

Towards Explicitness as a Language Design Criterion

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Language Design

- Cognitive Dimensions Framework
- Semantics-First Approach
- ???



Tension in Language Design



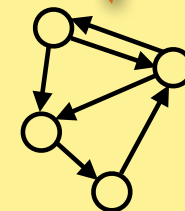
Simplification

λ

$\dots ::= \dots \mid \dots$

Domain Specificity

*select ...
from ...
where ...*



Language Design Criteria?

Compositionality



Gottlob Frege

Explicitness



*Help balance the simplicity/
domain-specificity trade-off*

Martin Fowler, IEEE Software (2001)
“... explicit code is easier to understand”

Kent Beck
“... explicit code is intention revealing”

Explicitness Trade-Offs

Advantages

- Better expression of intent
- Avoidance of hidden assumptions
- Manipulability of representation

Disadvantages

- Bigger and more complicated languages
- Extra burden through notational overhead
- Proliferation of feature interaction in language design

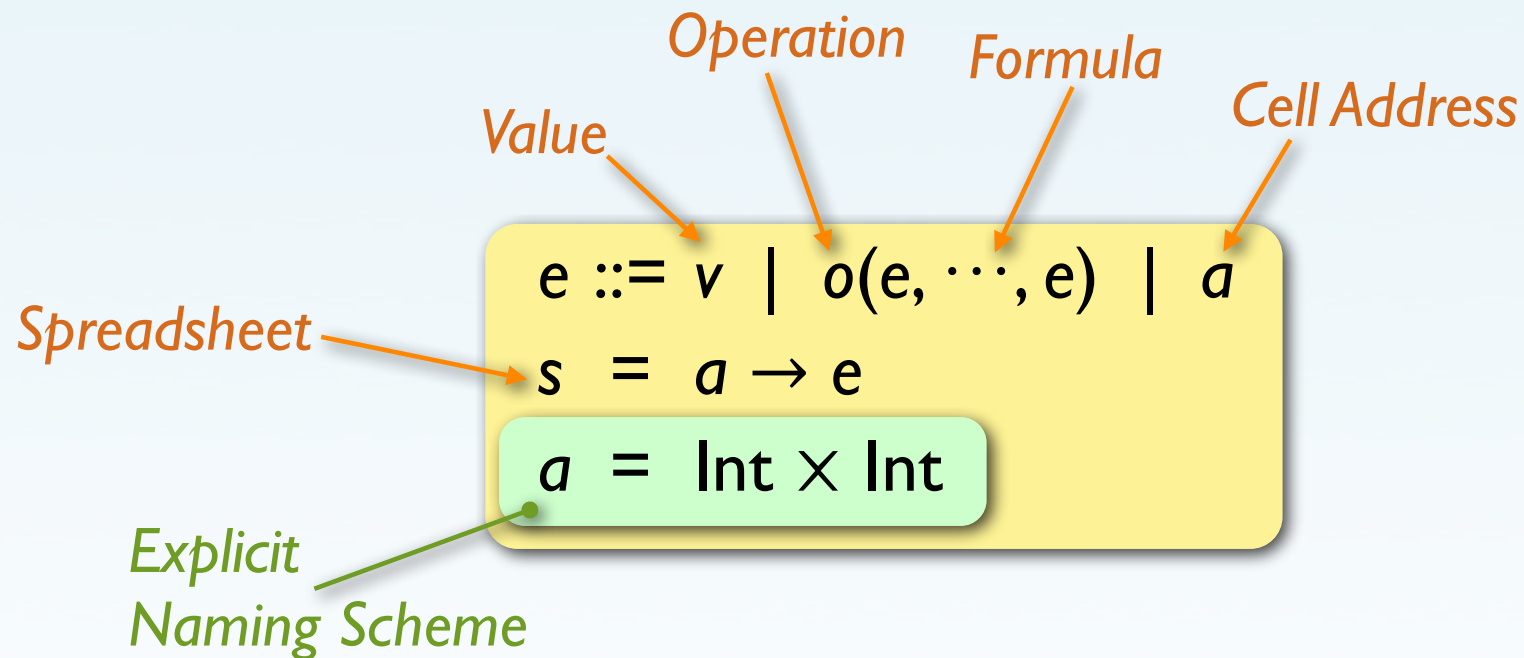
Examples

Type Checking in Spreadsheets

