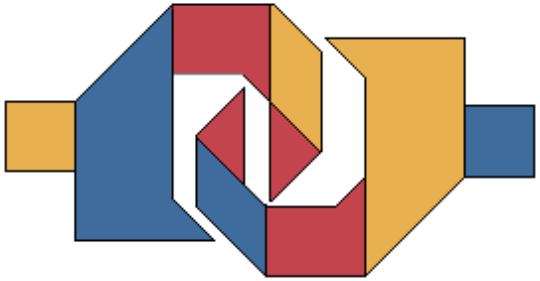
+complex shapes

Polyomino



Hinting

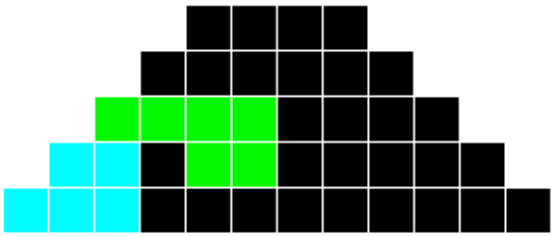




Double-Tangram

5 min.

Tangram



Polyomino

Configurations

corpus	puzzle	hint	language	eye-gaze
T2008-08	Tangram	yes	Japanese	no
T2009-11	Tangram	yes	Japanese	yes
N2009-11	Tangram	no	Japanese	yes
P2009-11	Polyomino	yes	Japanese	yes
D2009-11	Double-Tangram	yes	Japanese	yes
T2010-03	Tangram	yes	English	no

Annotation

- Transcription of utterances
- Actions on pieces
- Mouse cursor positions
- Eye-gaze

} automatic annotation

- Referring expressions
  - RE identification
  - Referent identification
  - Attribute assignment

} manual annotation

Translation of extra-linguistic information

- Action: piece ID+action type (flip, move, rotate)
- Mouse cursor: piece ID
- Eye-gaze → fixation point (I-DT algorithm)
  - fixation point: centroid of a gaze point cluster
  - fixation object: piece ID nearest to the fixation

Annotation

- Transcription of utterances
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- Eye-gaze

} automatic annotation

- Referring expressions
  - RE identification
  - Referent identification
  - Attribute assignment

} manual annotation

Target referring expressions

- Expressions referring to puzzle piece(s) with their referents
- Criteria
  - Annotate a minimum span of NP to identify its referent including repairs, demonstrative adjectives and erroneous one
  - Allow indefinite expressions
  - Exclude expressions in muttering to oneself

