

Judgments of Functional Relationships in Systems of Three Variables

Kent L. Norman & Benjamin K. Smith

Department of Psychology

www.psychology.umd.edu

Laboratory for Automation Psychology and Decision Processes

lap.umd.edu

Human-Computer Interaction Laboratory

www.cs.umd.edu/hcil

University of Maryland, College Park, MD 20742

Psychonomic Society, November 17, 2006

Functional Processing

- Motivation: Many judgments and decisions are based on cue-criterion relationships (Brunswik, 2000; Dawes, 2001; Gigerenzer, 1999).
- Researchers often infer the subjects' understanding of these relationships from the judgments and decisions they make.
- We decided to ask about the relationships directly.
- If variables are functions of other variables, how are these functions processed?

Systems of Variables

- Consider 3 Variables:

$$V = \{A, B, C\}$$

- Consider an incomplete set of bivariate and multivariate relationships on these variables:

$$R = \{A=f(B), A=f(C), A=f(B,C), B=f(A), B=f(C), B=f(A,C), \dots\}$$

Knowledge Base

- How do we store relationships in memory?
(direction: +, -, 0; strength: da/db)
- How do we make inferences about unknown relationships from known relationships?

Inferences

- **Bi-directionality:** If A increases with B, then B increases with A.
- **Transitivity:** If A increases with B, and B increases with C, then A increases with C.
- **Solvability:** If A increases with B, and A increases with C, then B increases with C.

- One might expect different rules of inference to apply for sets of variables in different systems:
 - mathematical systems (e.g., $A = B + C$)
 - physical systems (e.g., $A = \text{velocity}$, $B = \text{mass}$, $C = \text{force}$)
 - economic systems (e.g., $A = \text{net profit}$, $B = \text{advertising cost}$, $C = \text{market penetration}$)
 - ecological systems (e.g., $A = \text{population of Species 1}$, $B = \text{population of Species 2}$, $C = \text{population of Species 3}$)
 - social and personality systems (e.g., $A = \text{self esteem}$, $B = \text{personal income}$, $C = \text{number of friends}$).

Method - Order of variables in relationships

- Consider 3 variables: A, B, & C
- Given two pairwise relationships:
 - Between A and B
 - Between B and C

Infer a third relationship between A and C
- 8 permutations of A-C and B-C relationships in the second and third part, but all three relationships are part of every problem

Method

Directions of Relationships

- First two relationships were either positive, no change, or negative.
- 9 possibilities x 8 orders resulted in 72 total items.
- Each was randomly assigned a set of 3 variable names.
- No repeating initials were used within a set.
- Items were presented in a random order

Positive - Positive

	Relationship 1			Relationship 2			3		+	0	-
1	A	B	+	A	C	+	B	C			
2	A	B	+	A	C	+	C	B			
3	A	B	+	C	A	+	B	C			
4	A	B	+	C	A	+	C	B			
5	A	B	+	B	C	+	A	C			
6	A	B	+	B	C	+	C	B			
7	A	B	+	C	B	+	A	C			
8	A	B	+	C	B	+	C	A			

Social and Behavioral Relationships

Imagine that you are a social and behavioral scientist.

You have measures of three different factors (A, B, and C) in a set of people. You are now interested in studying the *relationships* between the measures of these factors. To do this, imagine that you line up the folders on each person so that as you look at each one from left to right, the level of the factor (let's say Factor X) increases from folder to folder. The measures of each factor for each person's folder, of course, are constant, but they change from folder to folder.

Without changing the order of the folders, you then look at the measure of a different factor (let's say Factor Y), again from left to right. If this second factor is generally found to have higher values as we go from left to right, we would say, "As X increases, Y increases." If it is generally found to have lower values as we go from left to right, we would say, "As X increases, Y decreases." If the factor is not generally found in higher or lower values as we go from left to right, we say "As X increases, Y doesn't change."

In the problems that follow, you will be told two such relationships between factors. You are then asked to infer whether for a third relationship, the factor increases, decreases, or doesn't change.

Start Task -->

1. As Attachment increases, Fixation doesn't change.
As Phobia increases, Fixation decreases.

Then as Attachment increases, what happens to Phobia?

- increases
- decreases
- doesn't change

Continue

Economic and Financial Relationships

Imagine that you are a economist or an investor.

You have measures of three different economic/financial indicators (A, B, and C) for a set of countries. You are now interested in studying the *relationships* between the levels of these indicators. To do this, imagine that you line up the financial reports for each country so that as you look at each one from left to right, the level of the indicator (let's say Indicator X) increases from report to report. The measures of each indicator for each company's report, of course, are constant, but they change from report to report.

Without changing the order of the reports, you then look at the level of a different indicator (let's say Indicator Y), again from left to right. If this second indicator is generally found to have higher levels as we go from left to right, we would say, "As X increases, Y increases." If it is generally found to have lower levels as we go from left to right, we would say, "As X increases, Y decreases." If the factor is not generally found in higher or lower levels as we go from left to right, we say "As X increases, Y doesn't change."

In the problems that follow, you will be told two such relationships between indicators. You are then asked to infer whether for a third relationship, the indicator increases, decreases, or doesn't change.

Start Task -->

1. As Amortization increases, Indifference Curve increases.
As Indifference Curve increases, Progressive Tax decreases.

Then as Progressive Tax increases, what happens to Amortization?

- increases
- decreases
- doesn't change

Continue

Geological Relationships

Imagine that you are a geologist.

You have found the concentration of three chemicals (A, B, and C) in a set of rocks. You are now interested in studying the *relationships* between the concentrations of the chemicals. To do this, you line up the rocks so that as you look at each one from left to right, the concentration of one chemical (let's say chemical X) increases from rock to rock. The concentrations of chemicals in each individual rock, of course, are constant, but they change from rock to rock.

Without changing the order of the rocks, you then look at the concentration of a different chemical (let's say chemical Y), again from left to right. If this second chemical is generally found in higher concentrations as we go from left to right, we would say, "As X increases, Y increases." If it is generally found in lower concentrations as we go from left to right, we would say, "As X increases, Y decreases." If the concentration is not generally found in higher or lower concentrations as we go from left to right, we say "As X increases, Y doesn't change."

In the problems that follow, you will be told two such relationships between chemicals. You are then asked to infer whether for a third relationship, the chemical increases, decreases, or doesn't change. If you can not determine the answer, select "don't know."

1. As Nontronite increases, Lannate decreases.
As Lannate increases, Fullerene doesn't change.

Then as Nontronite increases, what happens to Fullerene?

- increases
- decreases
- doesn't change
- don't know

Continue

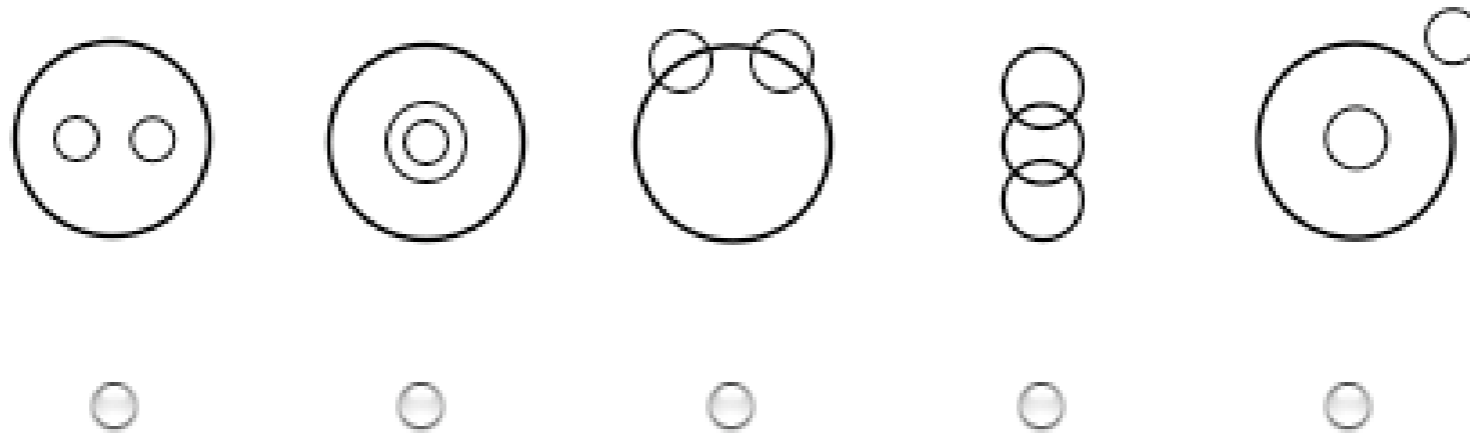
4 conditions

- Psychological, $n = 15$
- Economic, $n = 15$
- Chemical (Geological), $n = 15$
- Chemical with “Don’t Know” option, $n = 14$

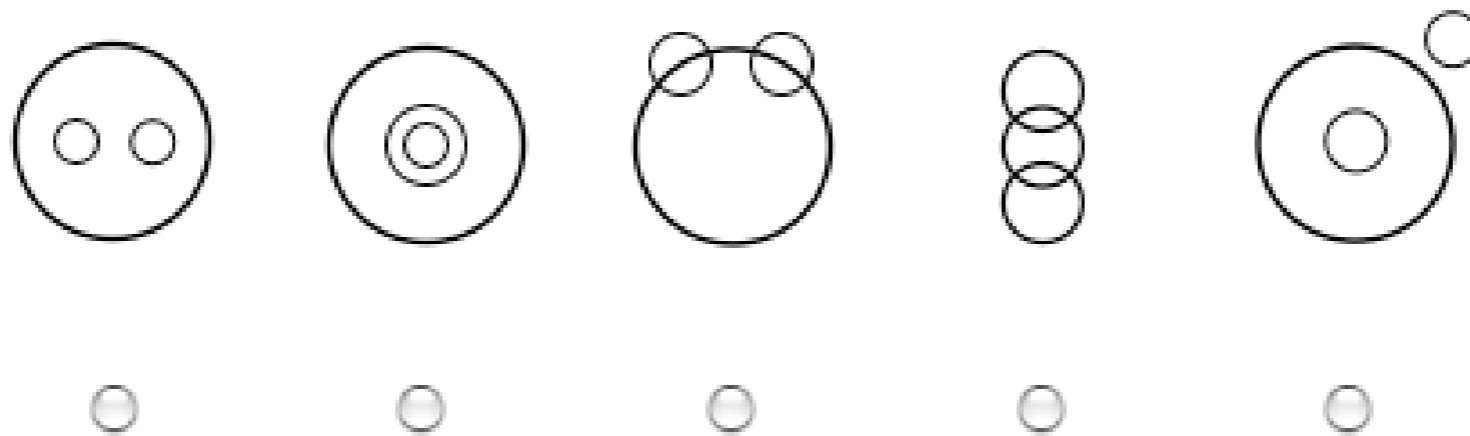
Logical Reasoning

Try these sample items:

1. Animals, cats, dogs



2. Desks, furniture, pencils

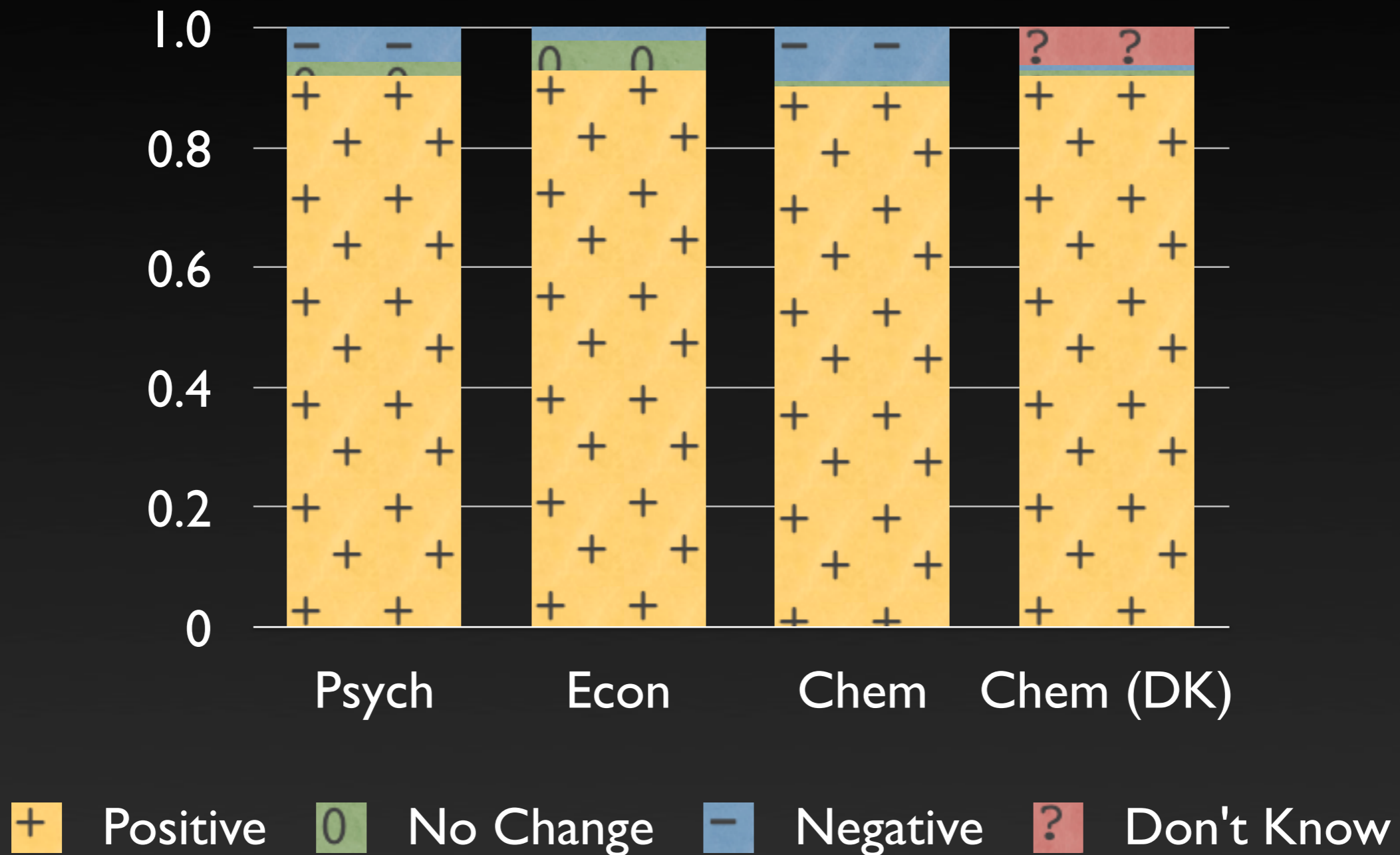


Spatial Reasoning

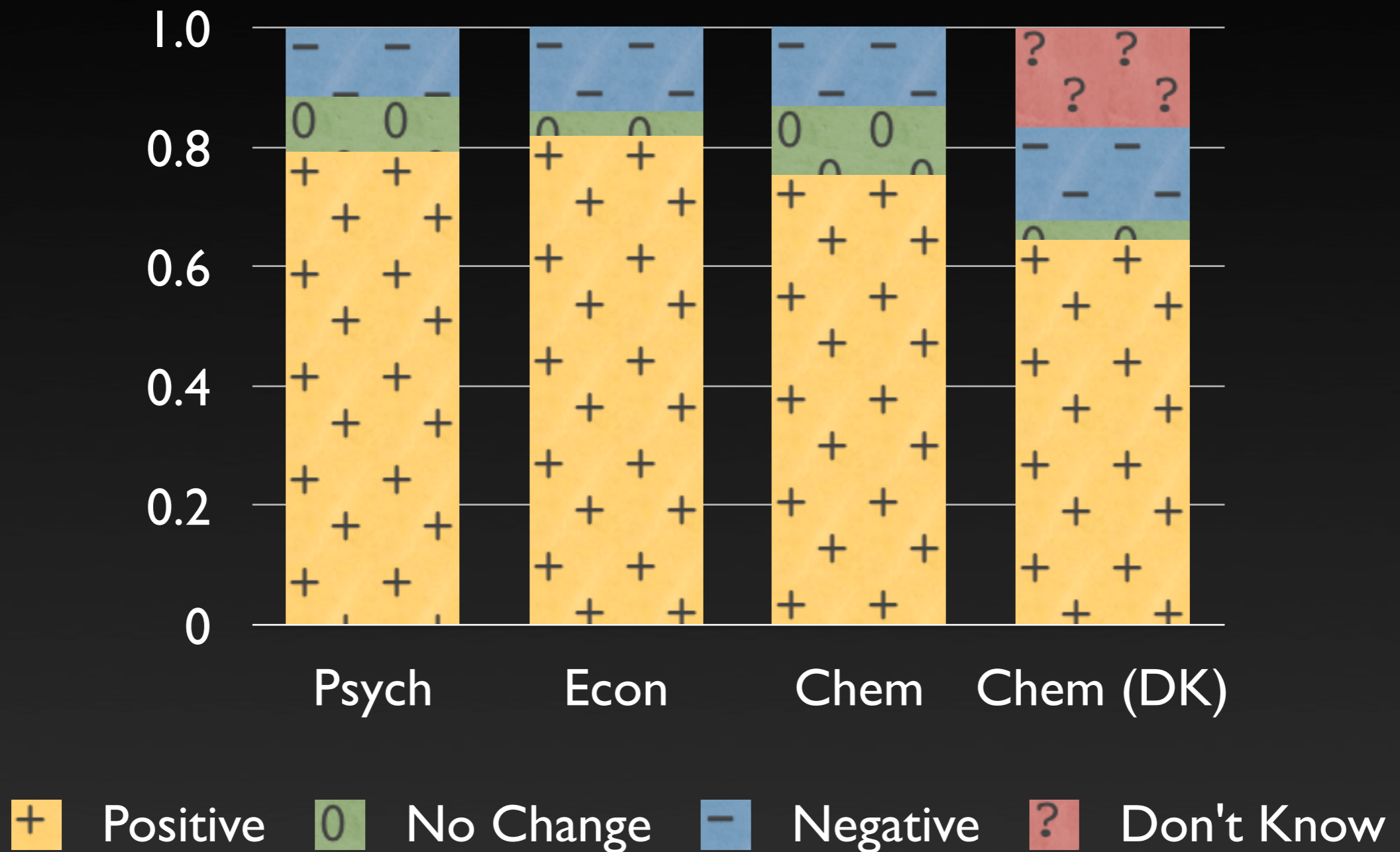
Here's another sample problem:

18

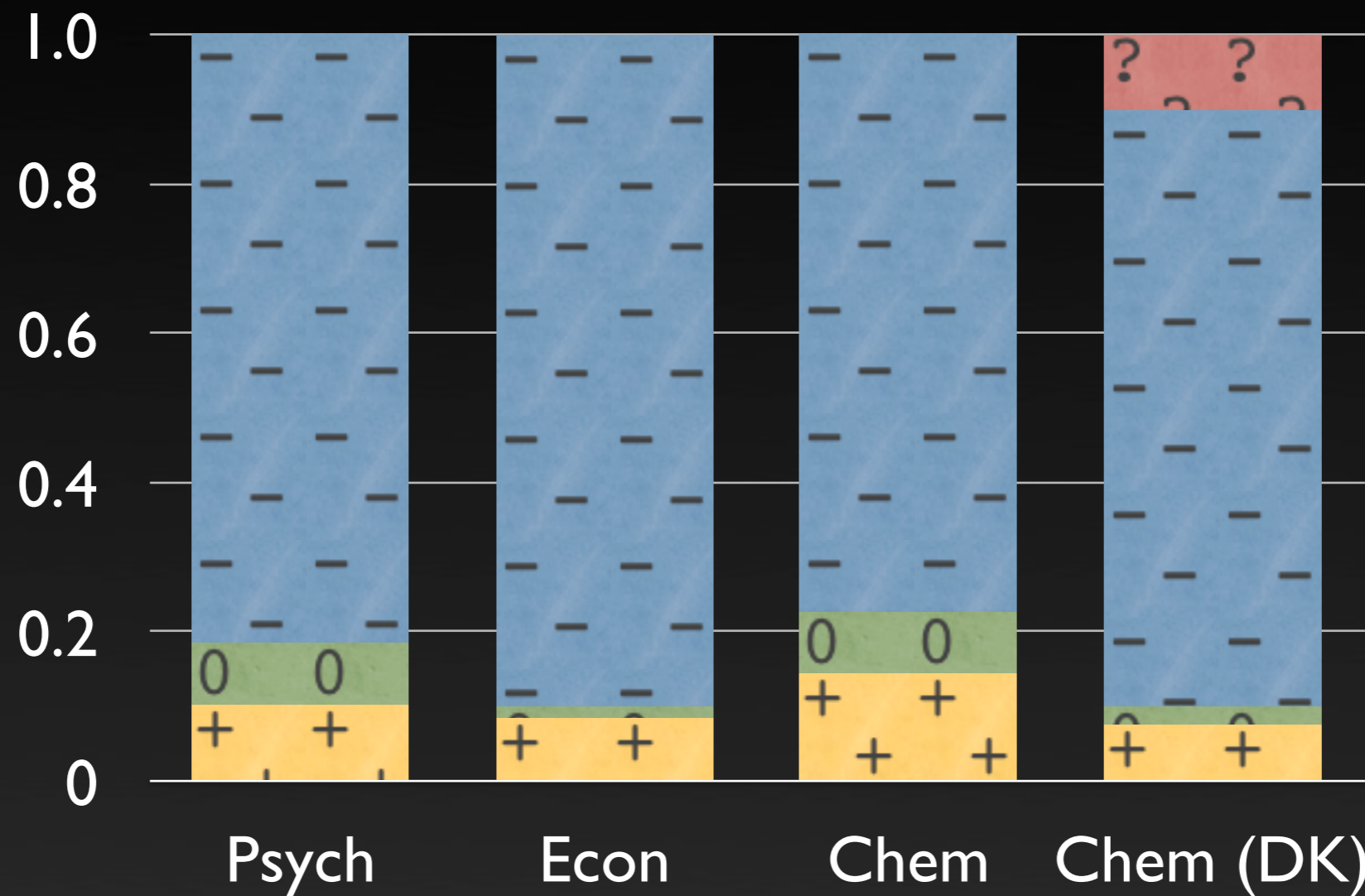
Inferred Relationship (pos, pos)



Inferred Relationship (neg, neg)

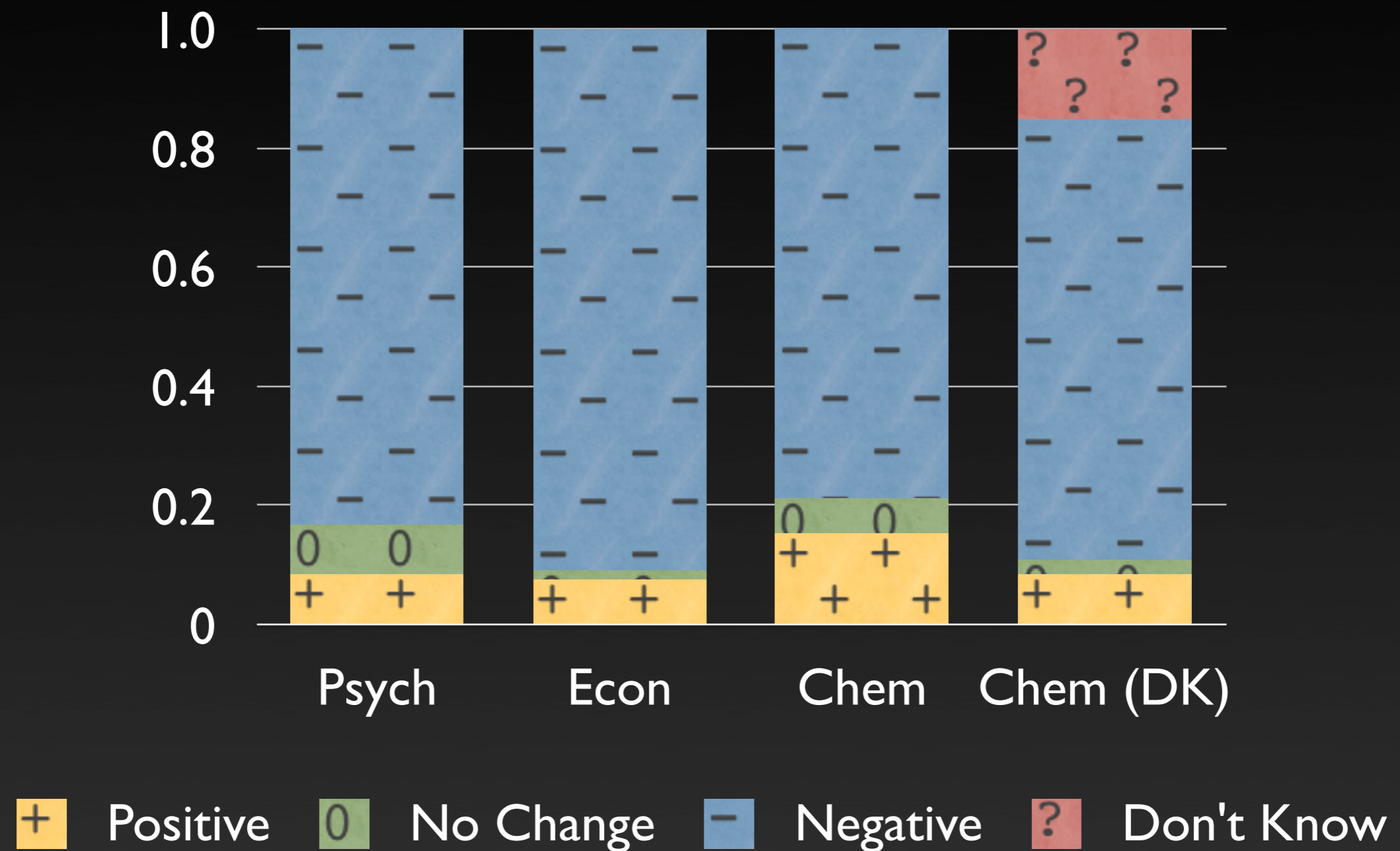


Inferred Relationship (pos, neg)

