Grounded Acquisition of Symbols

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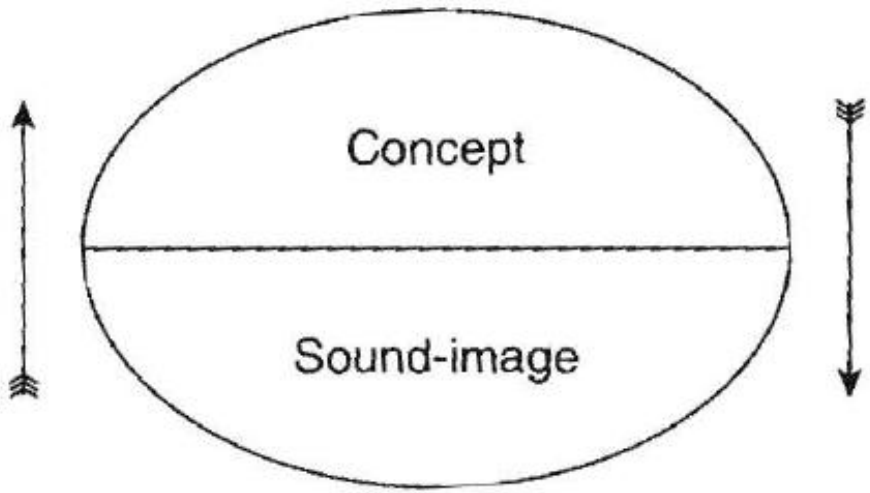
Symbol

- Saussure:



- People consider symbols as <term,meaning> pairs which emerge while interacting with real designs

How do symbols get grounded?

How do they get associated with concepts?