Causal Reasoning Neuron Diagrams

Explaining Probabilistic Reasoning

Spreadsheets



Provides structure among definitions $\Rightarrow$

Computation/value A “next to” or “above” computation B

Label-Based Typing

	A	B	C	D	E
1		Fruit			
2	Month	Apple	Orange	Total	
3	May	17	9	26	
4	June	8	13	21	
5	Total	25	22	47	
6					

May Fruit

May Apple

June Orange

Labeling Rules

$e : L$ and $L : K \Rightarrow e : K \triangleright L$

Fruit $\triangleright$ Apple

$e : L$ and $e : K \Rightarrow e : L \& K$

Month $\triangleright$ May & Fruit $\triangleright$ Apple

$e : L$ and $e' : K \Rightarrow e + e' : L \mid K$

May Apple $\mid$ May Orange

May (Apple $\mid$ Orange)

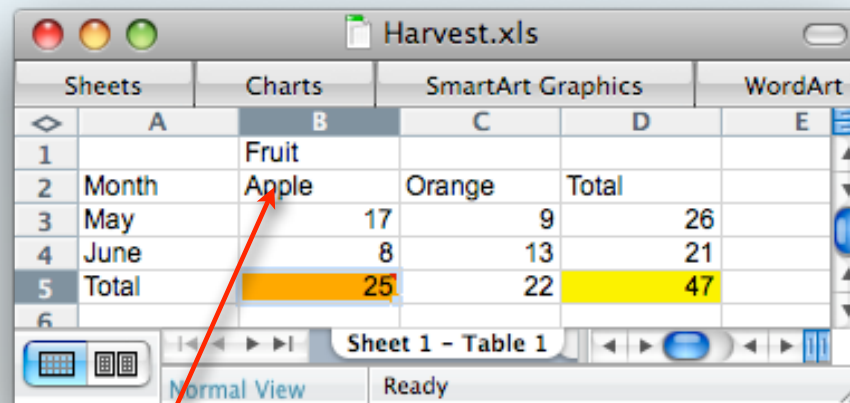
May Fruit

Factoring

Generalization

	A	B	C	D	E
1		Fruit			
2	Month	Apple	Orange	Total	
3	May	17	9	26	
4	June	8	13	21	
5	Total	25	22	47	
6					

Error Detection



	A	B	C	D	E
1		Fruit			
2	Month	Apple	Orange	Total	
3	May	17	9	26	
4	June	8	13	21	
5	Total	25	22	47	
6					

B5 = SUM(B2:B4)