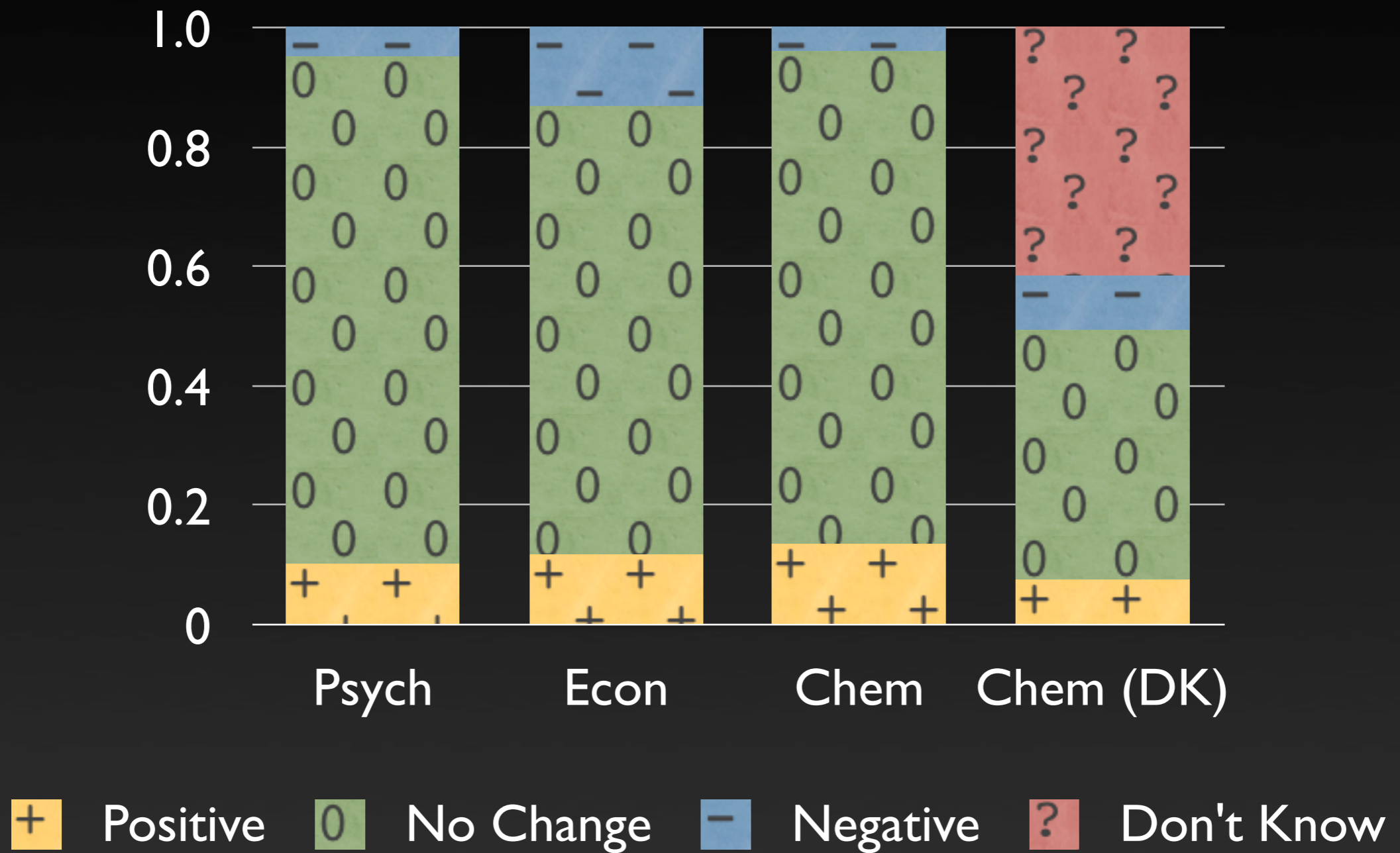


+ Positive 0 No Change - Negative ? Don't Know

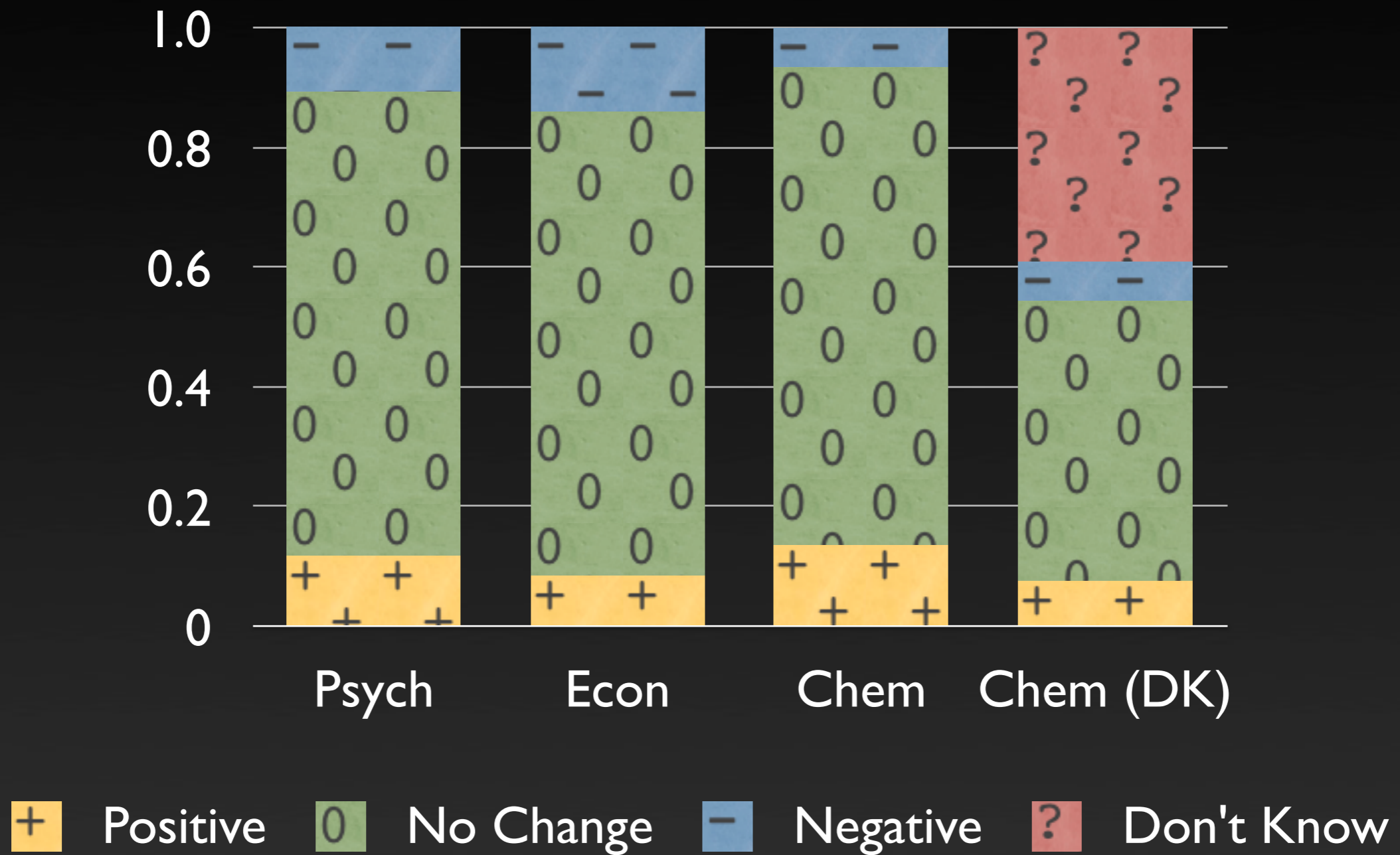
Inferred Relationship (neg, pos)



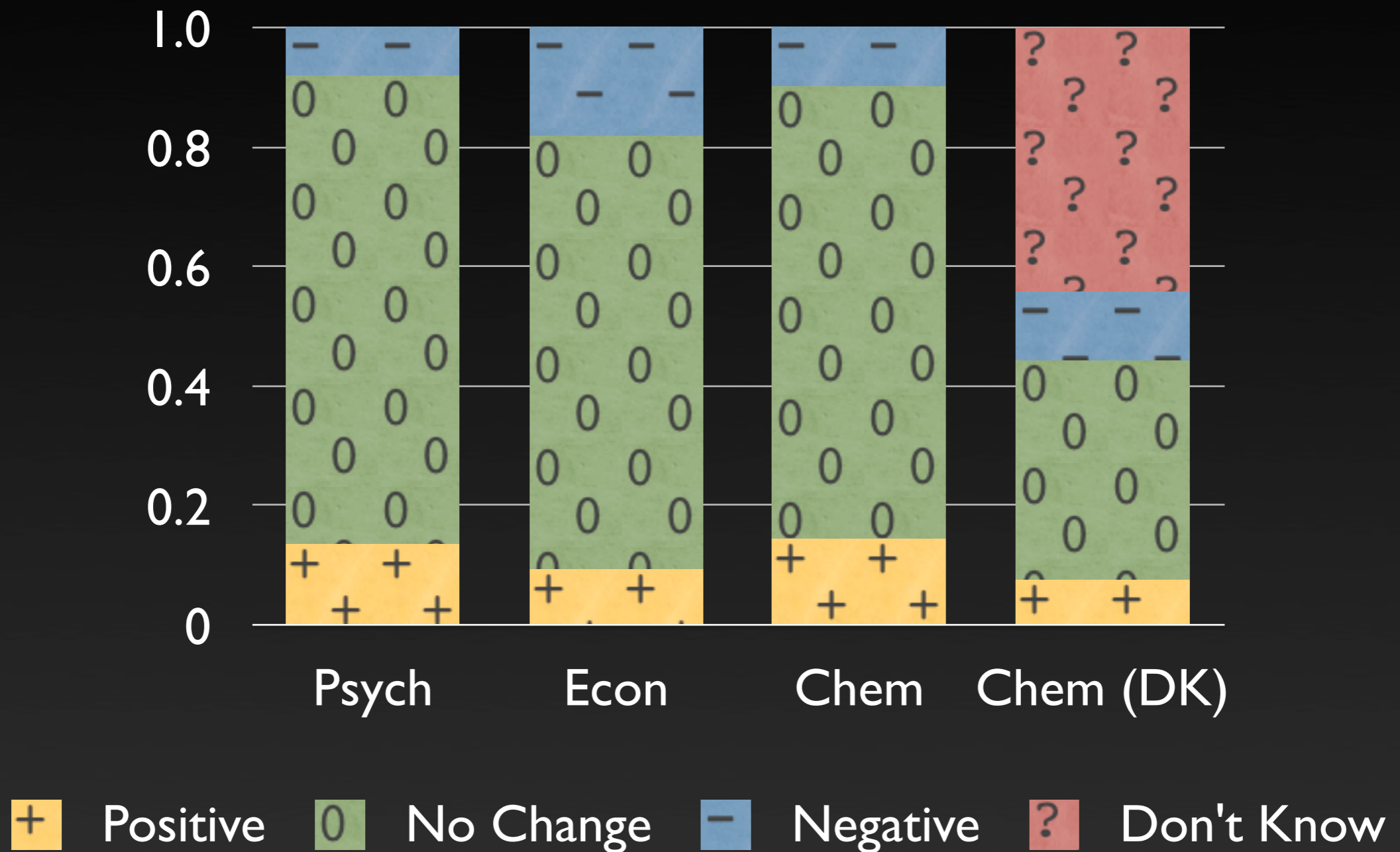
Inferred Relationship (pos, n. c.)



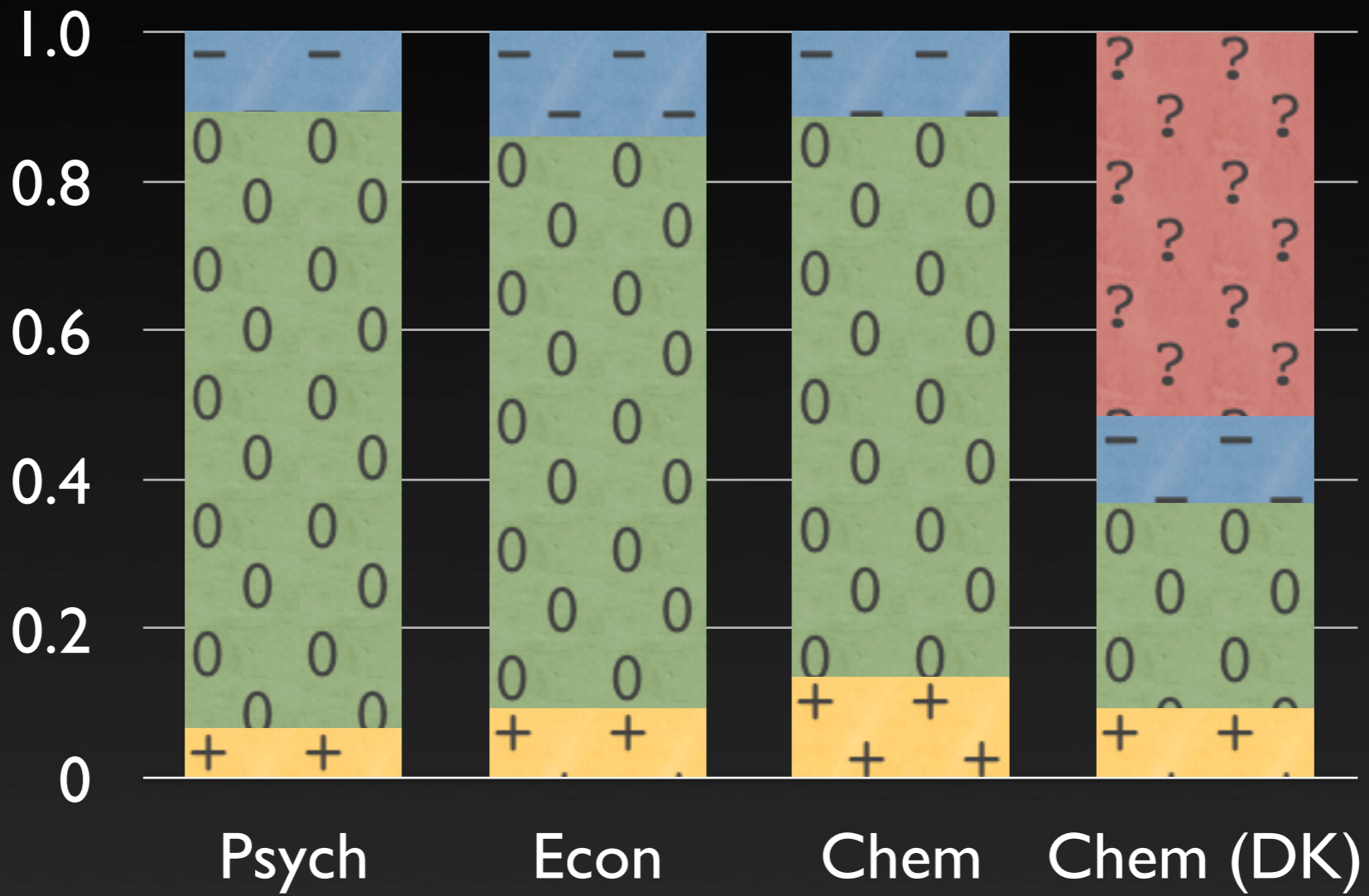
Inferred Relationship (n. c., pos)



Inferred Relationship (neg, n.c.)

