Conditional Reasoning

Modus Ponens
(1) P → Q
(2) P
(3) Therefore: Q

Modus Tollens
(1) P → Q
(2) ~Q
(3) Therefore: ~P

P: John gets B or better on final exam
Q: John passes the course

Invalid Inferences

Denying the Antecedant
(1) P → Q
(2) ~P
(3) Therefore: ~Q

Affirming the Consequent
(1) P → Q
(2) Q
(3) Therefore: P

P: The object is square
Q: The object is blue.

Conditional vs. Bi-conditional

P	Q	P→Q	P←→Q
T	T	T	T
T	F	F	F
F	T	T	F
F	F	T	T

If you pick up your toys, I'll read you a story.
If our quarterback is injured, then our team will lose.

Conditional vs. Bi-conditional

P	Q	P→Q
T	**T**	**T**
T	F	F
F	**T**	**T**
F	F	T

Affirming the Consequent
(1) P → Q
(2) Q
(3) Therefore: P

Conditional vs. Bi-conditional

P	Q	P→Q	P←→Q
T	**T**	T	**T**
T	F	F	F
F	T	T	F
F	F	T	T

'Affirming the Consequent'
(1) P ←→ Q
(2) Q
(3) Therefore: P

On the biconditional reading of "if", 'Affirming the Consequent' is a valid inference schema!

Conditional vs. Bi-conditional

P	Q	P→Q
T	T	T
T	F	F
F	T	**T**
F	F	**T**

Denying the Antecedant
(1) P → Q
(2) ~P
(3) Therefore: ~Q

Conditional vs. Bi-conditional

P	Q	P→Q	P←→Q
T	T	T	T
T	F	F	F
F	T	T	F
F	F	T	**T**

'Denying the Antecedant'

(1) P ←→ Q

(2) ~P

(3) Therefore: ~Q

On the biconditional reading of "if" 'Denying the Antecedant' is a valid inference schema.

Conditional Reasoning in Hypothesis Testing

- Difficulty w/modus tollens inferences seen in performance on hypothesis testing tasks
- Confirmation Bias – tendency to look for evidence that confirms hypothesis rather than falsifying evidence

Wason Selection Task

If a card has a vowel on one side, it has an even number on the other.

50% E

46% E & 4

4% E&7

Wason Selection Task

P	Q	P→Q
T	*T*	*T*
T	**F**	**F**
F	*T*	*T*
F	F	T

- P→Q is always true when Q is true
  - Turning over Q yields no information
- The only time when P→Q is false is when P is true and Q is false
  - Need to turn over P to be sure the reverse is Q rather than ~Q
  - Need to turn over ~Q to be sure the reverse is ~P rather than P

Poor Performance on the Wason Selection Task

- Matching Hypothesis
- Abstract, Artificial Materials
- Lack of Relevant Experience

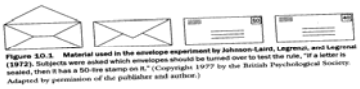
Matching Hypothesis

- People link hypothesis to cards by matching the terms in the hypothesis w/cards
- Predicts better performance for
  - A card that has a vowel on one side does NOT have an even number on the other side (shd pick: E&4)
- Predicts worse performance for
  - A card that does NOT have a vowel on one side has an even number on the other side.(shd pick: K&7)

Matching Hypothesis

- Supported by experiments done by Evans and colleagues
  - Matching at least part of the story…
- Why do people do this? Evans speculates
  - People assume the terms mentioned in the problem will be relevant to the solution
  - Because people find it difficult to reason with negative statements, they ignore them

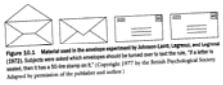
Concrete vs. Artificial Materials



If a letter is sealed, it has a 50 lire stamp on the other side.

- Johnson-Laird, Legrenzi, & Legrenzi
- 22/24 Correct (compared with 2/24 on Wason's original study)

Envelope Version of WST



- Do concrete materials make task easier?
- Griggs & Cox
  - American college students had trouble w/the envelopes
- Golding
  - Brits under 45 had trouble
  - Brits over 45 did not

Relevant Experience

- If a person is drinking beer, then the person must be over 21 years of age

BEER	PEPSI	16 Yrs	22 Yrs

- Performance on WST enhanced when thematic material cues retrieval of directly experienced knowledge in LTM

Pragmatic Reasoning Schemas

- Permission, Obligation, Authorization concepts organize conditional reasoning
- Reasoning schemas aren't completely abstract forms that are independent of their contents
  - Use schemas for permission, obligation, and authorization
- Thematic material triggers particular schemas
  - Anyone consuming Pepsi on these premises must be at least 100 years old.
  - Any lengths of red wool must be at least 6 meters long.

Cheng & Holyoak

Two Interpretations of Content Effects

☹ People have limited (or no) abstract reasoning abilities
  - They use frames and schemas instead

☺ People can reason abstractly, but their ability to link concrete information to abstract schemas depends on the content
  - That is, A → B, B → C, :. A → C
    - How to decide A, B, C instantiated in real world cases
    - Is B the same in Premise 1 and Premise 2 (J. Edgar Hoover example)

Syllogistic Reasoning

- Aristotle first developed formal logic
  - Syllogistic reasoning
- Categorical Syllogisms

  All men are mortal.
  Socrates is a man.
  Therefore: Socrates is mortal.
- Concrete as well as Abstract Instantiations

  All A's are B's.
  All B's are C's.
  Therefore: All A's are C's.