B2 : Fruit

B3 : Fruit▷ Apple

B4 : Fruit▷ Apple

B2's label cannot be factored ⇒ prevents generalization step

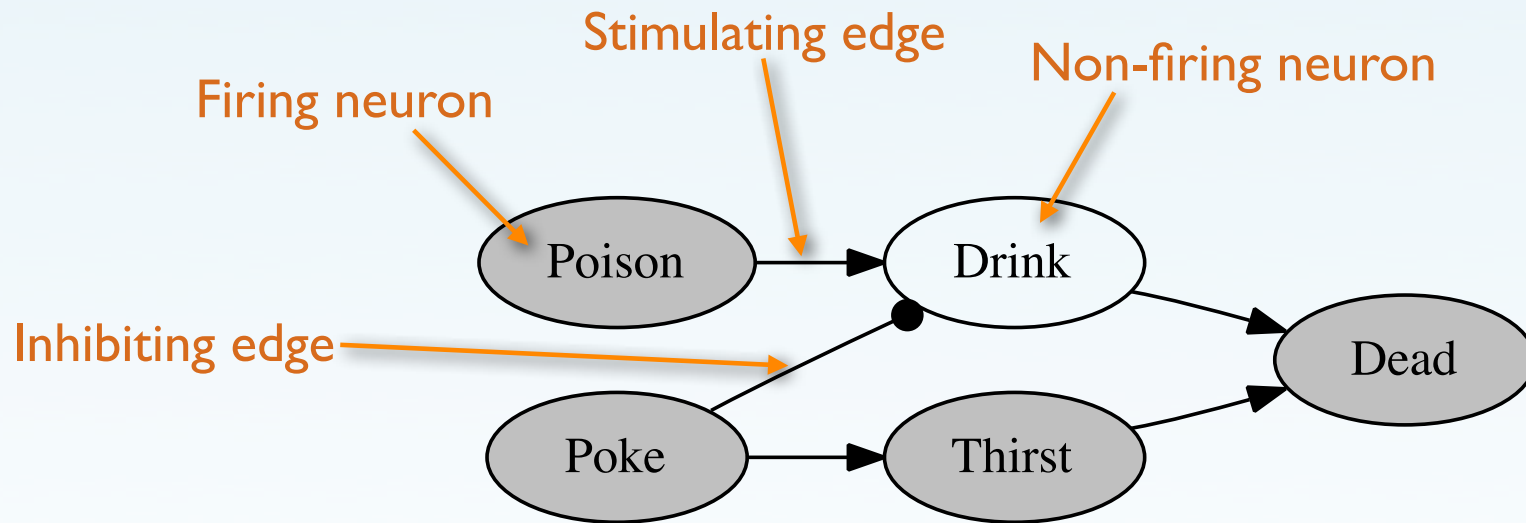
Explicitness Effect

Explicit notion of computation “position”