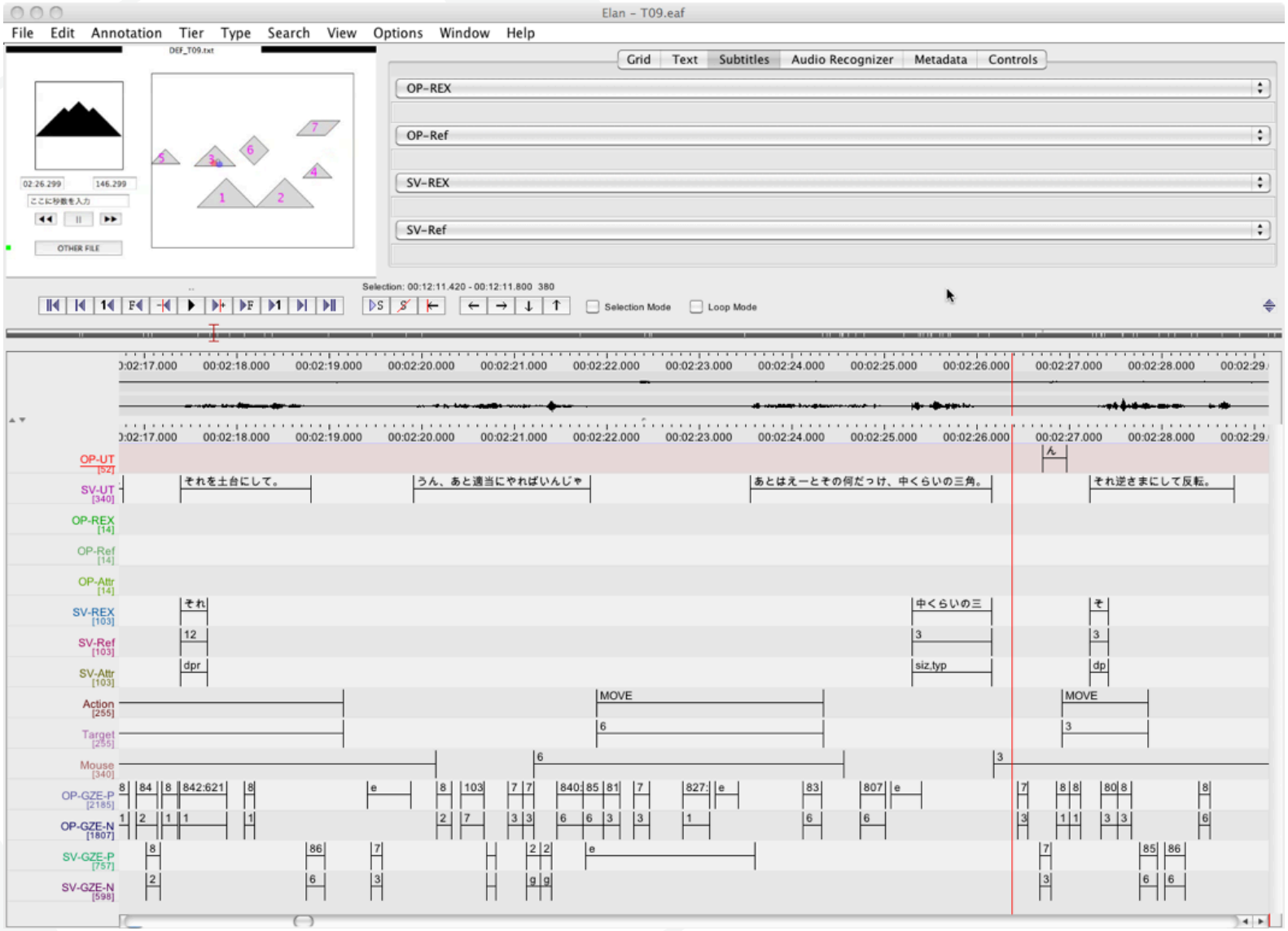
Attributes of referring expressions

dpr	: demonstrative pronoun
dad	: demonstrative adjective
dmn	: dummy noun
siz	: size
col	: colour
typ	: type
dir	: direction of a piece
prj	: projective spatial relation
tpl	: topological spatial relation
ovl	: overlap
act	: action on pieces
cmp	: complement
sim	: similarity
num	: number
rpr	: repair
err	: obvious erroneous expression
nest	: nested expression
meta	: metaphorical expression
nul	: no applicable attribute

e.g. “the large triangle that you just moved”

{siz,typ,act}

ELAN


Elan - T09.eaf
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Grid Text Subtitles Audio Recognizer Metadata Controls
OP-REX
OP-Ref
SV-REX
SV-Ref
Selection: 00:12:11.420 - 00:12:11.800 380
Selection Mode
Loop Mode
OP-UT
SV-UT
OP-REX
OP-Ref
OP-Attr
SV-REX
SV-Ref
SV-Attr
Action
Target
Mouse
OP-GZE-P
OP-GZE-N
SV-GZE-P
SV-GZE-N
それを土台にして。
うん、あと適当にやればいんじゃ
あとはえーとその何だっけ、中くらいの三角。
それ逆さまにして反転。
MOVE

ELAN tiers

tier	meaning
OP-UT	utterances (operator)
SV-UT	utterances (solver)
OP-REX	referring expressions (operator)
OP-Ref	referents of OP-REX
OP-Attr	attributes of OP-REX
SV-REX	referring expressions (solver)
SV-Ref	referents of SV-REX
SV-Attr	attributes of SV-REX
Action	action on a piece
Target	the target piece of Action
Mouse	the piece on which the mouse is hovering
OP-GZE-P	fixation point (operator)
OP-GZE-N	fixation piece (operator)
SV-GZE-P	fixation point (solver)
SV-GZE-N	fixation piece (solver)

Corpus size

corpus	#pairs	#dialg.	#valid	#succ.	ave. time (SD)
T2008-08	6	24	24	21	10:42 (3:16)
T2009-11	8	32	27	23	9:43 (3:32)
N2009-11	5	20	8	4	13:28 (2:48)
P2009-11	7	28	24	24	6:07 (1:33)
D2009-11	7	42	24	23	5:53 (2:08)
T2010-03	6	24	24	10	12:47 (3:34)

Number of referring expressions and its average

corpus	#utterances		#referring exp.	
	OP	SV	OP	SV
T2008-08	1,892	2,571	200	1,214
	78.8	107.1	8.3	50.6
T2009-11	2,382	4,613	271	1,192
	88.2	170.9	10.0	44.1
N2009-11	1,119	1,716	168	497
	139.9	214.5	21.0	62.1
P2009-11	1,903	2,920	325	1,056
	79.3	121.7	13.5	44.0
D2009-11	926	3,024	115	1,115
	38.6	126.0	4.8	46.5
T2010-03	2,049	4,848	310	2,396
	85.4	202.0	12.9	99.8

