Generating "initial" hypothesis

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Today's talk

- about hypothesis generation
- especially on "***initial***" hypothesis generation
  - cardinality - sparsity of hypothesis
  - an empirical data
  - possible future direction

Context of discovery

- Present investigation concerns about generation of hypothesis (***context of discovery***), not about context of justification
  - how do we form our hypothesis after seeing a small number of new cases

Generating *initial* hypothesis

- Previous work
  - showed that good hypothesis-generating ability fostered successful solution (e.g., Adsit & London, 1997; Lien & Lin, 2011)
  - however, they didn't show how *initial* hypothesis was formed

Empirical findings on *initial* hypothesis generation

- Cherubini et al. (2005)
  - ***regularity*** (common feature) available in initial triples affect hypothesis generation
    - some regularities contribute to the hypothesis more than do other regularities ... people estimate *amount of information* in the perceived regularities and then try to preserve as much information as possible in their hypotheses

Regularities in triplets

- **Low-information regularity (Low-IR)**
  - object regularity ... properties that can be predicated of single objects e.g. "2-4-6 is a triple of even numbers"
    c.f. *surface similarity* in analogical reasoning
- **High-information regularity (High-IR)**
  - relational regularity ... relation across items e.g. "2-4-6 is a triple of ascending by 2s"
    c.f. *deep structure*

Another findings...

- Norenzayan et al. (2002)
  - Is Western thinking more rule-governed and less intuitive than East Asian thinking?
    - Failed to show cultural difference in classification task. Both Westerner and Easterner preferred uni-dimensional rule
    - In similarity judgment, Easterners were affected by "***family resemblance***" (**FR**) between items

Result

- Rule vs. Family resemblance
  - Family resemblance was not used in classification task, however, Easterner judged similarity between target object and group in terms of FR

Present investigation

- Question
  - What kind of regularities in items affect generating *initial* hypothesis?
  - To investigate, 3-level regularity condition was set.
    - uni-dimensional (UNI)
    - conjunction (CNJ)
    - family resemblance (FR)

Task and Design

- Participants and tasks
  - Participants: 51 undergraduates (18 male, 33 female, mean age = 19.8, *SD* = 1.01) were randomly assigned to 3 conditions.
  - Independent variables
    - 2 task domain ... **within** participants

      2-4-6 / Bruner et al. (1956)'s concept identification
    - 3 levels of regularity in samples ... **between** participants

      uni-dimensional / conjunction / family resemblance
  - dependent variables
    - amount of information in hypothesis (cardinality ranks)

Information regularity in samples

- Four attributes and their values in 2 tasks

	Attributes (0/1)			
	a1*	a2	a3	a4
2-4-6	increasing	number	constant steps	__ than 20
	yes / no	evens / odds	yes / no	less / bigger
Bruner	figure	no. of figures	color	frame
	cross / circle	1 / 3	red / green	single / triple

* attribute a1 is always "1" across all conditions

Information regularity in samples

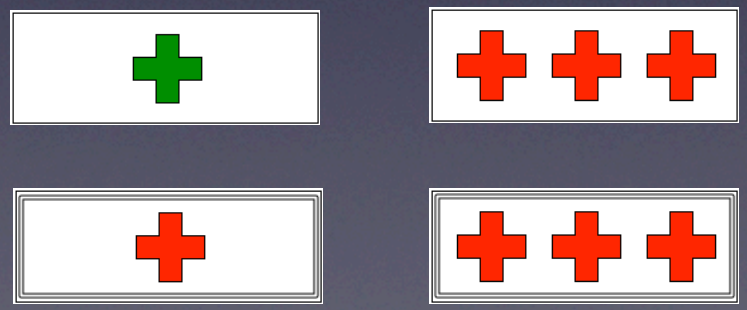
- uni-dimensional (UNI)
  - only one attribute (a1) is common across items.