Fine-grained reasoning about consistency

Causal Reasoning With Neuron Diagrams

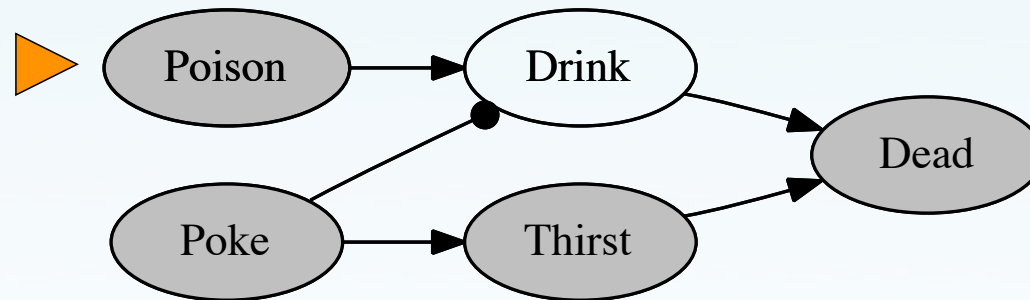


Desert traveler problem

Counterfactual Reasoning

*What would have happened if things had been different?**

**David Lewis, 1973*

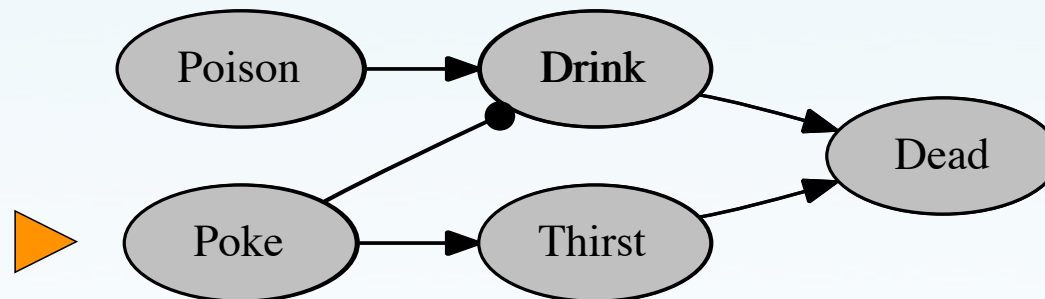


Dead is not CF-dependent on Poison or Poke

Counterfactual Reasoning

*What would have happened if things had been different?**

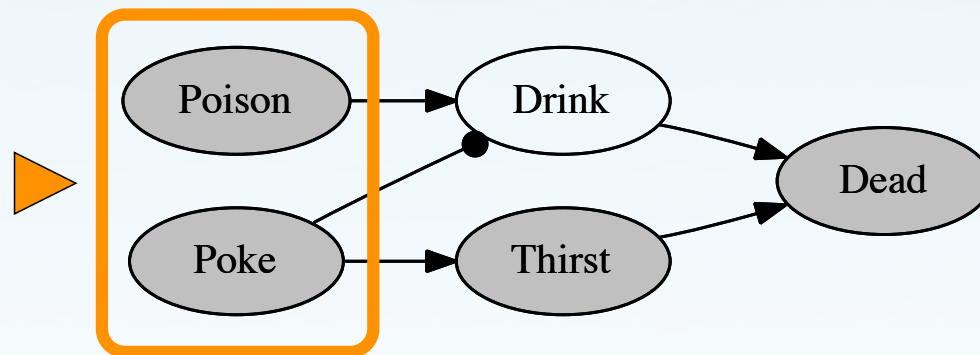
**David Lewis, 1973*



Dead is not CF-dependent on Poison or Poke

Preemption & Backup

Dead is CF-dependent on Poison and Poke together...



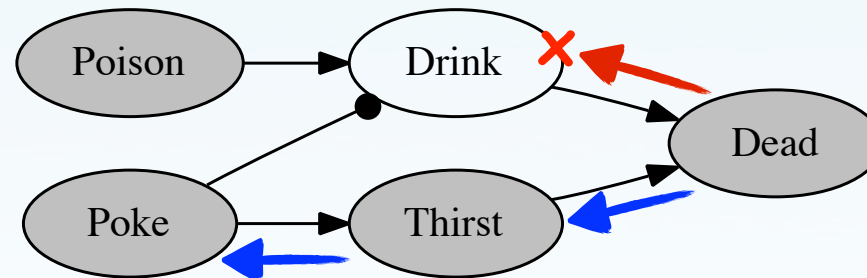
...but only Poke should be a cause of Dead

Causal Chains



*Solution: exploit transitivity of causation**

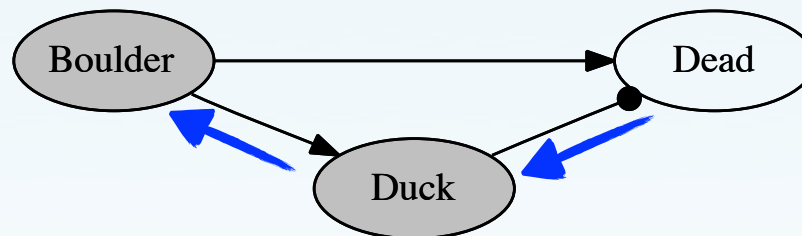
**David Lewis, 1987*



Poking is identified as the sole cause of death

Non-Transitive Causation

Unfortunately, causation is not always transitive ...