Analysis: Puzzle type (T2008-08+T2009-11 / P2009-11 / D2009-11)

- OP's utterances (OP's RE)
  - 2-Tangram < Tangram, Polyomino
- dpr, prj, meta
  - Polyomino > Tangram, 2-Tangram
- siz, typ
  - Polyomino < Tangram, 2-Tangram
- typ
  - Tangram > 2-Tangram
- rpr, err
  - 2-Tangram > Tangram, Polyomino

Analysis: Hinting (T2008-08+T2009-11 vs. N2009-11)

- Completion time
  - No hint > W/ hint
- Success rate
  - No hint < W/ hint
- OP's utterances, SV's utterances
  - No hint > W/ hint

Analysis: Language (T2008-08+T2009-11 vs. T2010-03)

- Completion time
  - Japanese < English
- Success rate
  - Japanese > English
- SV's REs
  - Japanese < English
- dpr, dad, tpl, cmp, num
  - Japanese < English

Summary (Corpus construction)

- The REX corpora: a collection of multimodal corpora of referring expressions
- Situated dialogues for collaborative problem solving
- Linguistic + extra-Linguistic annotation
- Various configurations for dialogue collection

Referring expression generation:
A comparative study
- English vs. Japanese -

Corpora used

corpus	puzzle	hint	language	eye-gaze
T2008-08	Tangram	yes	Japanese	no
T2009-11	Tangram	yes	Japanese	yes
N2009-11	Tangram	no	Japanese	yes
P2009-11	Polyomino	yes	Japanese	yes
D2009-11	Double-Tangram	yes	Japanese	yes
T2010-03	Tangram	yes	English	no

- Tangram puzzle
- 6 pairs of native speaker per corpus → 24 + 24 dialogues
- 4 trials per pairs
- 15 minutes time limit

Problem setting

- Given a situation and a target, to judge if producing a demonstrative pronoun for referring to the target is appropriate or not (with respect to the collected corpus)
- To what extent the computer can replicate human usage of demonstrative pronouns?

Why demonstrative pronouns?

Attributes		Japanese		English	
		Total	[%]	Total	[%]
dpr	demonstrative pronoun	668	23.1	1,835	46.9
dad	demonstrative adjective	176	6.1	374	9.6
dmn	dummy noun	39	1.3	0	0
siz	size	285	9.9	422	10.8
col	color	0	0	37	0.9
typ	type	647	22.4	725	18.5
dir	direction of a piece	7	0.2	2	0.1
prj	projective spatial	141	4.9	132	3.4
tpl	topological spatial	10	0.3	40	1.0
ovl	overlap	2	0.1	7	0.2
act	action on pieces	94	3.3	48	1.2

Generating demonstrative pronouns

- SVM classifier to decide to use a demonstrative pronoun in an utterance in the dialogue
- 10-fold cross validation
- Features
  - Dialogue history features (5)
  - Action history features (5)
  - Current operation features (2)

Features for SVM

Dialogue History	Action History	Current Operation
D1: time distance to the last mention of target	A1: time distance to the last action on target	O1: target is under operation
D2: last expression type referring to target	A2: last operation type on target	O2: target is under the mouse
D3: number of other pieces mentioned during A1	A3: number of other pieces operated during D1	
D4: time distance to last mention of another piece	A4: time distance to last operation on another piece	
D5: target is last mentioned piece	A5: target is last operated piece	

Result with balanced set (targeting DP)

Features	Japanese			English		
	Recall	Precision	F	Recall	Precision	F
All	0.789	0.785	0.786	0.795	0.752	0.772
w/o Dn	0.786	0.785	0.784	0.768	0.733	0.749
w/o An	0.786	0.785	0.784	0.768	0.733	0.749
w/o On	0.719	0.689	0.698	0.759	0.700	0.727

Learnt feature weights (Top 10)

	Japanese		English	
1	O2=target	0.8344	O2=target	0.3225
2	D1≤10	0.1793	D1≤10	0.2620
3	A5=yes	0.1149	A5=yes	0.2567
4	O1=target	0.0596	D2=pron	0.2444
5	D2=pron	0.0592	A1≤10	0.1969
6	D5=yes	0.0584	D5=yes	0.1487
7	A1≤10	0.0456	O1=target	0.0785
8	D4≤10	0.0420	A2=rotate	0.0722
9	A4≤20	0.0389	D4≤10	0.0631
10	A4>20	0.0378	A4≤20	0.0382

Piece was under mouse cursor

Piece was mentioned ≤ 10 seconds ago

Summary (Referring expression generation)

- Comparing performance of a GRE algorithm with Japanese and English corpora, focusing on DP
- Extra-Linguistic and Linguistic features are both combined to generate DP
- Features related to current operation, particularly in case of mouse cursor, are dominant in both Japanese and English

