The Suppression Task Revisited
final paper for the course
Rationality, Cognition and Reasoning
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Abstract

The apparent inconsistency of subjects' answers in logical reasoning tasks, along with the fact that these answers do not comply with those predicted by classical logic, has been used to argue that human reasoning can not be described adequately by any logical formalism. In particular, Byrne [5] devised a logical experiment, the suppression task, in which subjects seem to suppress valid logic inferences when additional premisses are added. She concludes that human reasoning is governed by the mental models theory of Johnson-Laird [4]. However, closer analysis of the suppression task reveals subtle differences between the logical forms of the subtasks, which were presumed to be equivalent. A Closed World Reasoning (CWR) interpretation may account for the perceived suppression patterns [6]. Byrne's experimental design restricted the permitted answers to a fixed set. This set excluded a possible interpretation of the premise which we call "strengthening", and thus may have distorted her results on suppression. The current research replicated Byrne's experiment, but allowed for open answers. Most of the subjects' answering patterns were found to match those predicted by CWR with strengthening.

1 Introduction

In the past decades, the field of psychology of reasoning has been dominated by the view that the reasoning mechanism in humans cannot be adequately described by any logical formalism. Logic theories are claimed to have a normative status. Conversely, empirical observations of human reasoning show all but normative behaviour; for example, the Wason Selection Task [3].

There seems to be an unbridgeable conflict between formal theories and human reasoning behaviour. This has lead most cognitive researchers to abandon formal logic as a choice of analysis for reasoning, in favour of paradigms such as the 'mental models theory' and 'evolutionary theory'.

The mental models theory, advocated by Johnson-Laird [4], claims that no formal logic is involved in reasoning. Instead, the theory claims that people construct a model (or script) of the described situation, based on the meanings of the premises plus their own domain-specific knowledge. In the mental models theory, inferences such as modus ponens can be read out of the model without the need for a formal rule. Reasoning depends on a search for counterexamples that falsify the validity of the conclusion.

Evolutionary theory [1] embodies the idea that humans have developed their reasoning skills as an answer to certain evolutionary challenges. It is claimed that evolution provided solutions for adaptational problems in specific domains, which are organised in a modular way in the brain. An example is the cheater detection module, which was developed as a means to detect those who take benefits without reciprocating - those who betray social contracts [1].

Cosmides [1] has tried to demonstrate that the Wason Selection task, reformulated as a 'cheater detection task', was much easier for subjects to solve than the original task. Based upon these results she proposed an evolutionary psychology account of human reasoning.

More recently, there have been attempts to rehabilitate the role of formal logic in human reasoning. In their upcoming book [6], Stenning and van Lambalgen advocate a modern adaptation of Husserl's views [2] that reasoning is simultaneously formal and relative to a domain. They distinguish between reasoning towards an interpretation and reasoning from an interpretation, thereby disentangling formal logic from the process of fitting an appropriate logic system onto the world. This view of human reasoning effectively solves the normativity issue, since it leaves freedom of choice in the empirical process of reasoning towards an interpretation.

Reasoning towards an interpretation may be viewed as setting parameters for the logic of choice. As such it bears similarity with, for example, the problem in physics of empirically determining which metric from a set of alternatives is most suitable to describe physical space. This interpretation can be seen in opposition

to accepting classical logic and Euclidean metrics respectively as a dogma.

Stenning and van Lambalgen demonstrate that the formulation of the Wason Selection Task as a 'cheater detection task' effectively changes the interpretation that subjects give to the task [6]. As a consequence, the logic subjects choose to solve the task with a deontic logic, which makes the task easier to solve than if it is interpreted as a classical logic task.

1.1 The suppression task

The suppression task [5] was designed to show that subjects can suppress valid logical inferences, such as modus ponens, when these are accompanied by additional premises (preconditions). If subjects were to reason according to classical logic, this should not be the case, since classical logic is monotonic; addition of premises should never alter the conclusion. Suppression means that subjects review their conclusion in light of an additional premise, evidencing the application of non-monotonic reasoning.