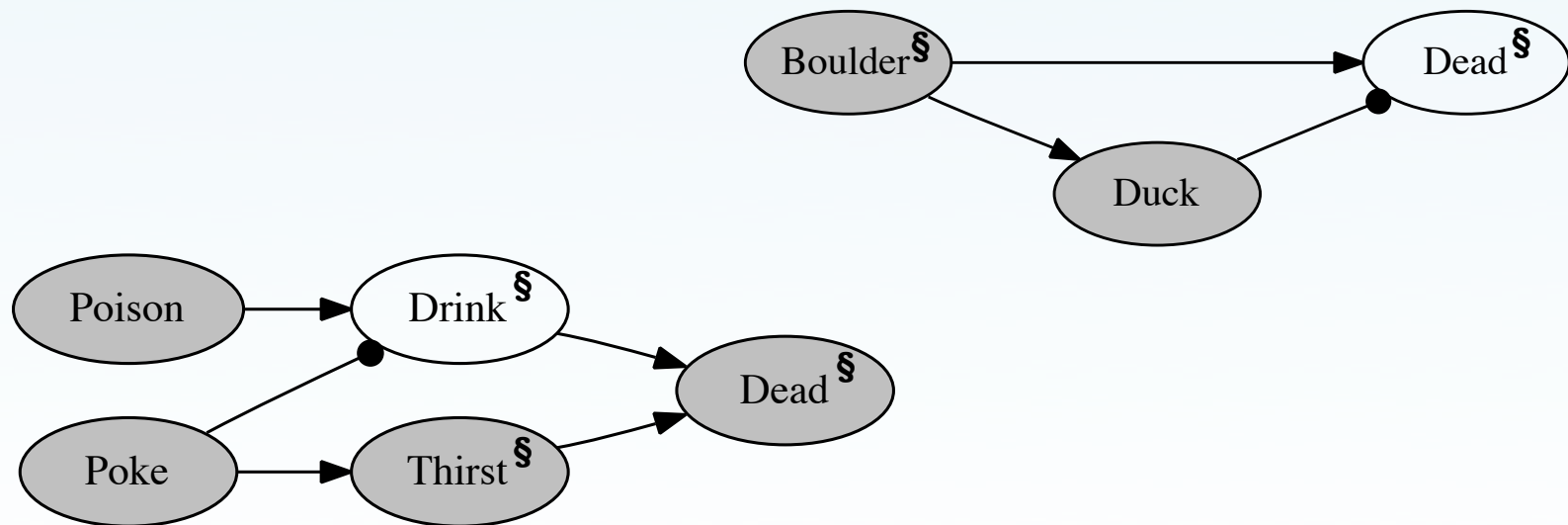
Boulder problem

The falling boulder causes the hiker to live?

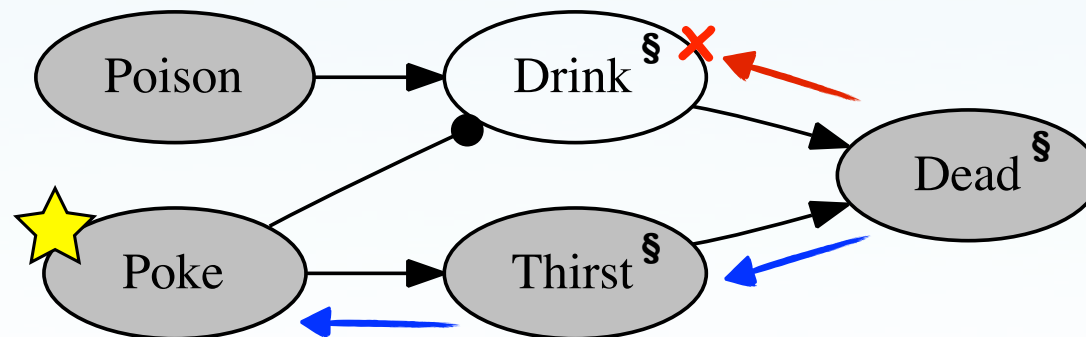
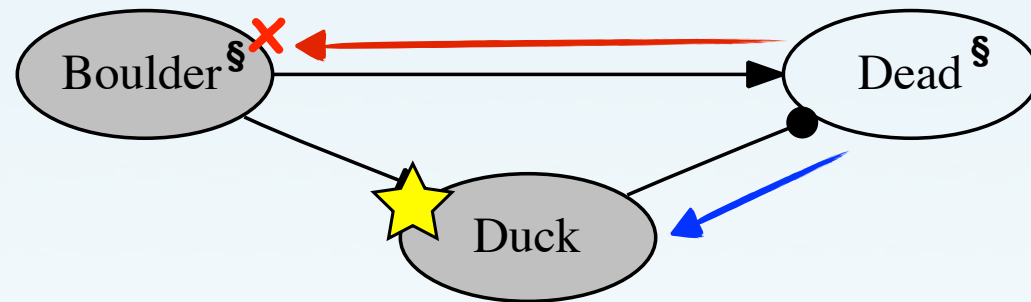
Two Kinds of Neurons

Separate neurons into:

- *Actions*: choices, neurons we want to reason about
- *Laws*: immutable facts and relationships



