The Dual-Strategy model of reasoning

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Conditional reasoning

This requires accepting an initial if antecedent-then consequent premise as true, and making inferences based on this major premise and a minor premise which is one of four possible statements:

Accepting/rejecting antecedent/consequent

Conditional reasoning is a fundamental component of scientific and mathematical reasoning

Two types of conditional inferences:

1. Logically certain inferences, e.g.

Modus ponens (MP)

If P then Q
P is true

Then Q is certainly true

or Modus tollens (P is true, thus Q is false)

2. Logically uncertain inferences

Affirmation of the consequent (AC)

If P then Q
Q is true

P could be true or not true

Or Denial of the antecedent (DA: P is false: no conclusion)

Much of the variability in inferential performance is found with these inferences, both developmentally and in adults

Empirical data has shown that the AC, DA inferences that are made to formally similar premises vary. One of the clearest forms of this variation are content effects. Specifically, the relative number of alternative antécédents is strongly correlated with the tendency to reject the conclusion.

If a rock is thrown at a window, the window will break.

A window is broken. Was a rock thrown?

Many ways of a window breaking without a rock being thrown

If John's finger is cut, it will bleed.

John's finger is bleeding. Was his finger cut?

Very few ways of a finger bleeding without cutting it.

Within each class of conditional (i.e. with identical semantics), the number of potential alternatives is correlated with conclusions:

If a rock is thrown at a window, the window will break.

A window is broken

Most people will not infer that « a rock was thrown »

If a finger is cut, then it will bleed.

A finger bleeds.

Many people will infer that « the finger was cut »

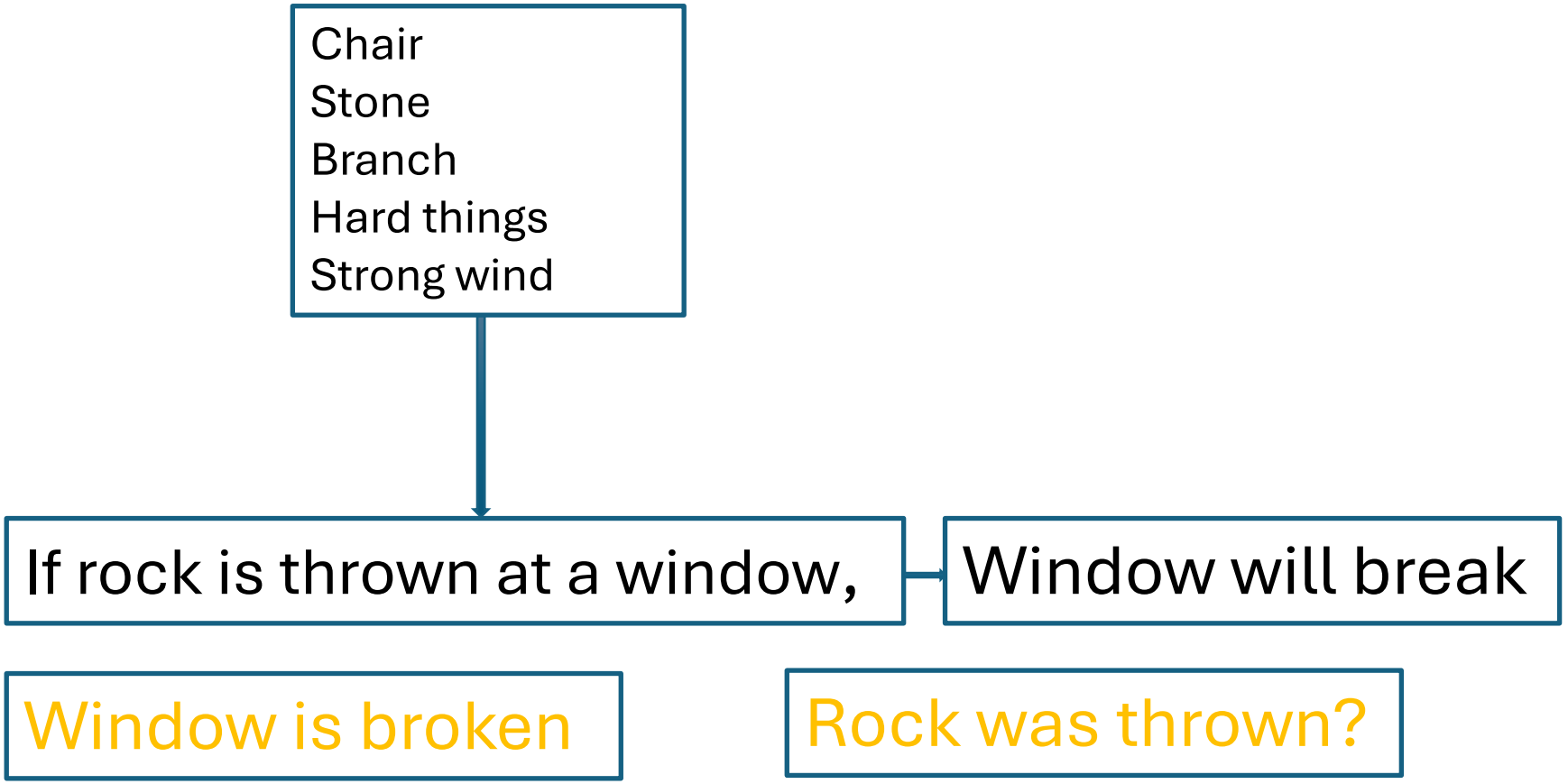
Theories that can explain variability in inferences within the basic processes postulated by the theory.