Moreover, Byrne demonstrates that whether subjects do or do not suppress their earlier inference is related to the content of the added premise and not to the formal structure of the argument. When the third premise is, what Byrne calls, an 'alternative premise', then the classical inferences of modus ponens (MP) and modus tollens (MT) are not suppressed. In contrast, when it is a so-called 'additional premise', then they are suppressed. An example of MP with an alternative premise is the following:

> If Marian has an essay to write, she will study late in the library.
> She has an essay to write.
> If Marian has an exam, she will study late in the library.

The following is an example of MP with an additional premise:

> If Marian has an essay to write, she will study late in the library.
> She has an essay to write.
> If the library is open, she will study late in the library.

These results have again, as with the Wason Selection Task, been used to argue that logical form plays no role in reasoning. Since they can be suppressed, Byrne goes on to argue, MP and MT need not be represented as mental rules. This is the same argument that logicians employ to argue that fallacies like denial of the antecedent (DA) and affirmation of the consequent (AC) should not be considered to be implemented as mental rules. Byrne proposes, therefore, that reasoning is governed by the mental models theory of Johnson-Laird [4] mentioned earlier. MP, MT, DA and AC will be introduced in a more formal way in section 1.3.

1.2 Closed world reasoning

On the other hand, as Stenning and van Lambalgen [6] demonstrate, patterns of suppression and non-suppression can be explained if subjects were to employ a form of closed world reasoning (CWR). In short, CWR entails that you may take any proposition, for which you have no evidence, to be false. A time schedule for train departures may serve as an illustration: if a departure time is not listed in the schedule, you may assume that the train will not depart at that time. CWR enables you to construct a minimal model; a reduction of all the available information to a single and complete model. You may then draw inferences based only on this minimal model. This is much cheaper and imposes less of a load on working memory than if you were to employ classical logic. In classical logic, one always has to consider all possible models.

In conversation, CWR can be understood as an application of the Gricean conversational implicature. This idea, taken from the field of pragmatics, entails that speakers give as much information as they need for the purpose of being understood. From the Gricean convention, hearers understand that the information they have received is the only information that is relevant with respect to the topic of the conversation, and that they may assume all other information which is not given to be false. This invites hearers to combine all conditional statements that have the same consequent into a single bi-conditional, just like in CWR. For example, the previous syllogism would be interpreted according to CWR as:

> If and only if Marian has an essay to write or an exam to do, she will study late in the library.

Classical logic is monotonic, meaning that its inferences, being deductively valid, can never be 'undone' by new information. Thus the added conditional sentences will not alter the inference already made. Closed world reasoning in contrast is non-monotonic. The term 'non-monotonic logic' reflects the kind of inference in everyday life, in which reasoners draw conclusions tentatively, reserving the right to retract them in the light of further information. Such inferences are called 'non-monotonic' because the set of conclusions warranted on the basis of a given knowledge base does not increase (in fact, it can shrink) with the size of the knowledge base itself.

According to [6], CWR is the default parameter setting for applying a logic; CWR is the default reasoning pattern and it is automatic. It has an uncomplicated neural implementation in terms of a neural network model [6]. By setting the appropriate weights of this neural network, a minimal model is in fact constructed. Logic inferences such as MP are implemented in the brain simply by spreading activation. The more difficult backward inference used in MT is implemented

by back-propagation, a technique familiar from multilayered feed-forward neural networks.

1.3 Formalisation

Modus ponens (MP) is a conjunction of a conditional sentence such as: 'If Marian has an essay to write she will study late in the library' ($p \rightarrow q$) and a categorical sentence such as: 'She has an essay to write' (p). This is formally denoted as $\{p \rightarrow q;\ p\}$. Modus tollens (MT) is again a conditional sentence ($p \rightarrow q$) but in this case, the categorical sentence is of the form, 'She will not study late in the library' ($\neg q$). This would formally be denoted as $\{p \rightarrow q;\ \neg q\}$. Denial of the antecedent (DA) also consists of a conditional sentence ($p \rightarrow q$) but now the categorical sentence is of the form 'She doesn't have an essay to write' ($\neg p$). This would then be formally denoted as $\{p \rightarrow q;\ \neg p\}$. Finally, Affirmation of the consequent (AC) is a combination of a conditional sentence ($p \rightarrow q$) and a categorical sentence. The categorical sentence is of the form 'She will study late in the library' (q) which results in the denotation $\{p \rightarrow q;\ q\}$.