Recursive Cause Inference



Improved Precision & Correctness

		counterfactual reasoning ¹		causal chains ¹		structural equations ²	Hall's algorithm ³	our causal semantics
		CF	CC	SE	Hall	$\mathcal{C}$		
Desert traveler	<i>FF</i>	$\{P, K\}$	$\{P, K\}$	$\{P, K\}$	$\{P, K\}$	$P \wedge K$		
	<i>FT</i>	$\{K\}$	$\{K\}$	$\{K\}$	$\{K\}$	K		
	<i>TF</i>	$\{P\}$	$\{P, K\}$	$\{P\}$	$\{P\}$	$P \wedge K$		
	<i>TT</i>	$\{\}$	$\{K\}$	$\{K\}$	$\{K\}$	K		
Two doctors	<i>FF</i>	$\{\}$	$\{\}$	$\{A, B\}$	$\{\}$	$A \vee B$		
	<i>FT</i>	$\{A\}$	$\{A\}$	$\{A\}$	$\{A\}$	A		
	<i>TF</i>	$\{B\}$	$\{B\}$	$\{B\}$	$\{B\}$	B		
	<i>TT</i>	$\{A, B\}$	$\{A, B\}$	$\{A, B\}$	$\{A, B\}$	$A \wedge B$		
Boulder	<i>F</i>	$\{\}$	$\{B\}$	$\{B\}$	$\{B\}$	B		
	<i>T</i>	$\{\}$	$\{B, D\}$	$\{D\}$	$\{B, D\}$	D		

¹ Lewis, 1973

² Halpern and Pearl, 2005

³ Hall, 2007

Plus 13 additional test cases from Hitchcock, 2009

Explicitness Effect

Explicit distinction of neuron kinds



Improved causal reasoning algorithm

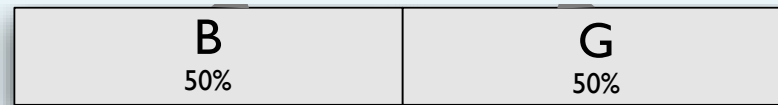
Explanation-Oriented Programming

Riddle:

A family has two children. One child is a boy.
What is the probability that the other child is a girl?

~~50%~~ **66.7%**

Explaining Probabilities



A family has two children. One child is a boy.
What is the probability that the other child is a girl?