Baby Designer Model

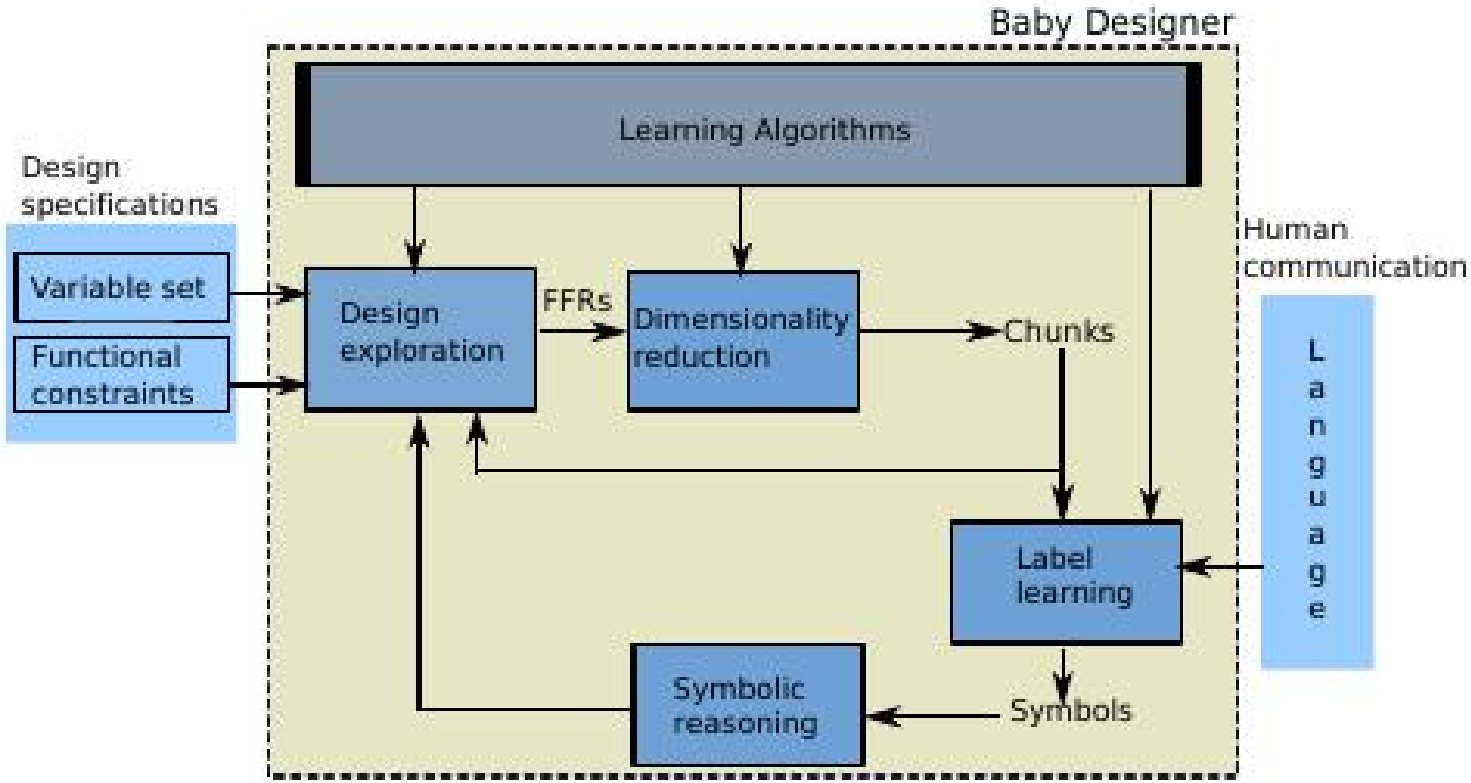


Figure: 1: Architecture of the Baby Designer

Previous Work

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@inproceedings{mukerjee2010using,
   title={Using emergent symbols to discover
          multi-lingual translations in design},
   author={Mukerjee, A and Dabbeeru, MM},
   booktitle={Proceedings of DETC},
   volume={10},
   year={2010}
}
```

Previous Work

(a) peg and hole

(b) peg-in-hole assembly

Figure: 2: peg-in-hole assembly

Previous Work

- The association of word w_i with concept C_j can be measured using conditional probability.
- Direction of association: $p(C/w)$ or $p(w/C)$???
- Only two concepts involved, so

$$\frac{p(C_L/w)}{p(C_T/w)} = \frac{p(w/C_L).p(C_L)}{p(w/C_T).p(C_T)}$$

- Number of instaces of C_L and C_T almost same in training data, so direction of association doesn't matter.
- For strongest association with C_T, compute $max_i\{\frac{p(w_i/C_T)}{p(w_i/C_L)}\}$

Emergent Associations

Term	f_L	$\hat{p}(\frac{w}{C_L})$	f_T	$\hat{p}(\frac{w}{C_T})$	$f_{T,L}$	$\hat{p}(w)$	$p(w)(T.V)$	$\frac{\hat{p}(\frac{w}{C_L})}{\hat{p}(\frac{w}{C_T})}$
Without stemming								
loose	27	0.0298	4	0.0036	31	0.0154	0.00003	8.2
much	10	0.0110	2	0.0018	12	0.0059	0.00117	6.07
can	28	0.0309	12	0.0109	40	0.0199	0.00912	2.83
quite	8	0.0088	4	0.0036	12	0.0059	0.00018	2.43
easily	10	0.0110	7	0.0063	17	0.0084	0.00002	1.73
With stemming								
loose	30	0.0331	4	0.0036	34	0.0169	0.00003	9.11
much	10	0.0110	2	0.0018	12	0.0059	0.00117	6.07
can	28	0.0309	13	0.0118	41	0.0206	0.00912	2.62
easy	17	0.0187	9	0.0081	26	0.0129	0.00023	2.29
in	15	0.0165	13	0.0118	28	0.0139	0.00966	1.4

Table 3. English results: [loose] corpus: Top five words by conditional ratio

Emergent Word Associations

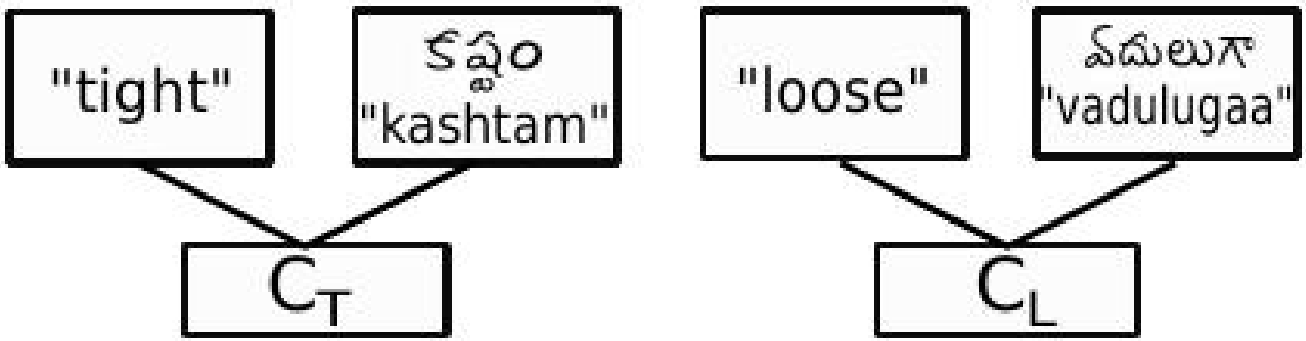

Figure: 4

Methodology

- Extension to Hindi Corpus in a similar manner.
- Include the case when the person tries to insert the peg in the hole while the block is in air.
- Plan to include native hindi speaking people (who have very less contact with English).

Expected Results

- Hindi would be similar to Telugu (more similar in structure as compared to English)
- Influence of English in the Hindi narrations ("Tight : Taang" is uncommon)

References:

1. [Madan Dabbeeru, Amitabha Mukherjee]. "Using Symbol Emergence to Discover Multi-Lingual Translations in Design". Proceedings of the ASME 2010 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference Proceedings of IDETC/DTM 2010, 2010.