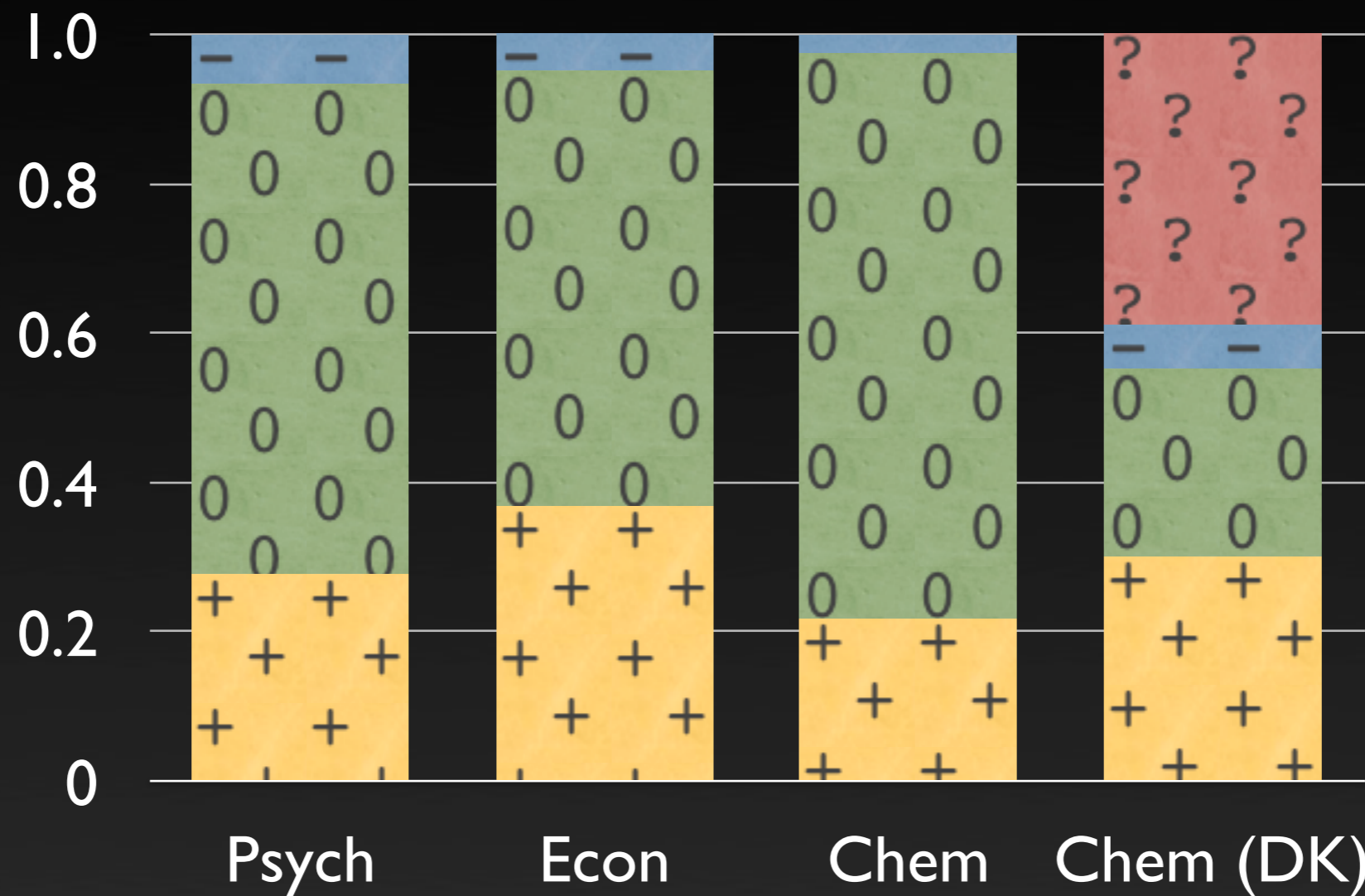


Inferred Relationship (n. c., neg)



+ Positive
 0 No Change
 - Negative
 ? Don't Know

Inferred Relationship (n. c., n. c.)



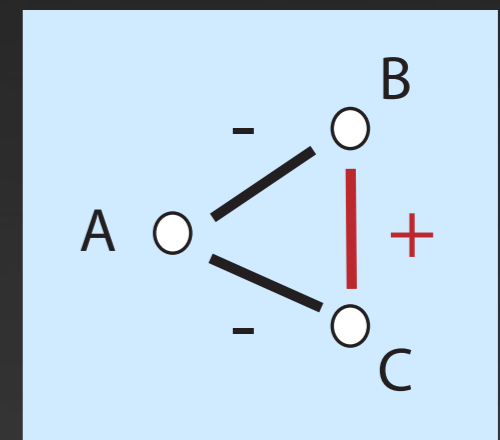
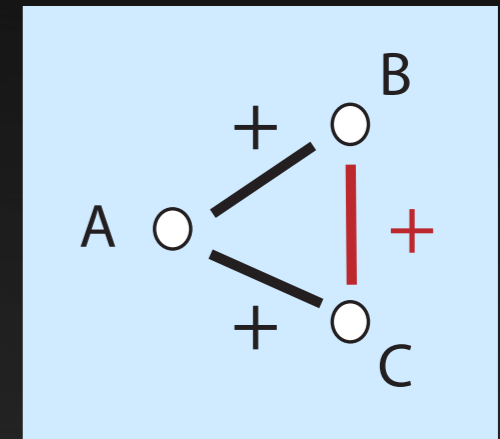
+ Positive **0** No Change **-** Negative **?** Don't Know

Variable Names

No significant differences in the number of positive, negative, or no change responses based on the names of the variables

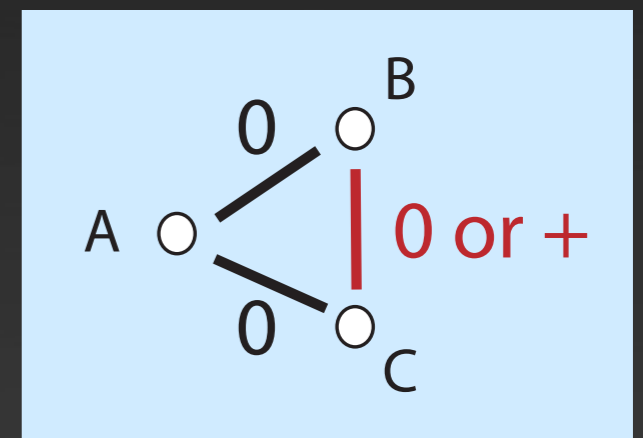
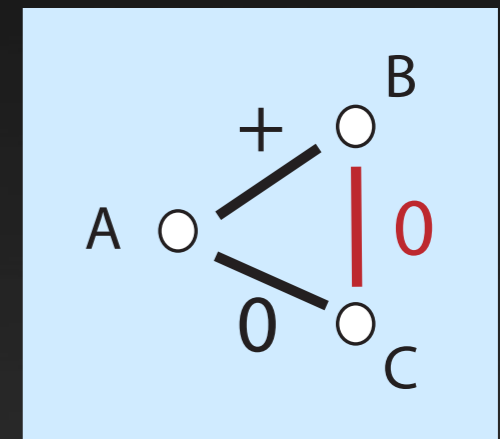
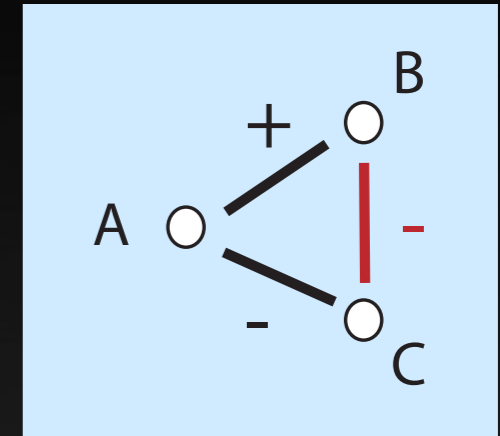
Conclusions

- The most dominant pattern was for positive relationships to lead to a positive inference.
- The next clear pattern was for two negative relationships to result in a positive inference.



Conclusions

- Mixed relationships, one positive and one negative, resulted in a negative relationship.
- If one or the other relationship was zero, it resulted in a zero relationship.
- If both were zero, it resulted in a zero relationship and sometimes a positive relationship (?).



What's the right answer?

There is no way to know what the third relationship is, so in a sense, “don't know” is the only right answer.

This experiment did not distinguish between “I don't know” and “It can not be determined.”