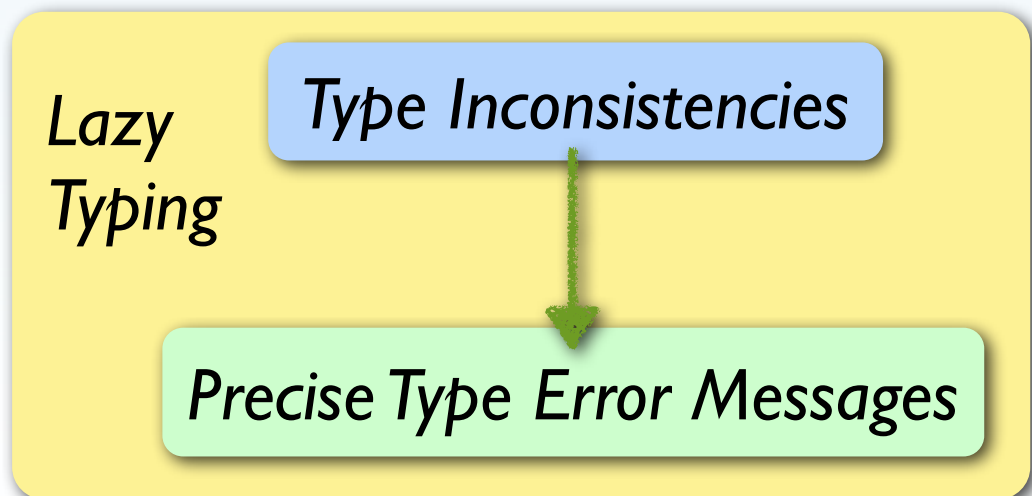
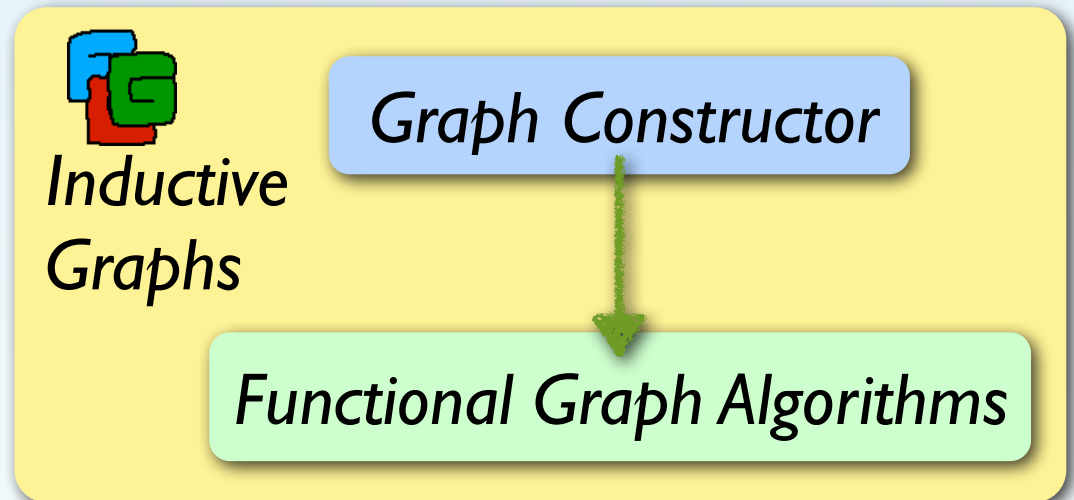
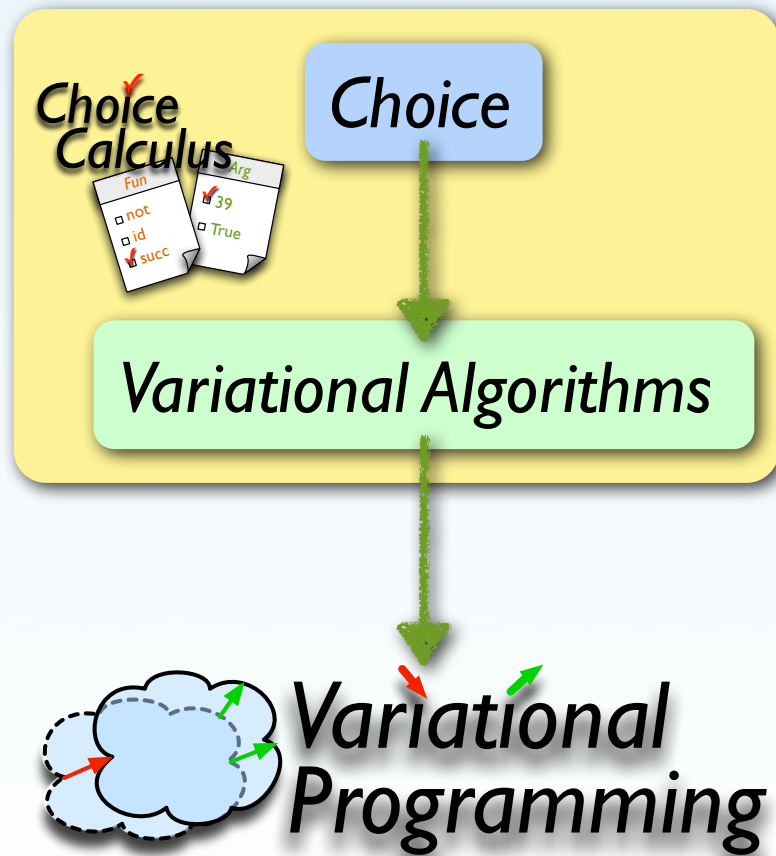
Explicitness Effect

Explicit probability distributions & story



Explanation of probabilistic reasoning

More Examples ...



Next Step ...

All examples: Explicit representation was accidental



Making explicitness explicit

Research Questions

- Scope of the explicitness criterion
- Dependencies among explicit things
- Syntactic/semantic characterization of explicitness
- Manipulability
- Evaluation of trade-off between explicit and implicit representations

The Explicit End

End