2. [Dabbeeru, Madan Mohan and Mukerjee, Amitabha]. "Learning concepts and language for a baby designer". Design Computing and Cognition'10, 2011.
3. [S V P Gopi Srinath, Nikhil Joshi, Prabhat Mudgal, Amitabha Mukerjee]. "Learning grounded semantics of Hindi nouns from video surveillance and user commentary". Proceedings of ICON-2010: 8th International Conference on Natural Language Processing, 2010.

References (cont...):

1. [Madan Dabbeeru, Amitabha Mukerjee]. "Computational models of tacit knowledge."
2. [De Saussure, Ferdinand]. "Nature of the linguistic sign". Course In General Linguistics, 1916.

Extra Slides for discussion...

Term	f_L	$\hat{p}(\frac{w}{C_L})$	f_T	$\hat{p}(\frac{w}{C_T})$	$f_{T,L}$	$\hat{p}(w)$	$p(w)(T.V)$	$\frac{\hat{p}(\frac{w}{C_L})}{\hat{p}(\frac{w}{C_T})}$
Without stemming								
loose	27	0.0298	4	0.0036	31	0.0154	0.00003	8.2
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much	10	0.0110	2	0.0018	12	0.0059	0.00117	6.07
can	28	0.0309	13	0.0118	41	0.0206	0.00912	2.62
easy	17	0.0187	9	0.0081	26	0.0129	0.00023	2.29
in	15	0.0165	13	0.0118	28	0.0139	0.00966	1.4

Table 3. English results: [loose] corpus: Top five words by conditional ratio

Term	f_T	$\hat{p}(\frac{w}{C_T})$	f_L	$\hat{p}(\frac{w}{C_L})$	$f_{T,L}$	$\hat{p}(w)$	$p(w)(T.V)$	$\frac{\hat{p}(\frac{w}{C_T})}{\hat{p}(\frac{w}{C_L})}$
Without stemming								
tight	26	0.0236	3	0.0033	29	0.0144	0.00004	7.14
cannot	7	0.0063	1	0.0011	8	0.0039	0.0001	5.76
to	33	0.0300	8	0.0088	41	0.0204	0.0281	3.40
into	12	0.0109	3	0.0033	15	0.0074	0.0009	3.29
am	9	0.0081	3	0.0033	12	0.0059	0.0012	2.47
With stemming								
tight	34	0.0309	3	0.0033	37	0.0184	0.00004	9.33
to	33	0.0300	8	0.0088	41	0.0204	0.02810	3.4
into	12	0.0109	3	0.0033	15	0.0074	0.00093	3.29
not	19	0.0172	7	0.0077	26	0.0129	0.00660	2.24
rotate	23	0.0209	12	0.0132	35	0.0174	0.00000	1.58

Table 2. English results: [tight] corpus: Top five words by conditional ratio

Term		Gloss	f_T	$\hat{p}(\frac{w}{C_T})$	f_L	$\hat{p}(\frac{w}{C_L})$	$\frac{\hat{p}(\frac{w}{C_T})}{\hat{p}(\frac{w}{C_L})}$
Without stemming							
టైటుగా	tightugaa	tightly	5	0.01506	0.5	0.00155	9.7
లేదు	ledu	not there	4	0.01205	0.5	0.00155	7.76
బహుశ	bahusa	perhaps	3	0.00904	0.5	0.00155	5.82
అస్సలు	assalu	at all	3	0.00904	0.5	0.00155	5.82
కష్టం	kashtam	difficult	3	0.00904	0.5	0.00155	5.82