1.3.1 Classical logic

Using formal rules of classical logic, predictions can be made as to what the conclusions for these inference forms would be. For MP, the valid conclusion to draw is that 'She 'will study late in the library' (q). This is formally denoted as $\{p \rightarrow q;\ p;\ q\}$. For MP, the valid inference is 'She doesn't have an essay to write' ($\neg p$). Applying classical logic on DA and AC means that one cannot make a valid inference. Concluding 'She will not study late in the library' confronted with DA $\{p \rightarrow q;\ \neg p;\ \neg q\}$ would be, according to classical logic, a fallacy. Also fallacious would be if one inferred 'She has an essay to write' when confronted with AC $\{p \rightarrow q;\ q;\ p\}$.

1.3.2 CWR

Closed world reasoning (CWR) assumes that people reason according to the rule $\{p \wedge \neg ab \rightarrow q\}$, which if implemented into a sentence would look like this: 'If Marian has an essay to write, and nothing abnormal happens, she will study late in the library' This has, contrary to classical logic, major consequences for the effect of added conditional sentences, leading to the suppression of the classical inferences of MP and MT. The fact that reasoning takes the form $\{p \wedge \neg ab \rightarrow q\}$ implies that people might take extra information as ab which alters the conclusion drawn from the first premise. Hence CWR will predict that a person confronted with the additional premise in the MP case is inclined to view this as ab. This

in turn might suppress this person's inference, p. They might reason that the additional conditional sentence also needs to be satisfied. Formally, this would look like:

$$p \wedge \neg ab \rightarrow q;\ p;\ s \wedge \neg ab' \rightarrow q;$$
$$\neg s \rightarrow ab;\ \neg s \leftrightarrow ab;\ s \leftrightarrow \neg ab;$$
$$p \wedge s \rightarrow q$$

from which q does not follow given p only.
This works in a different way for MT and AC. In these cases a slightly different form of CWR comes to the fore, namely: 'assume that only those rules hold which you know to be true'. This is called closed world reasoning for rules. The argument pattern is now what can be called diagnostic reasoning: 'what must the world be like for a given sentence to be true?'. If $p \rightarrow q$ is the only rule and q is false, then the reason must be that $\neg p$. People are less inclined to infer $\neg p$ when they are confronted with an additional premise. For MT with and additional premise, this would formally look like:

$$p \wedge \neg ab \rightarrow q;\ \neg q;\ s \wedge \neg ab' \rightarrow q;$$
$$\neg p \rightarrow ab';\ \neg p \leftrightarrow ab';\ p \leftrightarrow \neg ab';$$
$$\neg s \rightarrow ab;\ \neg s \leftrightarrow ab;\ s \leftrightarrow \neg ab;$$
$$p \wedge s \rightarrow q;$$

from which $\neg p$ does not follow given $\neg q$.
Added alternative premises have, according to CWR, no effect on the inferences drawn from MP and MT. On the contrary, they obstruct the closing of the world. For Modus Ponens, this looks like: $\{p \wedge \neg ab \rightarrow q;\ p;\ r \wedge \neg ab' \rightarrow q\}$. Applying CWR reduces ab and ab' to $\bot$, the combined premises therefore yield $p \vee r \rightarrow q$. From this, q follows given p, just as in the two premise case. Also in MT people will infer $\neg p$ given $\neg q$, just as in the two premise condition. Therefore no suppression will take place in the alternative premise case.

Concerning AC and DA, CWR predicts suppression of the, according to classical logic, 'fallacious' inferences when extra conditional sentences are presented. However, this time it is the alternative sentence that does the suppression. For the alternative premise, ab and ab' are reduced to $\bot$, and the combined premises yield $p \vee r \rightarrow q$.