Mental model theory (Johnson-Laird & Byrne)

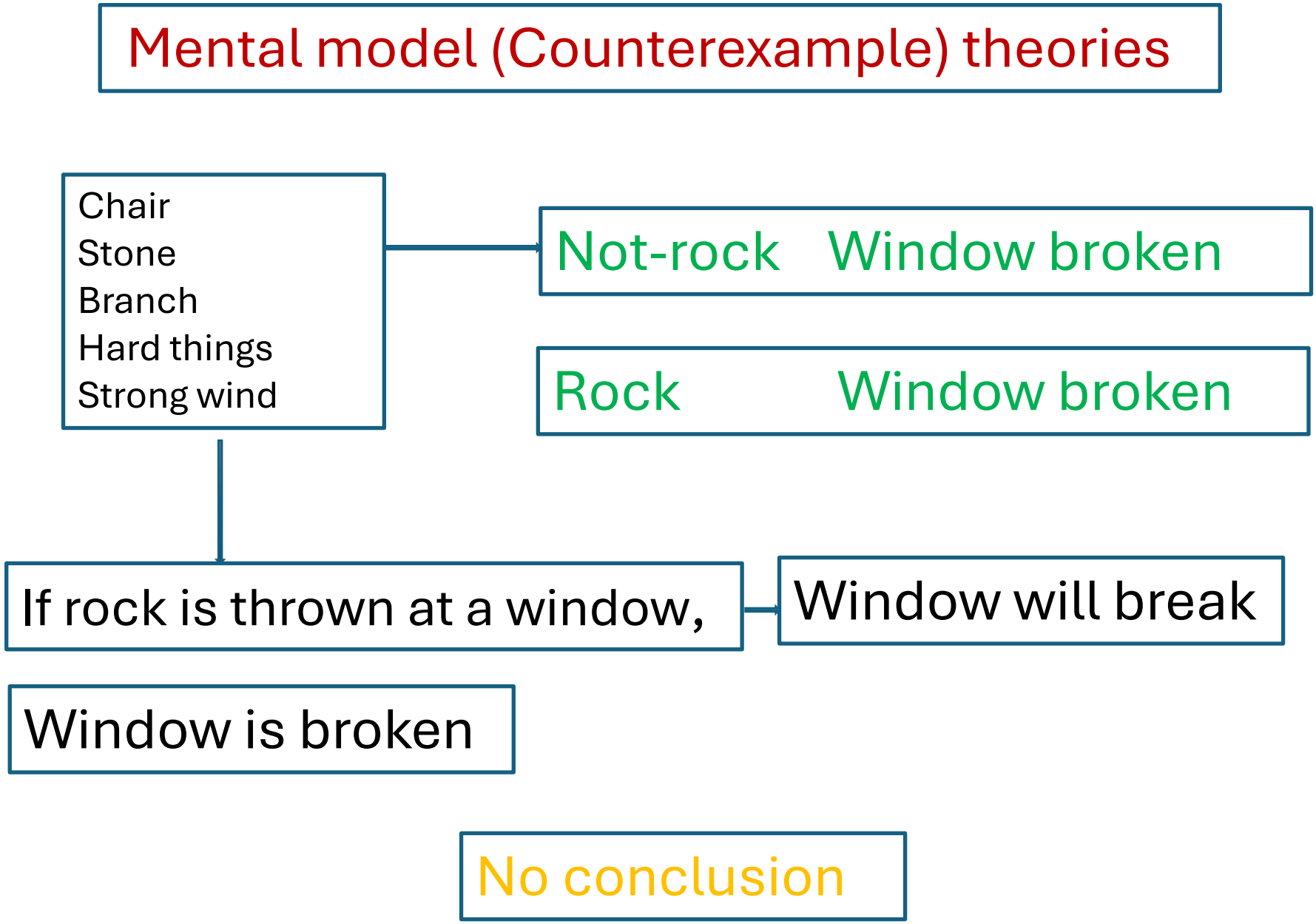
Inference supposes a representation of premises coupled with an internal search for counterexamples