2 - 4 - 10

24 - 26 - 28

3 - 5 - 7

29 - 31 - 33



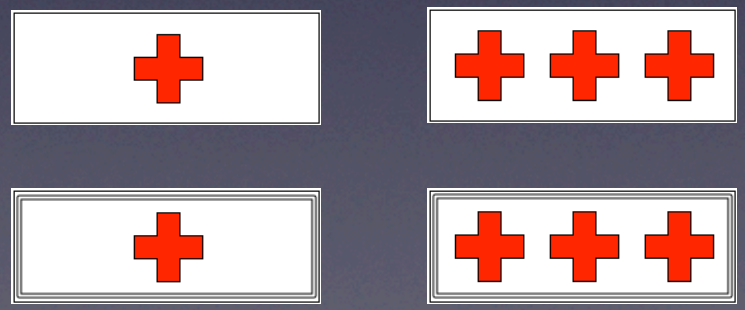
a1	a2	a3	a4
0	0	1	0
0	1	0	0
0	0	0	1
0	1	0	1

Information regularity in samples

- conjunction (CNJ)
  - common feature is consisted of ***conjunction of two attributes*** (a1 & a3)

6 - 8 - 10 3 - 5 - 7

24 - 26 - 28 29 - 31 - 33



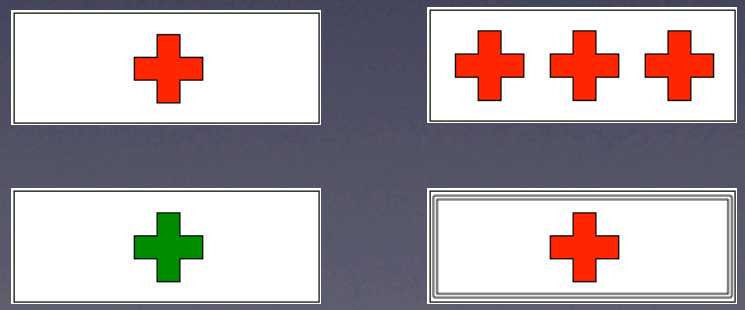
a1	a2	a3	a4
0	0	0	0
0	1	0	0
0	0	0	1
0	1	0	1

Information regularity in samples

- Family resemblance (FR)
  - samples were different only in one dimension with each other, and only a1 is common across items.
  - item structure was adopted from Norenzayan et al. (2002)

6 - 8 - 10 3 - 5 - 7

2 - 4 - 10 24 - 26 - 28



a1	a2	a3	a4
0	0	0	0
0	1	0	0
0	0	1	0
0	0	0	1

Example of task

- 2-4-6 task, uni-dimentional

Following 4 combinations of 3 numbers (called *triplet*) were categorized as Group A.

4 triplets of Group A	
2-4-10	3-5-7
24-26-28	29-31-33

a) In your opinion, how should you assemble 3 numbers in order for a triplet to be an instance of Group A. In other words, which triplets were instance of A. Please write your guess in order of occurrence.

Example of task continues...

- 2-4-6 task, uni-dimentional

b) Please list your guess(es) above in the order of likelihood (i.e. the most plausible guess ranks highest and will be assigned "1", next plausible one will be evaluated as "2"). Please write your answer in square boxes.

c) Imagine you are going to examine your guess(es). You have to check another triplet to investigate whether your guess(es) were correct. Please write such a triplet.