Some A's are B's

Some A's are B's.
Some B's are C's.
Therefore: Some A's are C's. (INVALID)

Some men are philosophers.
Some philosophers are women.
Therefore: Some men are women. (INVALID)

Atmosphere Effects

- Finding that people are more prone to accept arguments as valid if quantifiers in premises and conclusions are the same.
- Sometimes this works:

  All A's are B's.
  All B's are C's.
  Therefore: All A's are C's.
- Sometimes it doesn't work:

  No A's are B's. No women are robots.
  No B's are C's. No robots are ballerinas.
  Therefore: No A's are C's. No women are ballerinas.

Woodworth & Sells, 1935

Atmosphere Hypothesis

- Negative premise creates a negative atmosphere
  - Negative Conclusion
- Particular premise (some) creates a particular atmosphere
  - Particular Conclusion
- Valid > Invalid
  - Reflects reasoning processes

Evidence against the Atmosphere Hypothesis

- Most evidence consistent w/AH
- But:

  Some B are A.

  No C are B.

  Therefore: Some A are not C.

  (Only 10% of people offer this conclusion, while 60% say there is no valid conclusion.)

Conversion Hypothesis

- Syllogistic reasoning errors result because people reinterpret premises

  All A's are B's ⇒ All B's are A's
  Some A's are not B's ⇒ Some B's are not A's
- Predicts:

  All A's are B's.
  Some C's are B's.
  Therefore: Some C's are A's. ← INVALID (People do make this error.)
  A=ocean liners B=vehicles C=toys

Support for Conversion Hypothesis

- Restate premises in less ambiguous form
  - Performance improves!

All A's are B's, but some B's are not A's.
Some C's are B's.
Some C's are A's. ← INVALID (and everyone knows it!)

Belief Bias Effect

- Tendency to accept arguments with a true conclusion as being valid

All things that have motors need oil.
Automobiles need oil.
Therefore: Automobiles have motors. (INVALID)

All things that have motors need oil.
Wombats need oil.
Therefore: Wombats have motors. (INVALID)

Syllogistic Reasoning Errors

- Atmosphere Effects
  - Superficial Processing
- Conversion Effects
  - Comprehension Problems
- Belief Bias
  - Intrusion of Prior Beliefs
- Figural Effects
  - Findings that suggest people more likely to produce a conclusion that relates the subject of one premise to the predicate of another
  - More indicative of reasoning process itself

Figural Effects

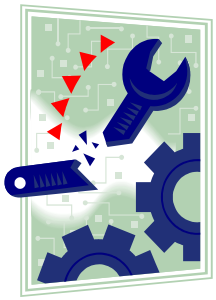
- Example
  - Some artists are beekeepers.
  - All of the beekeepers are chemists.
  - Therefore: Some of the artists are chemists.
  - Therefore: Some of the chemists are artists.
- More natural to go from subject of one premise to predicate of the other in formulating a conclusion

Potential Errors

- Figural effects also lead to errors
  - All of the beekeepers are artists.
  - None of the chemists are beekeepers.
  - Some of the artists are not chemists. (VALID)
  - Some of the chemists are not artists. (INVALID)

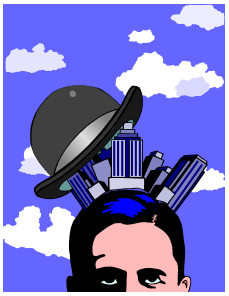
BA
CB
CA (Figural Effect)
AC (Contra-Figural Effect)

Processing Limitations



- Internal Consistency Check
- Failure to Consider All Possible Instantiations of Premises

Mental Models Theory



- Johnson-Laird
- People reason by constructing models
- Conclusions drawn by inspecting models
- If no alternative models refute, draw inference as valid conclusion

Mental Models Theory

- The lamp is on the right of the pad.
- The book is on the left of the pad.
- The clock is in front of the book.
- The vase is in front of the lamp.

	pad	lamp
book	pad	lamp
book	pad	lamp
clock		
book	pad	lamp
clock		vase

Multiple Models

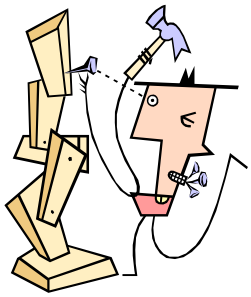
- The lamp is on the right of the pad.
- The book is on the left of the lamp.
- The clock is in front of the book.
- The vase is in front of the pad.

book	pad	lamp
clock		vase

pad	book	lamp
	vase	clock

Mental Models Theory

- 3 Stages
  - Comprehension of Premises
  - Formulate Conclusion
  - Search for Alternative Models
- Models
  - Specific
  - Analogue
  - Visual Images OR Unconscious



More Mental Models Theory

- Procedures
  - Conclusion-forming
  - Revision
- Errors caused by WM Limitations
  - More models needed, more errors likely

Syllogistic Reasoning & Mental Models Theory

(1) Some of the artists are beekeepers.

artist = beekeeper
(artist) (beekeeper)

artist = beekeeper
artist = beekeeper
(artist) (beekeeper)

All of the beekeepers…

(2) All of the beekeepers are chemists.

beekeeper =	chemist
beekeeper =	chemist
	(chemist)

Integrating Premises

(1) Some of the artists are beekeepers.
(2) All of the beekeepers are chemists.
(3) Some of the artists are chemists.

artist =	beekeeper =	chemist
(artist)	(beekeeper) =	chemist
		(chemist)