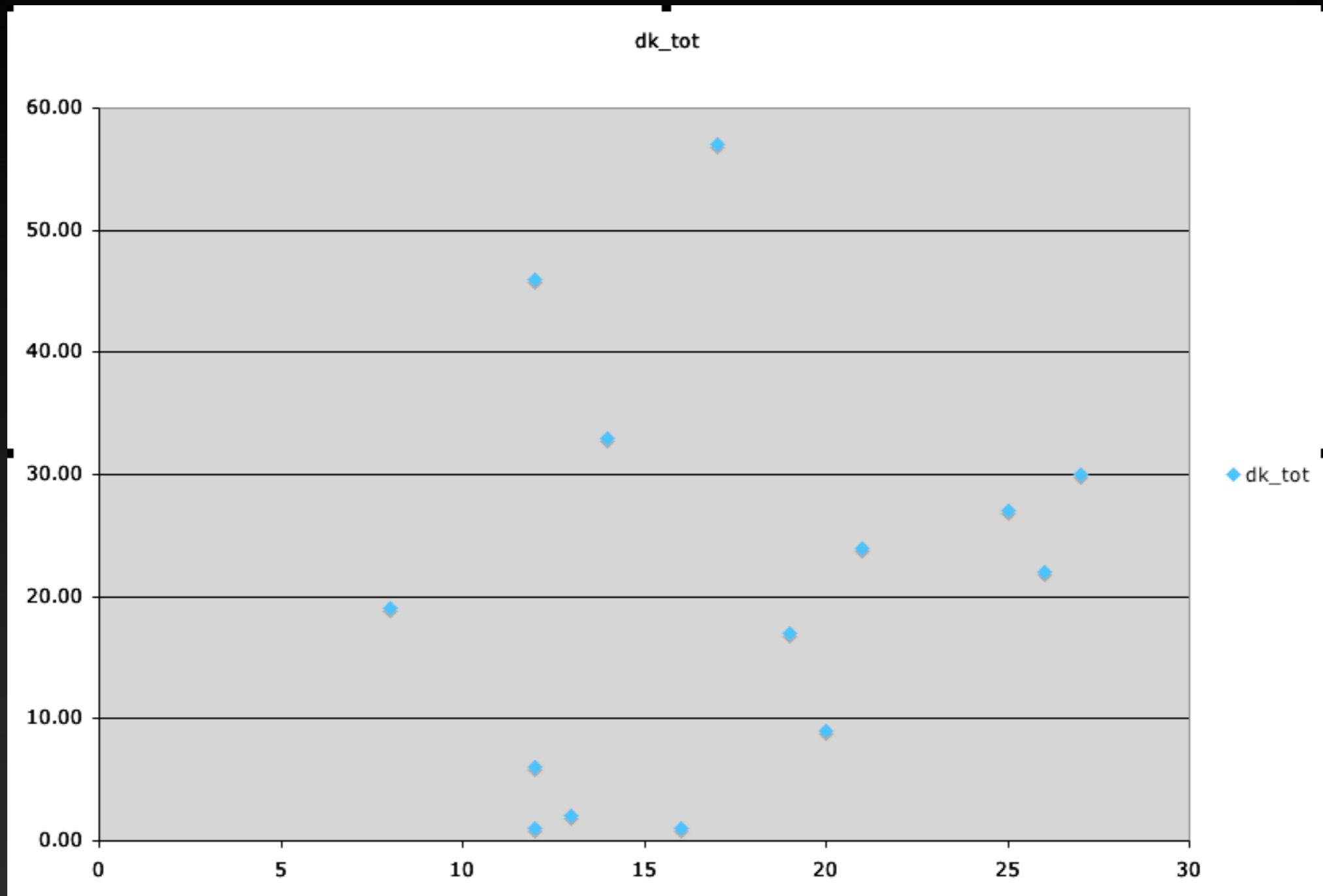
Visual/Logical Tests and “Don’t Know”

Visual (gamma = .143) and Logical Reasoning (gamma = .218) test scores were positively, but not significantly, correlated with a tendency to choose “don’t know.”

But we only had 14 subjects in this condition.

Don't know / Logical Reasoning

of
Don't
Know



Logical Reasoning Score

What about the 3-choice conditions?

45 subjects could not choose “don’t know.”

It looks as if people that would choose “don’t know” chose “no change” instead.

Do people that chose “no change” often differ from those that chose it less often?

Yes they do.

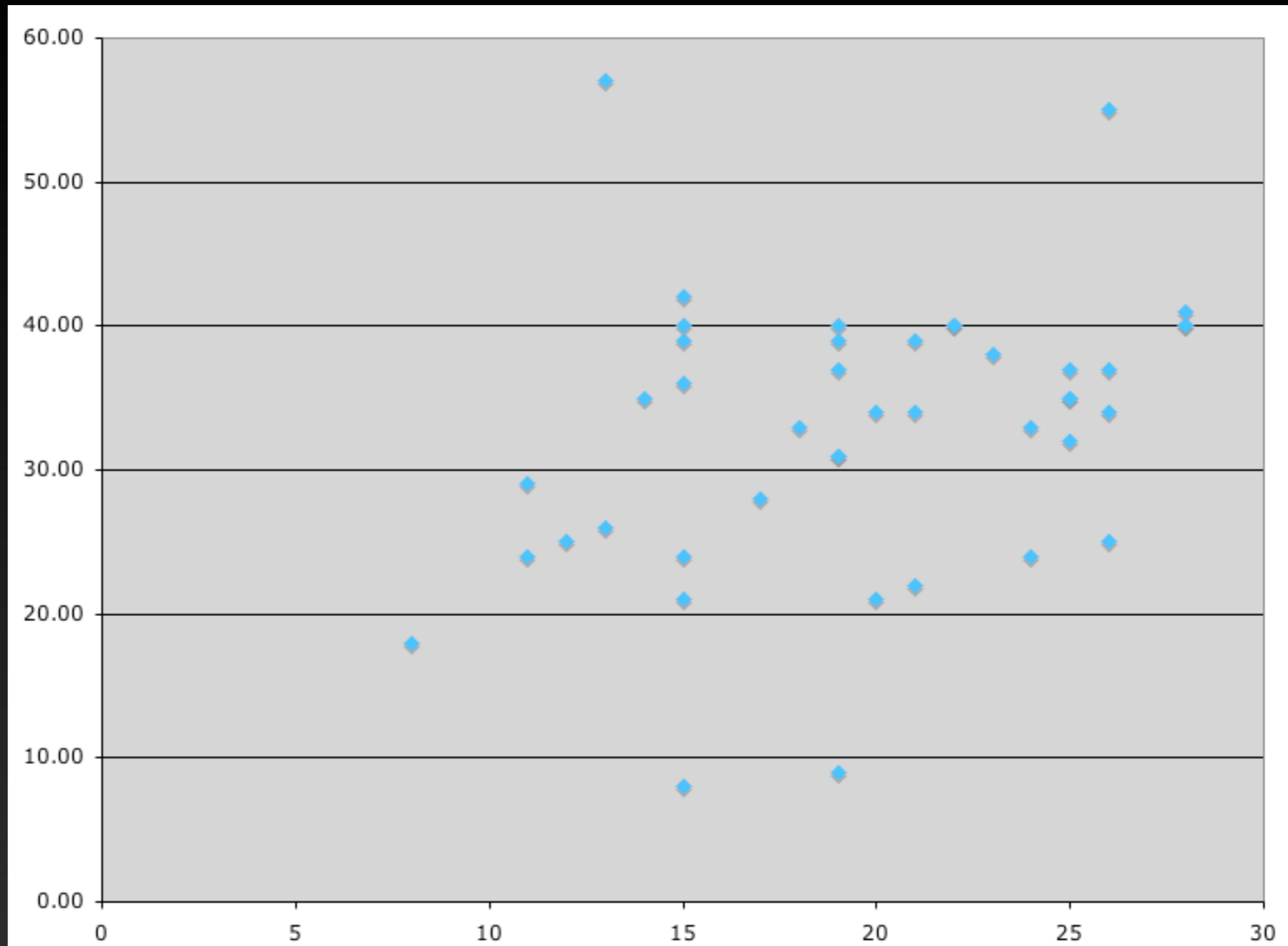
They have higher Spatial and Logical Test scores.

A tendency to choose “no change” was correlated with higher VZ2 scores. Gamma = .285, $p=.010$

A tendency to choose “no change” was correlated with higher RL2 scores. Gamma = .268, $p=.023$