With AC, backward chaining now results. People realise that p and r could both be valid reasons why q. Therefore the 'fallacious' inference p is suppressed. With DA, suppression of the so-called logic fallacious inference $\neg q$ occurs because

now the alternative premise r reminds people there could still be a reasons why q, so one cannot conclude $\neg q$ simply given $\neg p$.

1.3.3 Strengthening

Sometimes subjects interpret the additional premise as "whenever the library is open, Marian studies late in the library". By replacing "if" with "whenever", they assume that there are no exceptions to this rule. This is called the "strengthening" interpretation. In the strengthening interpretation, we still have $\neg s \rightarrow ab$, but there are no longer exceptions to the second conditional. Thus, ab' is reduced to $\bot$. This reduces the conditionals to $p \wedge s \rightarrow q$; $s \rightarrow q$, which combine to $s \rightarrow q$. This suppresses all inferences relating to p and q, but not inferences relating to s. It will be shown later that this has a major impact on the results of Byrne's experiment, where the answer set is restricted to p, q and their denials.

2 Research Questions and Hypotheses

The main goal of this research is to study individual's reasoning patterns and determine if a formal model exists that can describe them:

Research question I

> Is there a formal model that can describe the reasoning behaviour of an individual?

Since the literature suggests the use of three formal models that humans apply when reasoning - classical logic (CL), closed world reasoning (CWR) and closed world reasoning with strengthening (CWRS) - the hypothesis is formulated according to this:

Hypothesis I

> Subjects reason according to one of CL, CWR and CWRS.

The alternative hypothesis would be that subjects do not fit into any formal model, or that they reason perhaps according to a probabilistic model.

Table 1 outlines the predictions that are made. For each argument pattern, according to each formal model, expected answers are listed. Since probabilistic reasoning (PR) is not truth-functional, it is expected in this case that subjects would not conclude anything definitely:

The predictions follow from the analysis and formalisations described in section 1.3.

The table illustrates the instances in which the formal models can be differentiated. For example, in order to rule out CL, the MP and MT additional are particularly useful to study, as are all of the DA and AC cases. To determine whether a subject is using CWRS rather than CWR, all the additional cases are important (marked with a *). The two-premise cases are essential to study, to determine whether they are subsequently suppressed in the three premise instances.

In the original experiment carried out by Byrne, there were a restricted number of interpretations to conclude from each argument pattern, since subjects were required to choose from three answers. In Byrne's experiment, answer sets were as in tabel 2.

In order to be able to differentiate between the formal models, in the current research a more liberal answer set was permitted; subjects were not forced to a particular interpretation. In this way, we replicated Byrne's experiment, but allowed for open answers. As such additional clues to their interpretations would ensue, in particular where they may deviate from the standard predictions. Thus

	CL	*CWR*	*CWRS*
MP2	q	q	q
MP3Alt	q	q	q
MP3Add	q	-	- *
MT2	$\neg p$	$\neg p$	$\neg p$
MT3Alt	$\neg p$	$\neg p,\ \neg p \wedge \neg r$	$\neg p,\ \neg p \wedge \neg r$
MT3Add	$\neg p$	-	$\neg s,\ \neg p \wedge \neg s$ *
DA2	-	$\neg q$	$\neg q$
DA3Alt	-	-	-
DA3Add	-	$\neg q$	- *
AC2	-	p	p
AC3Alt	-	-	-
AC3Add	-	$p,\ p \vee s$	$s,\ p \vee s$ *

Table 1: Predicted answers according to the different formal models
p: Marian has an essay to write
q: Marian stays late at the library
r: Marian has an exam (alternative condition)
s: The library is open (additional condition)

	MP	*MT*	*DA*	*AC*
allowed answers	q $\neg q$ may/may not be q	p $\neg p$ may/may not be p	q $\neg q$ may/may not be q	p $\neg p$ may/may not be p

Table 2: Byrne's restricted answer sets

the second research question follows:

Research question II

> Does allowing for a more liberal answer set influence the results of the suppression task?

