

# SUPPRESSION EFFECTS BY CONTENT AND CONTEXT

## A KNOWLEDGE-BASED APPROACH

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### Motivation

**Background** Logical performance on conditional reasoning tasks can be facilitated (Rumain, Connell & Braine, 1983) or suppressed (Byrne, 1989) by changes in content and context of materials. This ambivalence provoked a vigorous debate between proponents of natural logic (Politzer & Braine, 1991) and mental models theory (Byrne, 1991). In concurrence with Fillenbaum (1993), we set forth that suppression effects challenge the methodology of both approaches, as they highlight the importance of interpretive processes. To understand this phenomenon, it is necessary to embed deductive reasoning in a knowledge-based approach (Beller, 1997).

**What is wrong with this argument?** Based solely on the two premises below, the following argument is fallacious:

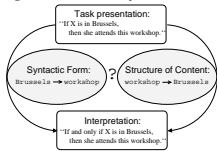
If X is in Brussels,  
then she attends this workshop.  
X is not in Brussels.  
∴ X does not attend this workshop.

Yet the inference is perfectly rational if we take into account knowledge about the location of this workshop (i.e., "If X attends the workshop, then she is in Brussels.").

This illustrates how effects of content and context come into play: conditionals are interpreted within the framework of a subject's background knowledge, and this, in turn, determines reasoning performance.

### Theory

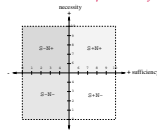
How does an experimental task interact with a subject's background knowledge? Any proper account of suppression effects has to distinguish among the following four levels of analysis:



Our basic claim is methodological: To understand processes of interpretation, relevant dimensions of a subject's background knowledge must be taken into account. (Beller, 1997).

This premise suggests a two-step strategy:

- **Conceptualization:** Knowledge about perceived sufficiency and necessity mediates the interpretation of conditional dependencies (Thompson, 1994). The two dimensions of necessity and sufficiency yield four distinct *patterns of dependence*:



- **Formalization:** The logical properties of semantic content are described separately from the syntactic form of materials. Contextual information is integrated by conjunction (∧) or disjunction (∨), depending on the type of semantic content (Byrne & Johnson-Laird, 1992).

This yields two predictive models—one of *form* and one of *content*—both of which can be formally represented. Their combination allows one of four qualitatively different predictions for any conditional inference:

Prediction of content	Prediction of form
++	+
+-	+
-+	-
--	-

Note: "++": definite conclusion predicted;  
"-": indefinite conclusion predicted.

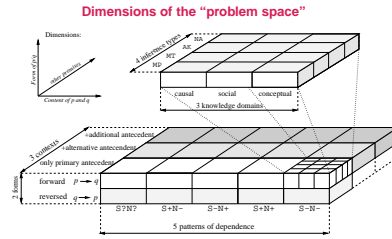
### Method

In order to demonstrate the generality of knowledge-based suppression effects we combined the contextual variation ("additional premise paradigm") employed by Byrne (1989) with factors of syntactic form and semantic content.

**Materials** Fifteen concrete scenarios were constructed. Each scenario consists of four components: a *primary antecedent p*, an *alternative or additional antecedent p<sub>alt</sub>* or *p<sub>add</sub>*, and a *consequent q*. Relations between *p* and *q* varied over two dimensions of content:

- Five **patterns of dependence**:
  1. S+N-: *p* is sufficient and not necessary for *q*.
  2. S-N+: *p* is not sufficient but necessary for *q*.
  3. S+N+: *p* is both sufficient and necessary for *q*.
  4. S-N-: *p* is neither sufficient nor necessary for *q*.
  5. S?N?: It is unknown whether *p* is sufficient or necessary for *q*.

- Three **specific knowledge domains**:
  1. *causal knowledge* about relations between causes and effects.
  2. *social knowledge* about relations between conditions and actions.
  3. *conceptual knowledge* about relations between terms and concepts.



**Tasks** In order to focus on different aspects of reasoning processes we used three separate experimental tasks:

**A. Conditional syllogism task** Each relation between *p* and *q* is presented in two syntactic forms (forward: *p* → *q*; reversed: *q* → *p*), three contexts (*only p* → *q* / *p<sub>alt</sub>* → *q* / *p<sub>add</sub>* → *q*), and four inference types (MP, MT, AC, NA). (Three possible conclusions: affirmative, negative, indefinite.)

**Example.**  
Pattern of Knowledge: S-N+  
Dependence domain: causal  
Context & Form: (t) S?N? causal *p* → *q* + *p<sub>add</sub>* → *q* (additional)  
If the blood level of oxytocin rises, then lactation increases.  
If the patient is female, then lactation increases.  
⇒ What factors modulate the endorsement of conditional inferences?

**B. Rating task** Are our scenarios perceived as intended? Effects of contexts? ⇒ Assessment of perceived sufficiency and necessity of *p* in regard to *q* in different contexts. (Two rating scales from 0–100%.)