No change/Logical Reasoning

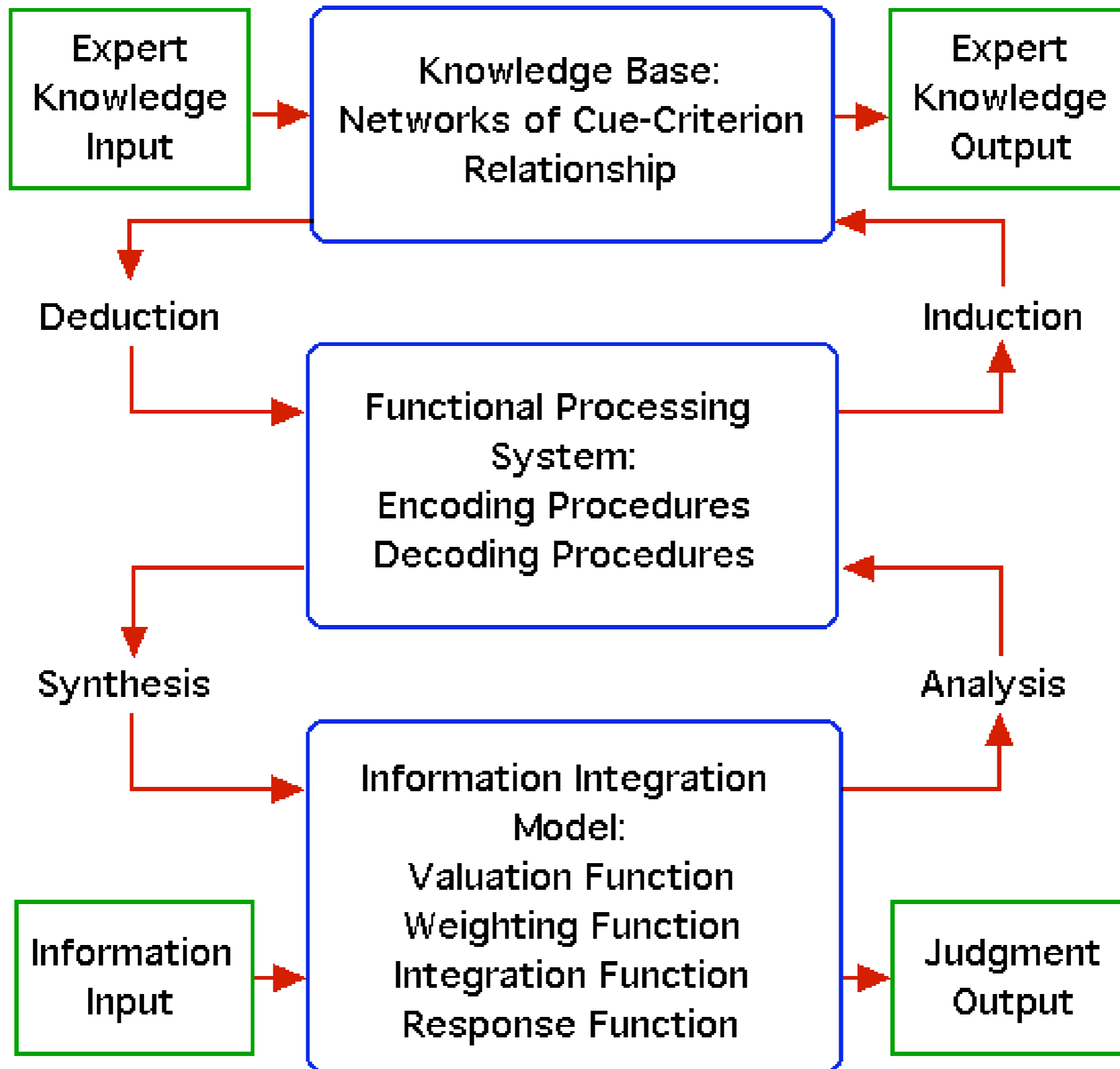
of
No
Change



Logical Reasoning Score

Future Directions

- Introduce a “Can’t be determined” option.
- Introduce new formats for presenting relationships (scattergrams, animation, better wording).
- Develop a formal theory of functional processing to link acquisition, decomposition, composition, and reformulation of rules involving functional relationships.

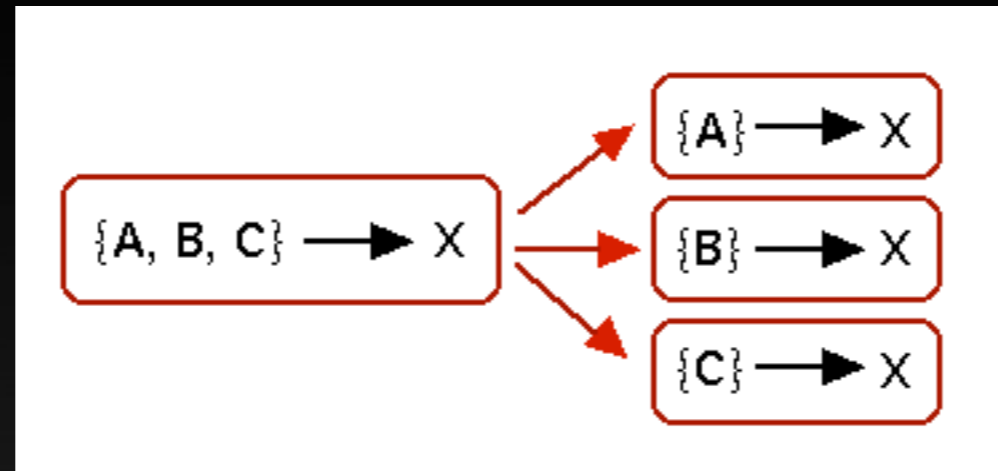


The End

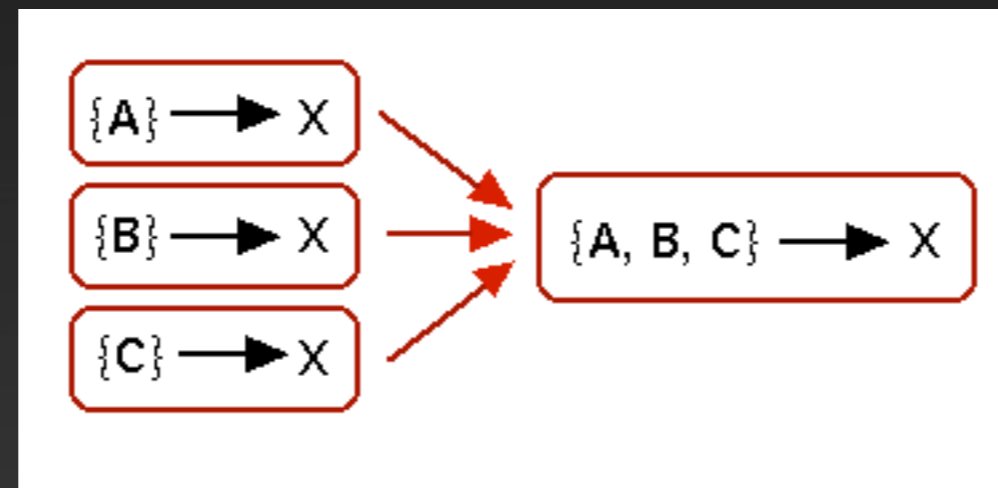
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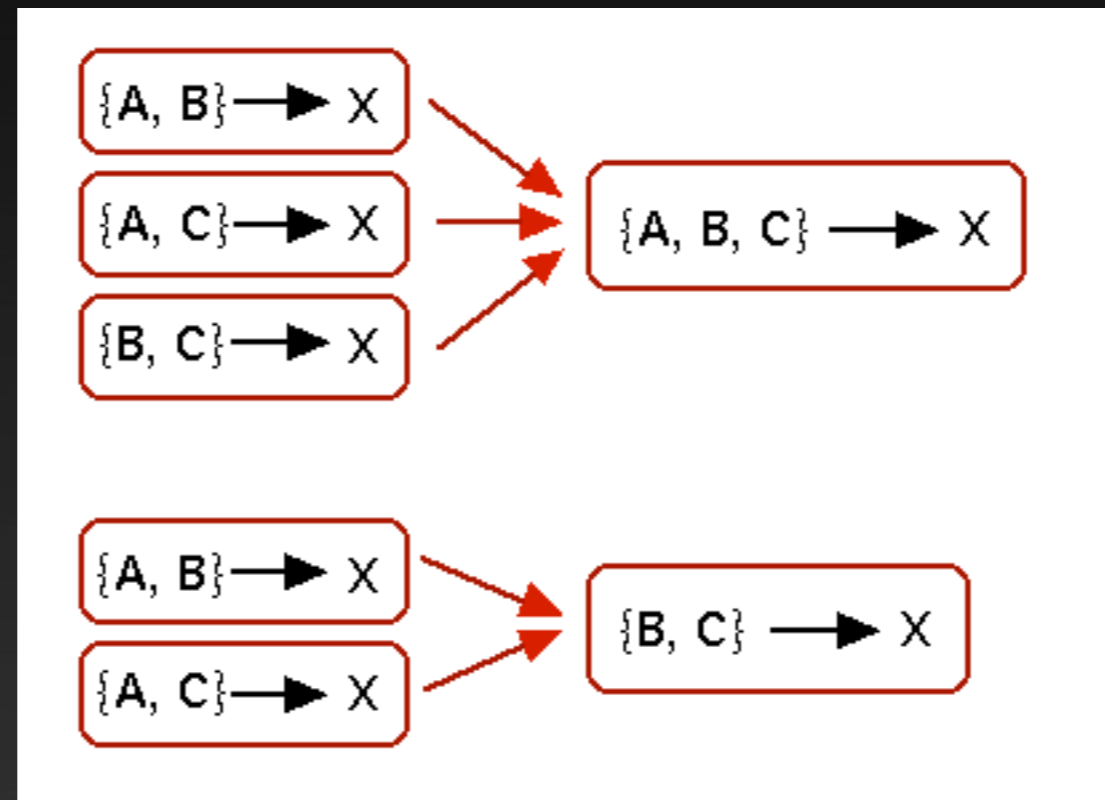
Decomposition