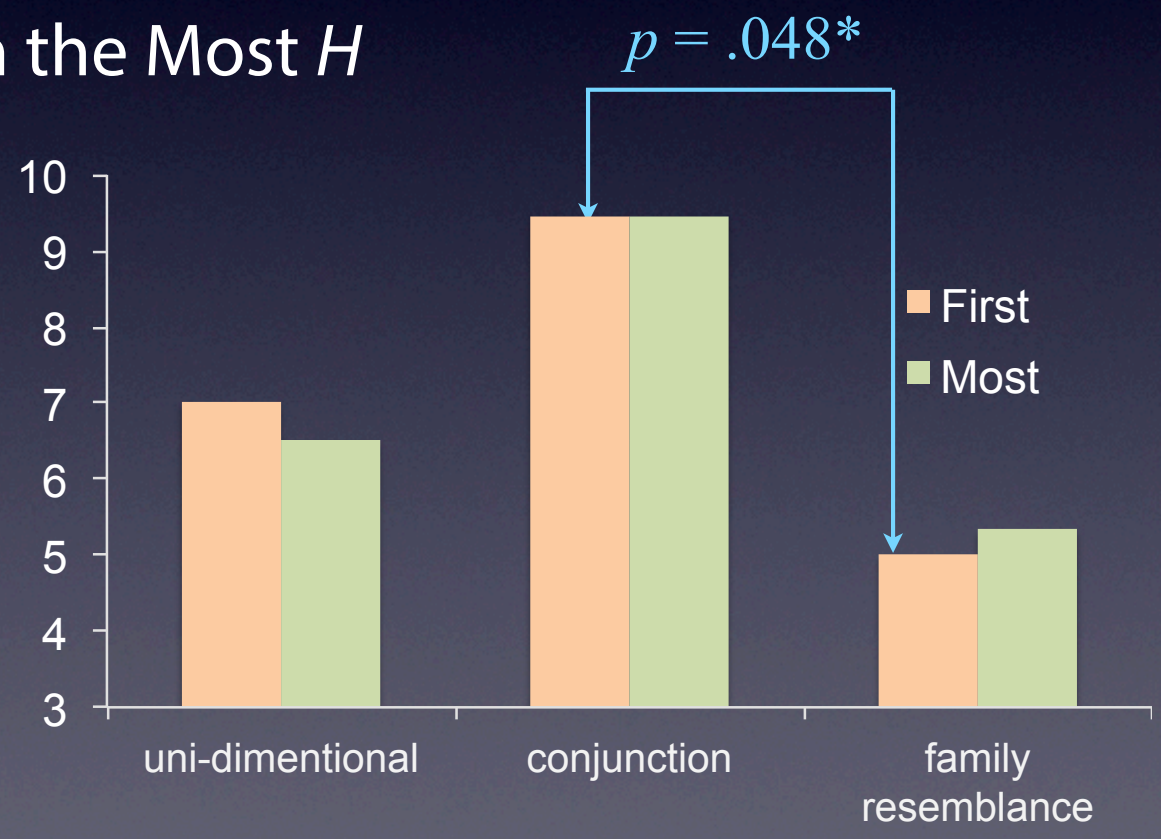
[ ] - [ ] - [ ]

Present Results

- Ranks of initial *H*s were calculated both on
  - the first *H*
    - *H* occurred to participants at the beginning.
  - the most plausible *H*
    - best-guess *H*

Hypothesis rank in 2-4-6

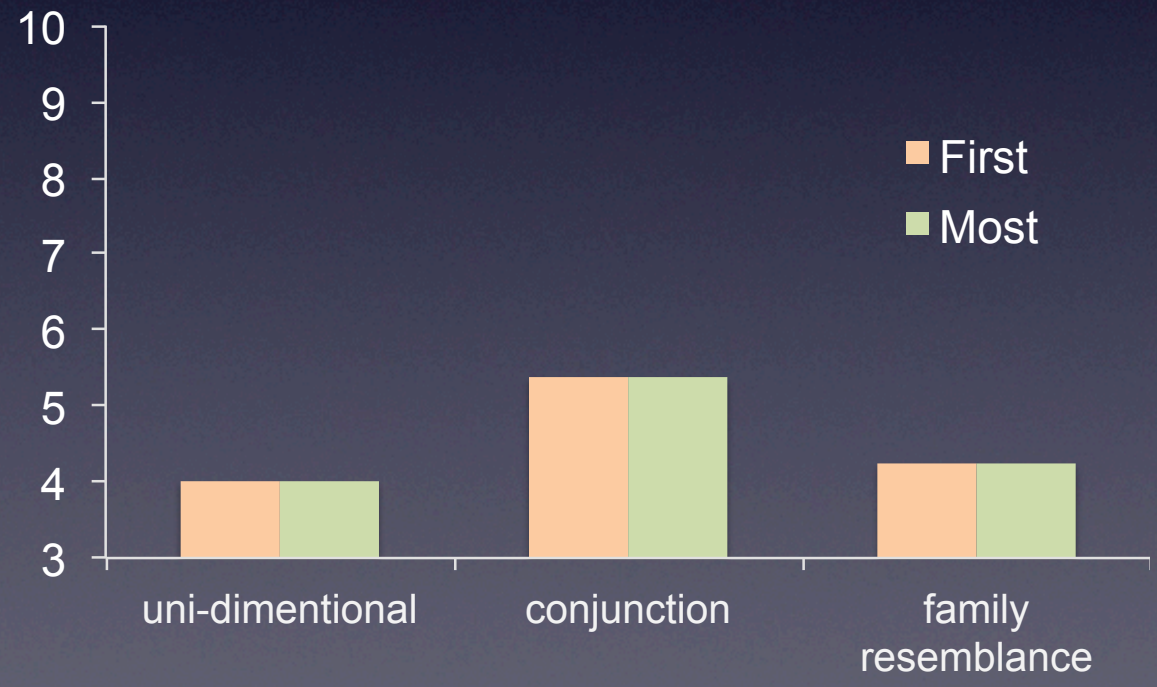
- Median ranks
  - Kruskal-Wallis test shows that amount of information ...
    - was marginally different on the First *H*, $\chi^2(2) = 5.58, p = .06$
    - was not different on the Most *H*



* Multiple comparison by Steel-Dwass method

Hypothesis rank in Bruner task

- Median ranks
  - Kruskal-Wallis test shows that amount of information was not different both on First and Most.