Probabilistic theories (Evans, Oaksford & Chater)

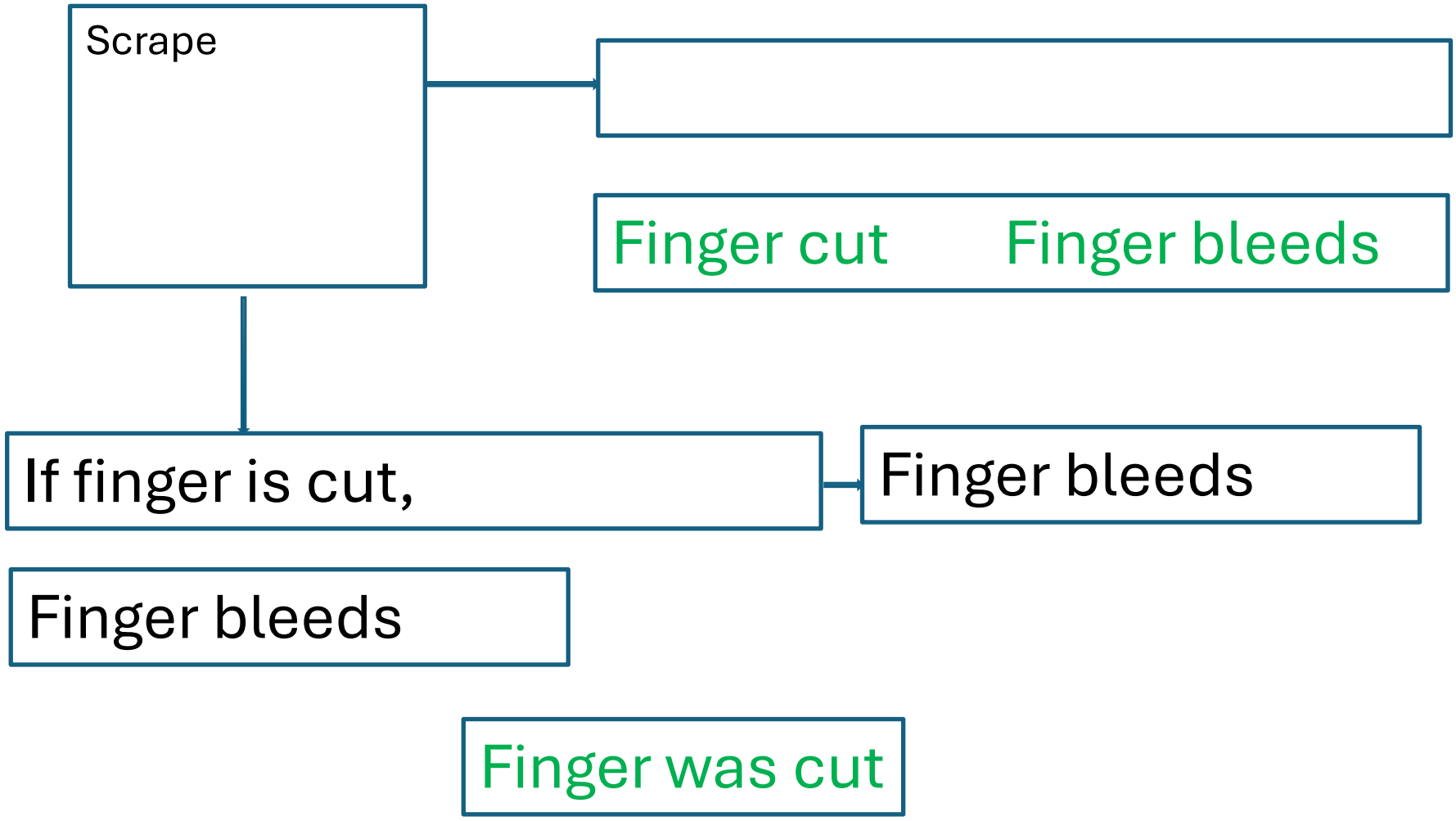
Inferences based on estimation of conclusion probability given premises


Chair
Stone
Branch
Hard things
Strong wind
If rock is thrown at a window,
Window will break
Window is broken
Rock was thrown?