**C. Formulation task** Will subjects discriminate between different wordings of conditional relations? ⇒ Choice of the most appropriate wording of the relationship between *p* and *q* in different contexts. (Four categories: conditional, converse, biconditional, none.)

**Subjects** 110 volunteers were recruited at the University of Freiburg (Germany). They were randomly assigned to one of the above tasks (*n*=30/50/30). Three subjects were replaced prior to data analysis because they had received formal training in logic.

### Conclusions

Suppression effects of content and context are multi-faceted, knowledge-based phenomena. In order to explain their underlying mechanisms, we must strive to integrate syntactic form and semantic content rather than pit them against each other.

A knowledge-based approach addresses questions of content without having to assert content-specific rules of inference. It adds predictive power to general theories of conditional reasoning and helps to clarify the role of interpretive processes.

### References

Beller, S. (1997). *Inhaltslogik beim logischen Denken — Der Fall der Wissenschaften Wahnlogik*. Unpublished PhD thesis, Albert-Ludwigs-Universität Freiburg.  
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Fillenbaum, S. (1993). Deductive reasoning: What are taken to be the premises and how are they interpreted? *The Behavioral and Brain Sciences*, 16(2), 348–349.  
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Rumain, B., Connell, J. & Braine, M. D. (1983). Conversational comprehension processes are responsible for reasoning fallacies in children as well as adults: *Is it not the biconditional*. *Developmental Psychology*, 19(4), 471–481.  
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### Results

#### A. Conditional syllogism task

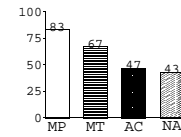
- Subjects prefer definite conclusions whenever they are endorsed by either form or content:

Prediction of content	Prediction of form				Σ(content)
	MP	MT	AC	NA	
++	98.9%	86.7%	83.9%	82.2%	87.9%
+-	78.3%	59.0%	24.7%	24.6%	46.4%
-+	86.0%	69.4%	46.9%	46.3%	62.2%
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Note: Frequencies based on a total of 1920 conditional syllogisms.

- Various effects of content and context:

Example (t)

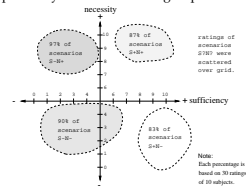


A hierarchical loglinear analysis revealed the following effects:  
– Main effects of *pattern of dependence*, *context*, and *inference type*.  
– Interactions of *pattern of dependence* with *syntactic form* and *inference type*.  
– No effects of *specific knowledge domains*.

- As models of syntactic form and semantic content are both formally specified, the quality of their predictions could be assessed. Whereas each model per se correctly predicted 65% of all inferences, their combination accounted for 78%.

#### B. Rating task

The relations between primary antecedents *p* and consequents *q* were perceived as intended. A hierarchical cluster analysis showed separability into four distinct groups:



Mentioning of alternative or additional antecedents *p<sub>alt</sub>* or *p<sub>add</sub>* led to the predicted effects of context:

Context	Perceived sufficiency $\bar{S}$	Perceived necessity $\bar{N}$
only <i>p</i> / <i>q</i> :	53.2%	58.3%
+ <i>p<sub>alt</sub></i> :	53.7%	46.5%
+ <i>p<sub>add</sub></i> :	40.4%	53.6%
mean:	49.1%	52.8%

Mean ratings of perceived sufficiency and necessity. (Each percentage is based on 150 ratings.)

#### C. Formulation task

Subjects had clear intuitions about logically appropriate expressions of content. If alternative or additional antecedents were mentioned, about 50% took them into account:

Context dependence	Response categories				
	Pattern of cond.: <i>p</i> → <i>q</i>	converse: <i>q</i> → <i>p</i>	bicond.: <i>p</i> ↔ <i>q</i>	none: <i>p</i> ↔ <i>q</i>	
only <i>p</i> / <i>q</i>	S+N-:	29**	0	1	0
	S-N+:	0	28**	1	1
	S+N+:	1	4	25**	0
	S-N-:	1	4	1	23**
	S?N?:	5	7	5	13*
+ <i>p<sub>alt</sub></i>	S+N-:	28**	0	0	2
	S-N+:	4	13*	2	11
	S+N+:	15**	3	9	3
	S-N-:	1	2	2	25**
	S?N?:	5	3	7	17**
+ <i>p<sub>add</sub></i>	S+N-:	15**	2	1	12
	S-N+:	1	27**	0	2
	S+N+:	2	12	10	6
	S-N-:	1	5	2	22**
	S?N?:	2	8	1	19**

Note: Predictions of content model are highlighted.  
\*  $P(X \leq 13, 30, \frac{1}{2}) < 0.05$ ; \*\*  $P(X \leq 14, 30, \frac{1}{2}) < 0.01$ .