The final research goal was to address the controversy between the formal logic explanation for suppression patterns (CWR) and the explanation provided by mental models theory. Since both models predict the same outcomes in the suppression task, evidence for this would have to be found in a close inspection of the subjects' dialogues:

Research question III

Is it possible to discriminate between a closed world reasoning model and mental models by examining the dialogues?

3 Method

3.1 Materials

As in the original suppression task [5], in the present research, four argument patterns were studied: MP, MT, DA and AC. Their two-premise forms were described in section 1.3, each consisting of the same conditional premise (the 'original' premise) and a different categorical premise. These were needed as a control to test whether suppression occurred in the three-premise case or not. There were two types of third premise; the alternative premise and the additional premise. Since the second research goal was to challenge Byrne's answer set, the materials in the current research stayed as close to the original as possible. For this reason, the story about Marian going to the library remained the theme. Here are the premises used:

Original premise: If Marian has an essay to write, she will study late in the library. $(p \rightarrow q)$
Alternative premise: If Marian has an exam, she will study late in the library. $(r \rightarrow q)$
Additional premise: If the library stays open, she will study late in the library. $(s \rightarrow q)$

Categorical premises:

> *MP*: She has an essay to write.
> *MT*: She will not study late in the library.
> *AC*: She will study late in the library.
> *DA*: She doesn't have an essay to write.

The order of the premises for each argument pattern was kept as natural as possible; also the same that was used in the original suppression task [5]:

1. Original premise
2. Alternative or Additional premise
3. Categorical premise

3.2 A more liberal answer set

For every argument pattern presented, there were three phases to finding out subjects' reasoning models:

3.2.1 Opening question

> Is there anything you can conclude from this?
> If yes, what?
> If not, why not?
> Please explain your arguments.

The idea of this was not to interrupt the subjects, but let them explain what they had drawn from the text. Crucially, this allows many interpretations (in comparison to the three offered by Byrne); it is also possible not to conclude anything.

3.2.2 Follow-up questions

Since we expected some subjects not to fully express their reasoning, questions were asked. Initially, these referred to something that the subjects would have said already and from which a fuller explanation was needed; the 'why did you say this?' kinds of questions. The purpose of this was not to lead the subjects to a certain interpretation, but to gain more understanding of their reasoning patterns. Other questions followed:

- Is there any information missing for you to be able to conclude anything? If yes, please explain why.
- Was every sentence necessary for you to reach your conclusion? If not, which sentence was not, and why?
- Do you find any of the sentences confusing or conflicting with another sentence? If so, please explain.

3.2.3 Rephrasing task

Finally, in order to ascertain more precisely how subjects were reasoning, they were asked to rephrase the text in a way that they had understood it:

> We are interested in improving the design of the experiment in such a way that the way you understood it should be made completely transparent to the subject, without any misunderstandings or irrelevant information. If you were asked to reformulate the text of the experiment as clear as possible, in the way that you understood it, how would you do this?

This was expected to help formulate how the argument pattern had been modelled. For example, the subject might say, 'if Marian has an essay to write and the library is still open, she will stay late in the library', which one could represent as $p \wedge s \rightarrow q$.

3.3 Subjects

10 subjects were tested: 6 female and 4 male. None had a background in logic, yet all were academics. See Appendix C for details.

3.4 Fillers

Each argument pattern was tested in the two-premise case, the three-premise additional case and the three-premise alternative case, resulting in 12 test items. They were presented separately on pieces of card. See Appendix A for all test items. Since the context for each test item was the same, fillers were used to distract the subjects in between, reducing implicit memory effects. The fillers were syllogisms selected from Lewis Carroll's website [ref xxx]. They were particularly taxing, involving much concentration, thus would disintegrate the recent answers for the test items from working memory. Here is an example of one of these :

> All writers, who understand human nature, are clever.
> No one is a true poet unless he can stir the hearts of men.
> Shakespeare wrote Hamlet.
> No writer, who does not understand human nature, can stir the hearts of men.
> None but a true poet could have written Hamlet.

There were 11 fillers, resulting in a total of 23 items in the test.