Mental model (Counterexample) theories



Mental model (Counterexample) theories



Probabilistic theories

Chair
Stone
Branch
Hard things
Strong wind

→ Prob (rock|window broken) = low

If rock is thrown at a window, → Window will break

Window is broken

Low probability → No conclusion

Probabilistic theories

Scrape

Prob (cut|finger bleeds) = high

If finger is cut,

Finger bleeds

Finger bleeds

High probability → Finger cut

Both mental model and probabilistic theories make similar predictions as to mean acceptance rates of inferences with premises having different numbers of alternative antecedents.

Verschueren et al. suggested that these models might be considered as differing ways of processing information, with probabilistic modes corresponding to Type 1 (intuitive) processes and mental model modes corresponding to Type 2 (working memory intensive) processes.

Our work has provided evidence for this distinction but has suggested that these can be considered as different **strategies**, which we refer to as Counterexample and Statistical strategies.

Verschueren, N., Schaeken, W., & d'Ydewalle, G. (2005b). Everyday conditional reasoning: A working memory-dependent tradeoff between counterexample and likelihood use. *Memory & Cognition, 33*(1), 107-119.

Consider ‘rock thrown → window broken; window broken’:

Lots of alternative ways of breaking window

Counterexample strategy

Statistical information about potential counterexamples to the conclusion is transformed into an explicit representation of the premises which requires working memory

rock thrown	window broken
chair (or other)	window broken

If window is broken, ‘rock thrown’ is not valid

Statistical strategy

Statistical information is used to generate the likelihood of the conclusion being true, given the premises using a low-cost associative procedure

If Window broken, probability of rock is LOW since there are many other ways of breaking windows

This likelihood is then translated into a judgment of validity :

If window is broken, ‘rock thrown’ is (probably) not valid

One key problem is that a probabilistic evaluation must be translated into a judgment of validity, and a single judgment (which is dichotomous) cannot adequately capture this process.

In order to distinguish the two strategies on an individual level, we have developed the following diagnostic procedure. This relies on giving a series of identical AC problems for which we provide explicit statistical information (these use non-familiar terms situated in a fantasy context to reduce the impact of previous knowledge)

If Fannar is eaten then then ground will be red.

For 1000 observations:

990 Fannar eaten and ground is red

10 Fannar not eaten and ground is red

Participants must evaluate the following reasoning:

Ground is red.

Therefore: Fanner eaten

Valid or not

Counterexample strategy: NO

Statistical strategy: HIGH prob = high prob of rejecting conclusion

If Fannar eaten then ground will be red.

For 1000 observations:

550 Fannar eaten and ground is red

450 Fannar not eaten and ground is red

Ground is red.

Therefor: Fanner eaten

Valid or not

Counterexample strategy: NO

Statistical strategy: LOW prob=low prob of rejecting conclusion

We give a series of 90% problems and a series of 50% problems.

Subjects who reject the conclusion on all problems = Counterexample strategy

Subjects who reject the conclusion more often on the 50% than on the 90% problems = Statistical strategy

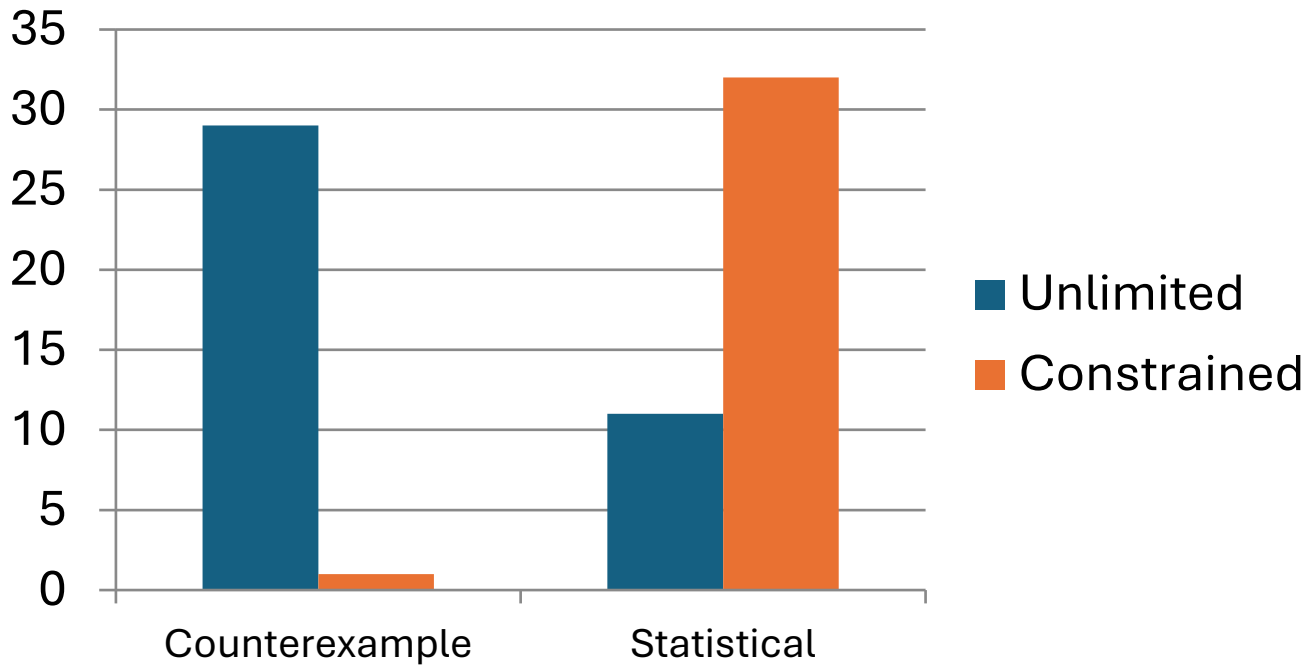
A statistical strategy is less cognitively costly, and should be preferentially used under cognitive constraint.