With stemming							
కష్టం	kashtam	difficult	10	0.03012	0.5	0.00157	20
టైట్	tight	tight	6	0.01807	0.5	0.00157	12
లేదు	ledu	Not there	4	0.01205	0.5	0.00157	8
సో	so	so	5	0.01506	1	0.00314	5
అస్సలు	assalu	not at all	4	0.01205	1	0.00314	4

Table 5. Telugu [tight] corpus: Top five words by conditional ratio

Term		Gloss	f_T	$\hat{p}(\frac{w}{C_T})$	f_L	$\hat{p}(\frac{w}{C_L})$	$\frac{\hat{p}(\frac{w}{C_T})}{\hat{p}(\frac{w}{C_L})}$
Without stemming							
దీనికి	deeniki	for this	6	0.01887	0.5	0.00151	12.53
వదులుగా	vadulugaa	loose	5	0.01572	0.5	0.00151	10.44
లూజుగా	loosugaa	loose	8	0.02516	1	0.00301	8.35
లోపలికి	lopaliki	into	3	0.00943	0.5	0.00151	6.26
అదే	adey	that one	3	0.00943	0.5	0.00151	6.26
With stemming							
వదులుగా	vadulugaa	loose	5	0.01572	0.5	0.00151	10.44
సులభంగా	sulabhamgaa	easy	8	0.02516	1	0.00301	8.35
మూడు	mudu	three	5	0.01572	1	0.00301	5.22
లూజుగా	loosugaa	loose	8	0.02516	2	0.00602	4.18
వెళ్ళి	velli	velli	7	0.02201	2	0.00602	3.65

Table 6. Telugu results: [loose] corpus: Top five words by conditional ratio

Action profiled: [tight] corpus							
Term	f_T	$\hat{p}(\frac{w}{C_T})$	f_L	$\hat{p}(\frac{w}{C_L})$	$f_{T,L}$	$\hat{p}(w)$	$\frac{\hat{p}(\ fracwC_T)}{\hat{p}(\frac{w}{C_L})}$
Without stemming							
tight	26	0.02050	4	0.00462	30	0.01406	4.43
first	13	0.01025	3	0.00347	16	0.00750	2.96
not	30	0.02366	8	0.00925	38	0.01782	2.56
a	11	0.00868	3	0.00347	14	0.00656	2.5
i	30	0.02366	9	0.01040	39	0.01828	2.27
With stemming							
tight	33	0.02603	4	0.00462	37	0.01735	5.63
first	13	0.01025	3	0.00347	16	0.00750	2.96
not	30	0.02366	8	0.00925	38	0.01782	2.56
i	30	0.02366	9	0.01040	39	0.01828	2.27
of	27	0.02129	11	0.01272	38	0.01782	1.67
Action profiled: [loose] corpus							
Term	f_L	$\hat{p}(\frac{w}{C_L})$	f_T	$\hat{p}(\frac{w}{C_T})$	$f_{T,L}$	$\hat{p}(w)$	$\frac{\hat{p}(\frac{w}{C_L})}{\hat{p}(\frac{w}{C_T})}$
Without stemming							
easy	13	0.01503	2	0.00158	15	0.00703	9.53
second	10	0.01156	2	0.00158	12	0.00563	7.33
easily	18	0.02081	4	0.00315	22	0.01031	6.6
can	13	0.01503	4	0.00315	17	0.00797	4.76
very	21	0.02428	11	0.00868	32	0.01500	2.8
With stemming							
ease	35	0.04046	6	0.00694	41	0.01922	5.83
second	10	0.01156	2	0.00231	12	0.00563	5.00
can	13	0.01503	6	0.00694	19	0.00891	2.17
very	21	0.02428	11	0.01272	32	0.01500	1.91
diameter	13	0.01503	9	0.01040	22	0.01031	1.44

Table 4. Action Profile: [tight] and [loose] corpora: Top five words by conditional ratio.