Referring expression resolution

Reference resolution

- Anaphora resolution vs. Reference resolution
  → antecedent vs. referent
- Monologue text vs. Dialogue
- Rule-based vs. Corpus-based
  - Rule-based: (Hobbs 1978, Grosz et al. 1995, Mitkov 2002)
  - Corpus-based: (Soon et al. 2001, Ng&Cardie 2002, Young 2005)

Referent ranking model

- Ranking SVM to rank puzzle pieces given a situation and a referring expression
- Features
  - Dialogue history features (10)
  - Action history features (mouse cursor&operation) (12)
  - Eye-gaze features (14)

Discourse history features

D1 P is referred to by the most recent RE

D2-4 the time distance to the last mention to P is {≦10, ≦20, >20}

D5 P is never mentioned before

D6 P's attributes are compatible with RE

D7,8 RE is followed by case marker {acc, dat}

D9 RE is a pronoun, and most recent reference to P is not pronoun

D10 RE is not a pronoun, and most recent reference to P is pronoun

Action history features

A1	mouse cursor is over P at the starting of RE
A2	P is the last piece that mouse cursor was over when M1 is false
A3-5	the time distance to the last mouse over on P is {≦10, ≦20, >20}
A6	mouse cursor was never over P before
A7	P is under operation at the starting of REX
A8	P is the last operated piece when A1 is false
A9-11	the time distance to the last operation on P is {≦10, ≦20, >20}
A12	P was never operated before

Eye-gaze features

- Frequency of fixations: G1, G4, G7, G8, G11, G12
  e.g.
  G1: the frequency of fixating P in [t-T, T], normalised by the frequency of the total fixations during the period
- Fixation length: G2, G3, G5, G6, G9, G10, G13, G14
  e.g.
  G2: the length of a fixation on P in[t-T, T], nomalised by T

Experimental setting

- 10-fold cross validation on 1,462 instances (27 dialogues)
  - true referent = 1st rank
  - distractors = 2nd rank
- Ranking software: *SVM*^{rank}
- Separate model
  - DP model
  - non-DP model

Result (each model)

Feature set	DP	non-DP
Discourse	0.560	0.654
Eye-gaze	0.567	0.480
Action	**0.792**	0.211
Discourse+Eye-gaze	0.665	0.757
Discourse+Action	0.790	0.671
Action+Eye-gaze	0.780	0.484
Discourse+Action+Eye-gaze	0.787	**0.760**

Result (overall)

model	accuracy
Discourse	0.618
Eye-gaze	0.512
Action	0.428
Discourse+Eye-gaze	0.723
Discourse+Action	0.715
Action+Eye-gaze	0.595
Discourse+Action+Eye-gaze	**0.770**

Effective features

	DP model		non-DP model	
rank	feature	weight	feature	weight
1	A1	0.4744	D6	0.6149
2	A3	0.2684	G10	0.1566
3	D1	0.2298	G9	0.1566
4	A7	0.1929	G7	0.1255
5	A9	0.1605	G11	0.1225

A1: mouse cursor was over a piece at the beginning of uttering a referring expression

A3: time distance is less than or equal to 10 sec after the mouse cursor was over a piece

Effective features

	DP model		non-DP model	
rank	feature	weight	feature	weight
1	A1	0.4744	D6	0.6149
2	A3	0.2684	G10	0.1566
3	D1	0.2298	G9	0.1566
4	A7	0.1929	G7	0.1255
5	A9	0.1605	G11	0.1225
6	G10	0.1547	G14	0.1134
7	G9	0.1547	G13	0.1134
8	D6	0.1442	G12	0.1026
9	G7	0.1267	D2	0.1014
10	D2	0.1164	G1	0.0750

D6: attribute consistency

Summary (reference resolution)

- The referents of pronouns rely on the visual focus of attention such as is indicated by moving the mouse cursor
- Non-pronouns are strongly related to eye fixations on its referent
- Integrating these two types of multi-modal information into linguistic information contributes to increasing accuracy of reference resolution

Summary

- Multi-modal corpus construction & analysis
- Referring expression generation
  Comparative study (English vs. Japanese)
- Referring expression resolution

Publication

- Corpus construction (@ENLG 2009, ALR2010, LREC2012)
- Generation of demonstrative pronouns (@PreCogSci WS 2009)
- Reference resolution (@ACL2010, IJCNLP2011)
- Evaluation proposal (@INLG 2010)

Acknowledgement

- Feraena Bibyna
- Kuriyama Naoko
- Kobayasi Syunpei
- Philipp Spanger
- Terai Asuka
- Yasuhara Masaaki

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