We gave reasoners the diagnostic test under two conditions:

Unlimited time Time constrained

Markovits, H., Brunet, M.-L., Thompson, V., & Brisson, J. (2013). Direct evidence for a dual process model of deductive inference. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 39*(4), 1213-1222.

When time constrained, even reasoners who gave Counterexample strategies with Unlimited time tended strongly to use Statistical strategies.



There is one critical question. The diagnostic criteria for a Counterexample strategy requires giving the logically correct response for all problems.

Are Counterexample reasoners simply more « logical » ?

We examined performance on MP inferences:

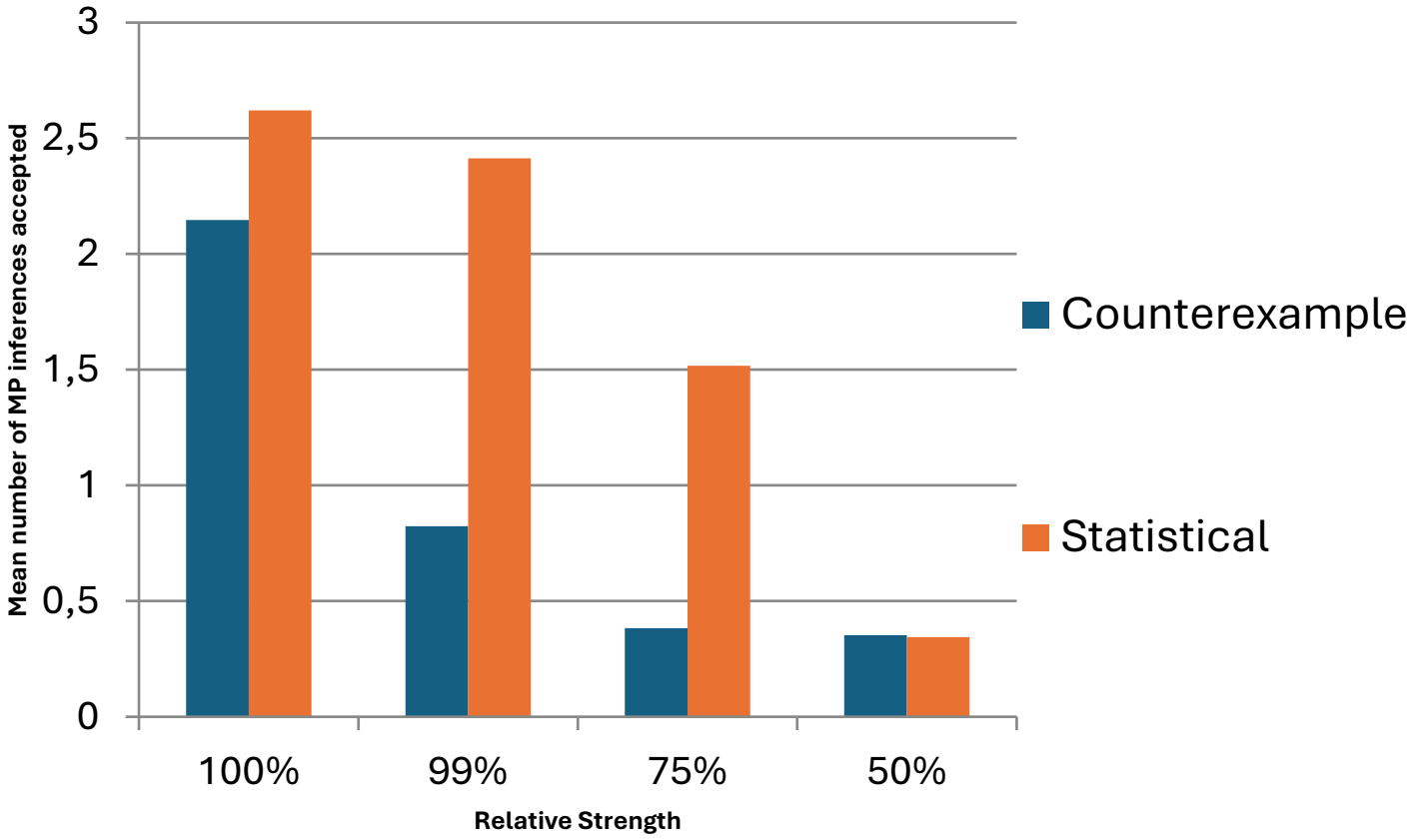
P implies Q, P is true. Is Q true?