Composition



Reformulation



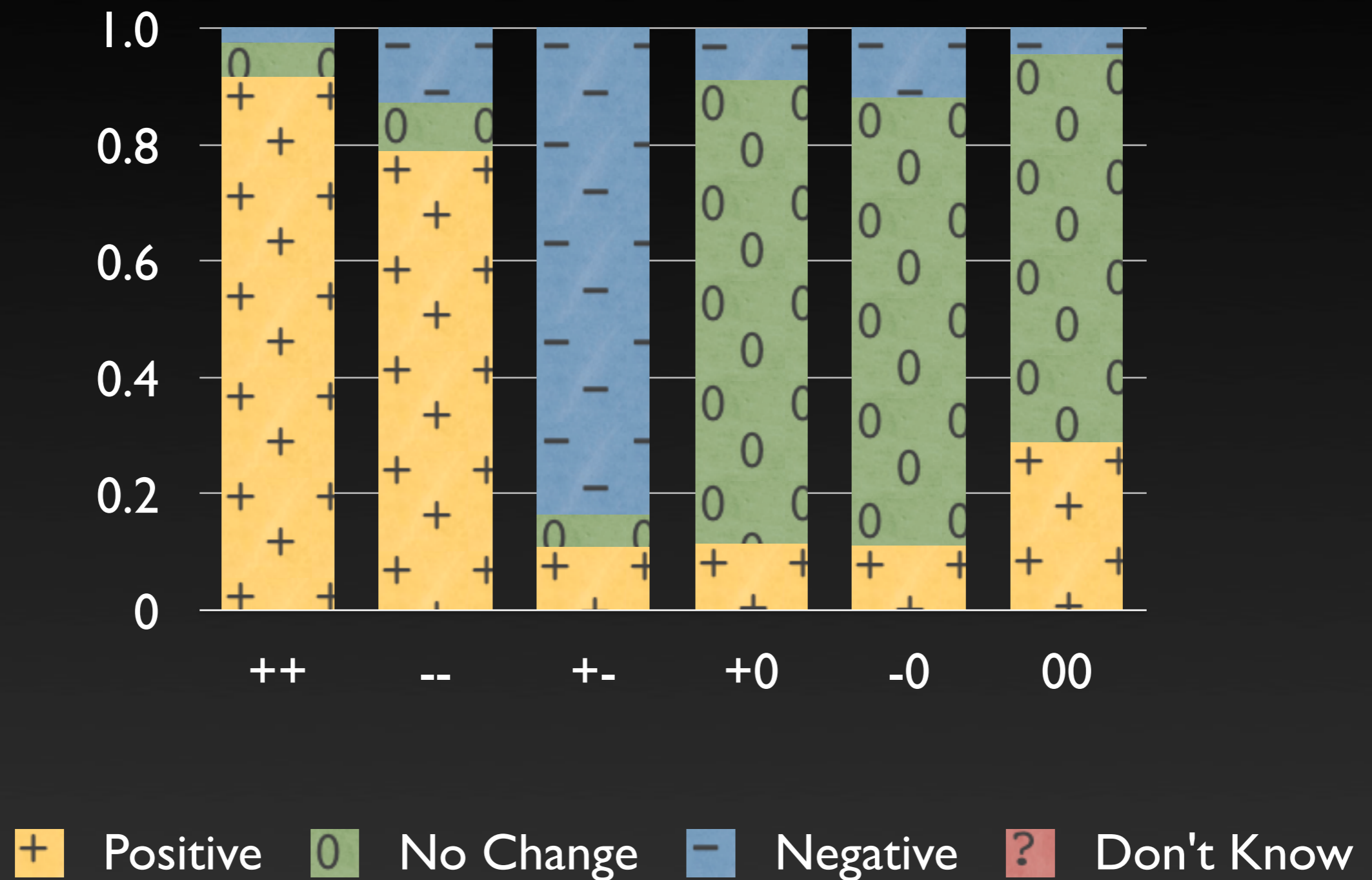
Inferences



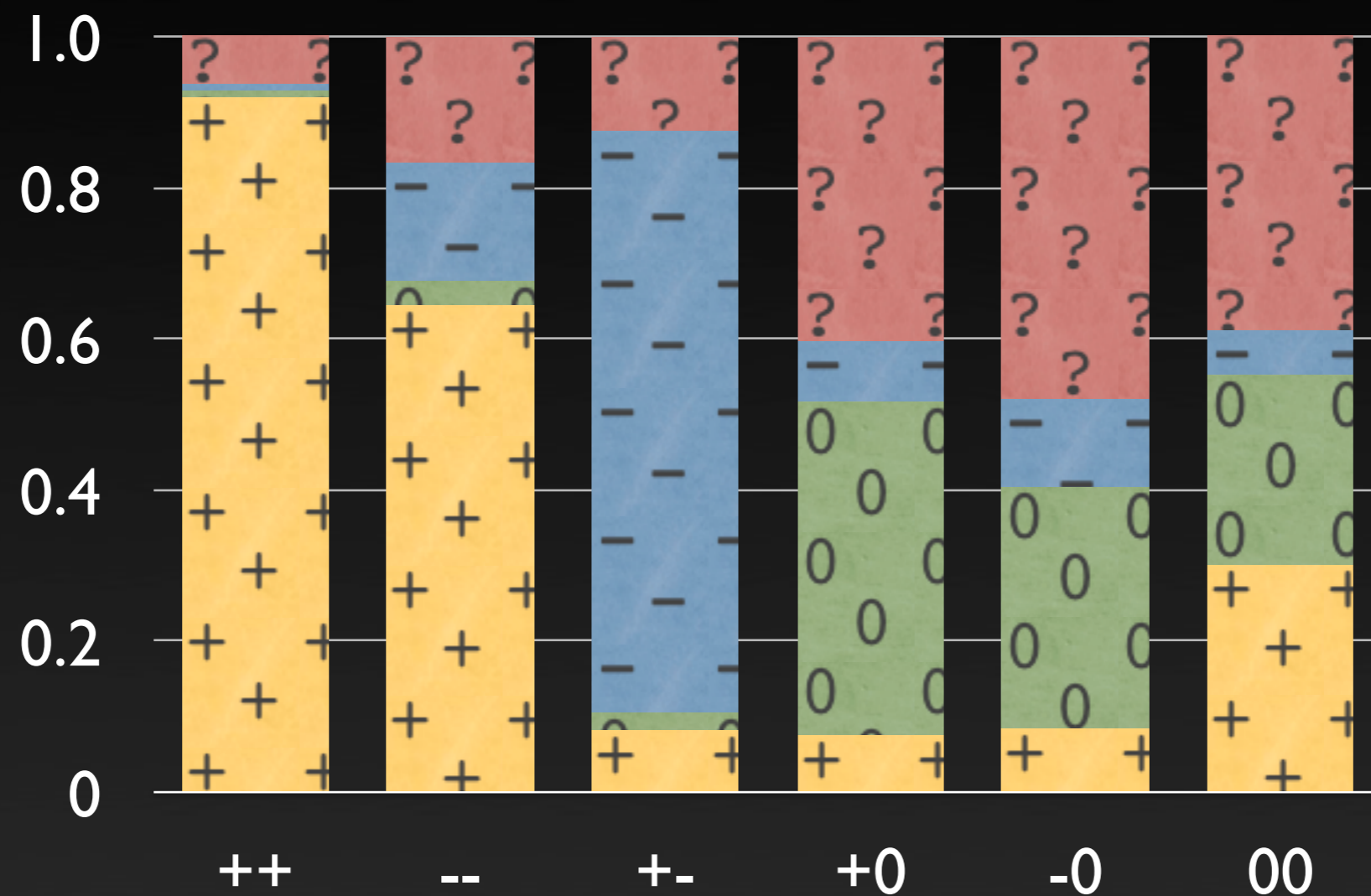
Explanation of the Next Slides

- The following slides summarize all of the data for the experiment
- All 3 conditions with 3 choices are summarized (the left side of each cluster) and compared to the condition with 4 choices (the right side of each cluster)
- Some conditions were averaged due to similarities in the conditions themselves and the results obtained (+-, +0, -0)

Inferred Relationship 3 choices

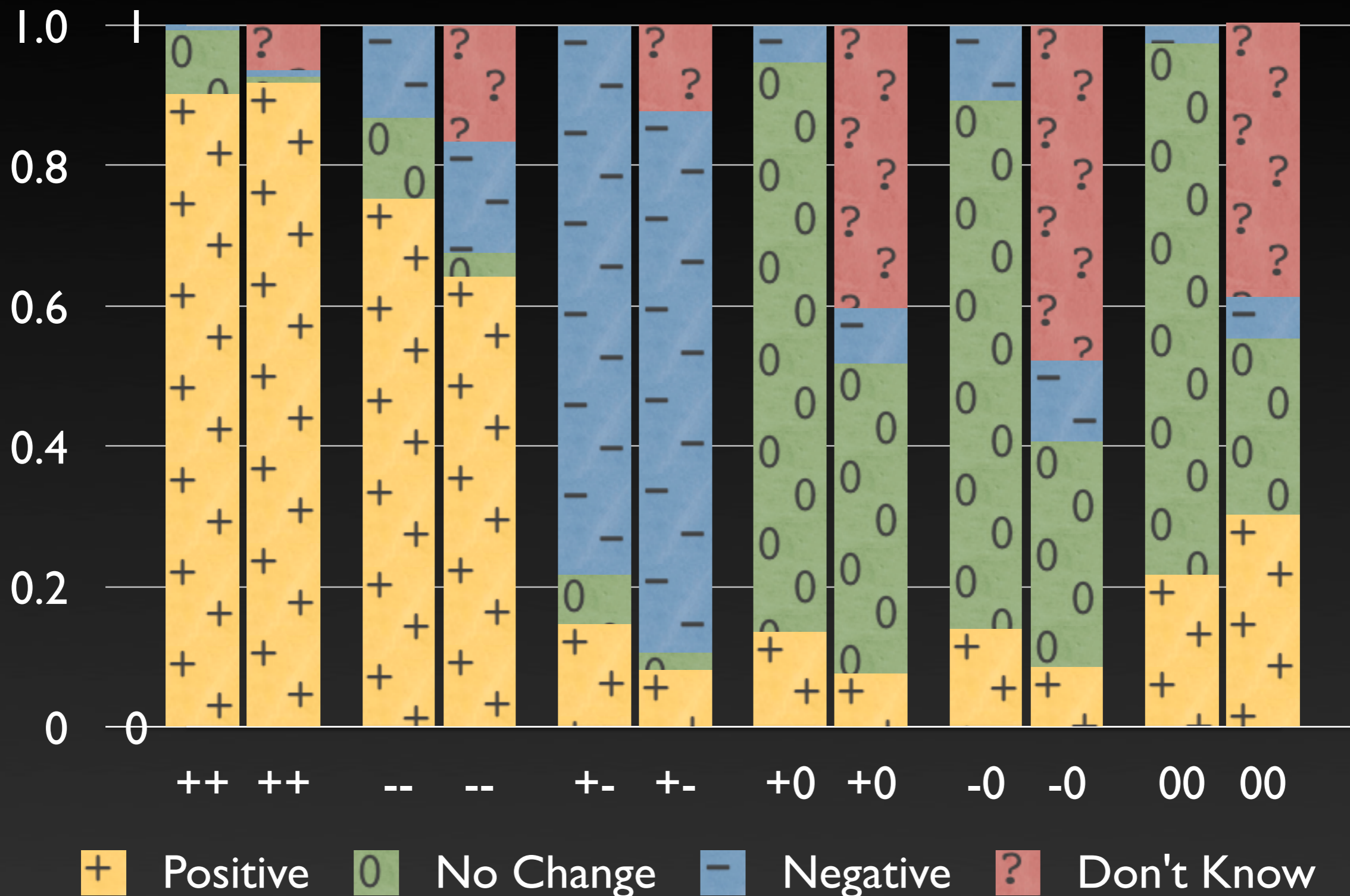


Inferred Relationship 4 choices



+ Positive **0** No Change **-** Negative **?** Don't Know

3 vs. 4 (chem only)



3 vs. 4 (chem only)

Another view