First *H*

- content of first H
  - 2-4-6

Any 3 evens or any 3 odds

Numbers increasing by 2s

	Type of hypothesis*												
	3	*4*	*5*	*6*	*8*	*10*	*11*	*12*	*14*	*15*	*16*	*17*	*18*
UNI	5	1	0	0	0	2	1	0	1	1	2	0	1
CNJ	2	0	0	0	0	3	0	0	0	0	10	0	0
FR	5	2	2	1	1	0	0	1	2	0	2	1	0

* see Appendix A. P(H) is high on the left

Numbers spaced by 2s

increasing numbers

not compatible with presented triplets

First *H*

- content of first H
  - Bruner

Red Cross

	Type of hypothesis*								
	3	*8*	*13*	*15*	*17*	*18*	*23*	*24*	*27*
UNI	0	1	0	0	0	14	0	0	1
CNJ	1	0	1	0	4	5	1	4	1
FR	0	0	0	1	0	14	0	1	0

* see Appendix A. P(H) is high on the left

Red figure

Cross

not compatible with presented items

First *H*

- content of first H
  - Bruner (revised)

	Type of hypothesis					
	Any items	Red figure	Cross	One Cross	Red Cross	Same figure
UNI	1	0	14	0	0	1
CNJ	1	4	6	1	4	1
FR	0	0	15	0	1	0

not compatible with presented items

Number of hypothesis

- Total number of hypothesis generated by regularity condition and task

	Regularities in samples				
	UNI	CNJ	FR	$F(2, 48)$	p
2-4-6	1.24	1.12 ⟷	1.71	3.25	.048
	(.75)	(.60)	(.77)		
Bruner	1.65	1.82	1.71	0.22	.803
	(.86)	(.73)	(.77)		

$p = .05$

Summary of results

- Cardinality - Sparsity of initial hypothesis
  - reflects regularities in presented items
    - CNJ -> specific hypothesis (i.e. numbers increasing by two2, red cross) were preferred
    - UNI, FR -> sparse hypothesis, such as “any 3 evens, or any 3 odds”, “cross” were preferred.

Summary of results

- Cardinality - Sparsity of initial hypothesis
  - When generating their hypothesis, people ***perceive regularity*** in the samples and *use it as a hint* to generate a hypothesis.
    - High-IR is more preferable, if available
    - however, FR (highest but not common among items) was not perceived as a regularity

people consider a rule as a set of *common* properties

Difference between 2 tasks

- Dominant initial hypothesis
  - 2-4-6
    - CNJ -> numbers increasing by 2s
  - Bruner
    - UNI, FR -> Cross

We have to consider *perceivability* of attributes?

Future directions

- Regularities in similarity judgment
  - Norenzayan et al. (2002) showed that FR did play a role in similarity judgment task, particularly for Easterner
  - When **High-IR and FR are competing** with each other, how do people estimate similarity between novel target object and existing groups
- Any cultural difference in hypothesis generation
  - Easterner thinking was considered as holistic, associative, similarity-based.
    - Were Easterner and Westerner different in *sparsity* of their initial hypothesis?

Key References

1. Adsit & London (1997). Effects of hypothesis generation on hypothesis testing in rule-discovery tasks. *The Journal of General Psychology*, 124, 19-34.
2. Cherubini et al. (2005). Generation of hypothesis in Wason's 2-4-6 task: An information theory approach. *The Quarterly Journal of Experimental Psychology*, 58A, 309-332.
3. Lien & Lin (2011). From falsification to generating an alternative hypothesis: Exploring the role of the new-perspective hypothesis in successful 2-4-6 task performance. *Thinking & Reasoning*, 17, 105-136.
4. Navarro & Perfos (2011). Hypothesis Generation, Sparse Categories, and the Positive Test Strategy. *Psychological Review*, 118, 120-134.
5. Norenzayan et al. (2002). Cultural preferences for formal versus intuitive reasoning. *Cognitive Science*, 26, 653-684.