Problems were presented in two ways.

Markovits, H., Brisson, J. & de Chantal, P.-L. (2017). Logical reasoning versus information processing in the dual strategy model of reasoning. *Journal of Experimental Psychology: Learning, Memory and Cognition*.

1. MP inferences with explicit statistical information concerning the probability of the conclusion.

Statistical reasoners are more ‘logical’, i.e. they correctly judge the conclusion that « Q is true » to be valid more often than Counterexample reasoners



Counterexample reasoners use a more cognitively taxing form of reasoning. There is clear evidence that Counterexample reasoners show higher levels of cognitive functioning than Statistical reasoners.

This has been found for IQ, working memory, CRT, AOT.

It is possible that the effects of reasoning strategy can be explained by these differences.

Thompson, V. A. & Markovits, H. (2021). Reasoning strategies vs cognitive capacity as predictors of reasoning performance. *Cognition*, 217.

Results show that reasoning strategy predicts performance on several reasoning and judgment tasks over and above effects of cognitive differences.

The key difference between the two strategies is how statistical information about premises is processed.

This has implications in two different directions.

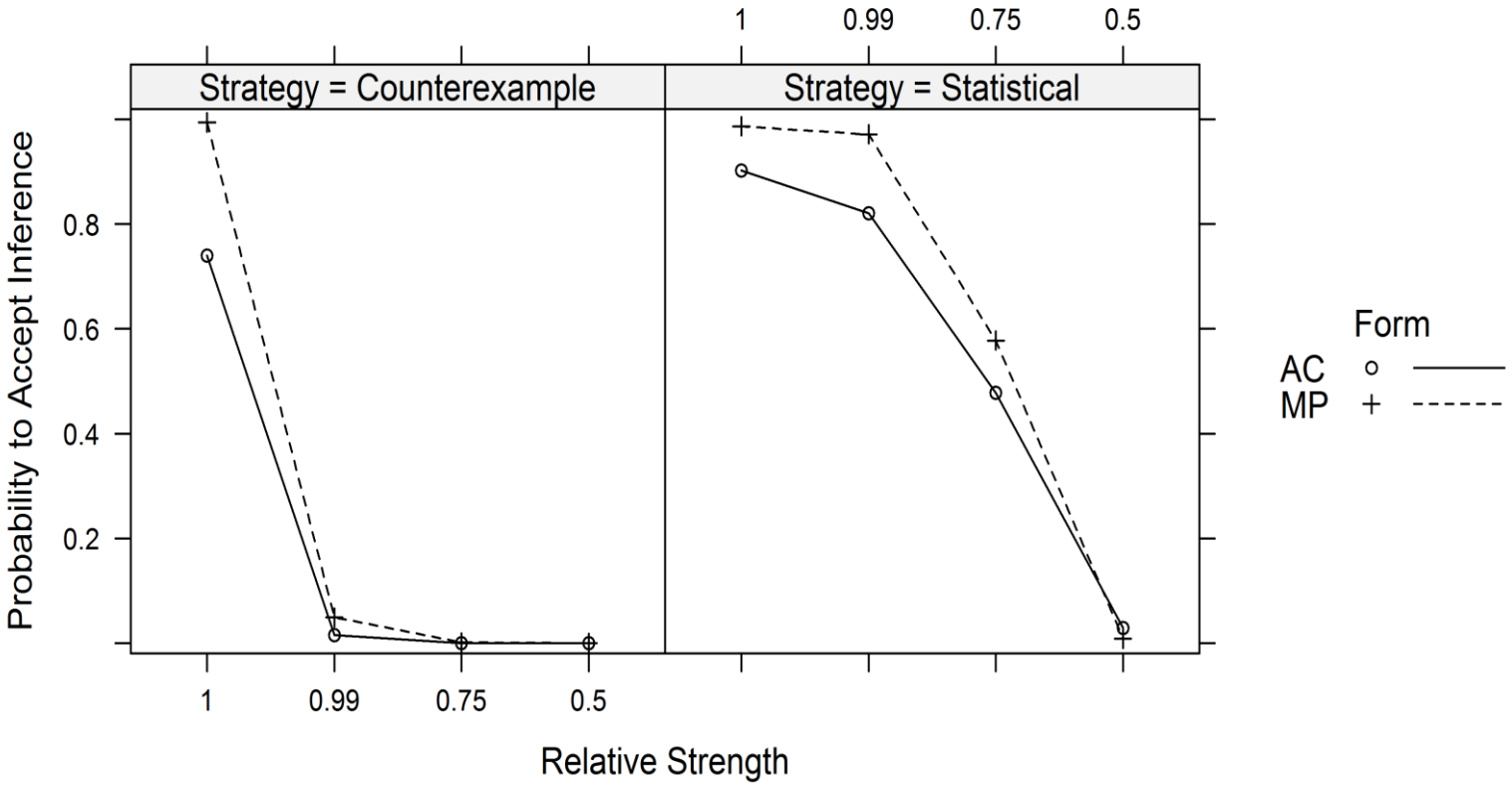
1. Potential counterexamples will have a stronger effect on inferences on Counterexample reasoners than Statistical reasoners.

Counterexample reasoner needs only to generate a single representation with a counterexample to reject a conclusion.

Statistical reasoner will calculate the revised probability of a conclusion given a counterexample which can lead to variable probabilities

Inferences presented with explicit counterexamples with varying overall probability of conclusion being true

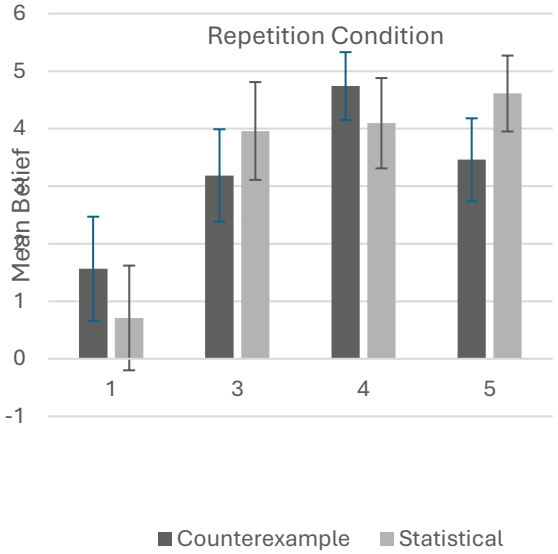
Markovits, H. Brisson, J., de Chantal, P.-L. & Singmann, H. (2018). Multiple layers of information processing in deductive reasoning: Combining dual strategy and dual-source models. *Journal of Cognitive Psychology*, 30(4), 394-405.

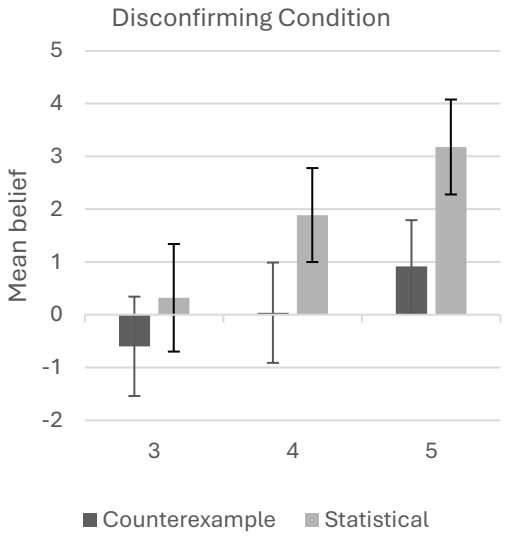


Brisson, J. & Markovits, H. (2020). Reasoning strategies and the semantic memory effect in deductive reasoning. *Memory and Cognition*, 48, 920-930.

	Uncertain inferences N acceptances		**Certain inferences N acceptances**	
Strategy	AC	DA	MP	MT
Counterexample	0,72	1.15	2.62	2.23
Statistical	1.55	1.58	2.47	2.18

Another example is given by a study that examined the effect of repetition on belief in fake news, when followed by a disconfirmation





Gratton, C. & Markovits, H. (2021). Reasoning strategy determines effects of disconfirmation on belief in false claims. *Memory and Cognition*, *49*(8), 1505-1525.

2. Strategy use changes the way that information is processed when making an inference.

Counterexample reasoners use a more focused attention to problem parameters, and will stop search for related information as soon as a counterexample is accessed.

Statistical reasoners use a more superficial, but wider search for related information, since this is required to give an estimation of probability.

➔Statistical reasoners will be more susceptible to information stored in memory that may not be relevant to a given judgment.

Statistical reasoners are more susceptible to the effects of conclusion believability than Countexample reasoners.

Classical belief-bias:

All flowers have petals.

Roses have petals.

Conclusion: Roses are flowers.

De Chantal, P. L., Newman, I., Thompson, V., Markovits, H. (2019). Who Resists Belief-biased Inferences? The Role of Individual Differences in Reasoning Strategies, Working Memory and Attentional Focus. *Memory and Cognition*, *48*, 655-671.

Markovits, H., Brisson, J., de Chantal, P. L., & Thompson, V. A. (2017). Interactions between inferential strategies and belief bias. *Memory & Cognition*, 45(7), 1182-1192

Statistical reasoners are more susceptible to the effects of social biases than Counterexample reasoners.

Statistical reasoners are more affected by

Self-serving bias

Racist stereotypes

Essentialist prime results in higher levels of gender bias among Statistical but not Counterexample reasoners

Gagnon-St-Pierre, E., Doucerin, M. & Markovits, H. (2020). Reasoning strategies explain individual differences in social reasoning. *Journal of Experimental Psychology: General*. 150(2). 340-353.

Two studies have examined interactions between gender biased intuitive processing and strategy use.

The basic logic is that overall gender differences will be less pronounced among Counterexample reasoners, since these will be more prone to producing a more « neutral » representation of problems.

Women have been shown to be more affected by negative stimuli than men.

Study 1: intensity of emotional reactions to film clips showing negative émotions

Statistical reasoners; women showed stronger reactions than men

Counterexample reasoners: no gender difference

Study 2: response times to sequences of negative stimuli

Statistical reasoners; women responded faster than men

Counterexample reasoners: no gender difference

Markovits, H., Trémolière, B., & Blanchette, I. (2018). Reasoning strategies modulate gender differences in emotion processing. *Cognition*, 170, 76-83.

Women are slower to process rotations than men.

Ps given a sequence of rotated figures and asked to match these with an original 3D form

Statistical reasoners; men were slower than men

Counterexample reasoners: no gender difference

Markovits, H. (2019). Reasoning strategy modulates sex differences in performance on spatial rotation. *Quarterly Journal of Experimental Psychology,* 72, 2870-2876.

How flexible are strategies?

We can use explicit instructions to reason with a focus on counterexamples to make Statistical reasoners reason more like Counterexample reasoners

On belief-biased reasoning problems

On base rate problems

Markovits, H. & Thompson, V. A. (2023). Can we change how people reason? Effects of instructions to reason differently and reasoning strategy. *Journal of Experimental Psychology: Learning, Memory and Cognition*.

Emilie Gagnon-St-Pierre has recently examined responses to the strategy diagnostic over a one-month interval.

Gagnon-St-Pierre, E., Gratton, C., Doucerain, M. M. & Markovits, H. (in revision) Are individual differences in reasoning strategies stable, and do they predict Ageism? Journal of Cognitive Psychology.

Table 5
Relation between Strategy use at Time 1 and at Time 2 (parentheses are percentage of Time 1 category)

Time 1	Time 2			
Strategy	Counterexample	Intermediate	Statistical	Other
Counterexample	44 (72.1%)	5 (8.2%)	5 (8.2%)	7 (11.5%)
Intermediate	13 (56.5%)	5 (21.7%)	4 (17.4%)	1 (4.3%)
Statistical	7 (7.1%)	8 (8.2%)	64 (65.3%)	19 (19.4%)
Other	4 (8.9%)	4 (8.9%)	20 (44.4%)	17 (37.8%)

Conclusion

Reasoning strategies measure an important individual difference in the way that people reason and make judgments.

This model also suggests that there is not one single model that can account for the way that people reason, but that there is a certain degree of flexibility that must be accounted for.