3.5 Procedure

The experiments were carried out in English, French and Dutch. The texts were translated, taking care that they sounded natural in the target language. The subjects were first introduced to the experiment. They were informed that it was a psychology experiment, that there were no right or wrong answers, that they would hear a series of short texts and be asked questions about them and that the whole dialogue would be recorded.

Subsequently, the two-premise test items followed. These were tested before the three-premise cases so as not to prompt exceptions. If exceptions were to be induced in these cases, they should come naturally from the subject herself. After

that the three-premise test items were presented. They were ordered in a way that no two argument patterns of the same type were shown consecutively and so additional and alternative cases came alternatively. The purpose of this, along with the fillers in between each test item, was to reduce implicit memory effects.

Each item was presented on a card. The subjects could both read the card and it was read out to them. For the test items, no time limits were set. Each item was questioned in the three phases outlined above. The same questions were asked for the fillers, since the subjects were not to know that the focus was on the other items.

3.6 Data Collection and Analysis

The dialogues of the ten subjects were transcribed (and translated) for the test items. This resulted in 120 test items in total. See Appendix C for the full transcripts.

For research question I, a formal model was constructed for each subject. Initially, subjects' answers were coded in formulas, in order to compare them with those in the predicted answers in table 1. Subsequently, a closer analysis was carried out. This was necessary since on many occasions the answers did not match any formal model exactly (according to table 1). Even if this were the case, it may still be possible that the subject does reason according to a model. Perhaps the subject changed his or her reasoning pattern somewhere in the middle of the experiment. Perhaps there is no model at all. In order to determine this, the dialogues were scrutinised for clues. The rephrasing task also played a significant role in this part of the analysis. Some clues were the following:

- *Clue 1: Exceptions*
  Since the context of studying in the library was something that subjects were familiar with, it was expected that they would be able to take exceptions to the normal case into account. This may have been a consequence of the subject herself (her own experiences may trigger it) or of the experimental manipulations - the additional and alternative cases (as described in section 1).

  Sometimes exceptions were raised that were not mentioned in the content (for example, 'she may be in the library because she fancies someone', Subject 1). This would suggest a non-CWR interpretation, unless the subject then dismissed it, perhaps saying something like, 'but that information is not given, so then I cannot conclude that'.

- *Clue 2: 'the given information', 'necessarily', 'only'*
  A clue to application of closed world reasoning is the extent to which subjects

stick to the information given to them. Sentences like 'if I only look at the information given here, then' suggest that subjects are aware of reasoning in a closed world. Also, 'only' turns an implication into a bi-conditional, again suggesting CWR (see section 1.2 for details).

- *Clue 3: 'always'; 'whenever'*
  In many instances, these words imply strengthening, since the extra premise is taken as the main conditional, inhibiting the exception to the first conditional.

- *Clue 4: 'usually', 'probably'; refusal to give a definite answer*
  Probabilistic reasoning could be evidenced for with words such as 'usually' and 'probably'. However, these may be uttered (and appears to in the subjects' dialogues) for other reasons. The use of the word 'probably' is quite frequent in English. It also appeared that subjects used 'probably' in illustrating their uncertainty. Often they wanted to know whether the information was complete or not, or if the first conditional should be translated as an 'only if'. 'Probably' seemed to show that subjects were aware of different interpretations or domains - for example a closed or open world.

With the help of these clues, the rephrasing phase and the prediction table, it would be possible to determine if a formal model could explain a subject's reasoning patterns, and if not, perhaps an explanation as to why not. See section (4.2) for this part of the analysis.

4 Results

4.1 Overall reasoning patterns

Table 3 summarises the answer patterns of the 10 subjects. Within brackets the proportion of subjects that reasoned according to the particular pattern is denoted. Since a fixed answer set was not employed, it was not always possible to exactly transcribe the answer into a formula. Where a subject gave two answers, each answer is counted as half.

	MP	*MT*	*DA*	*AC*
Simple argument	q (100%)	$\neg p$ (80%) $\neg p \vee ab$ (10%) ab (10%)	NC (75%) $\neg q$ (25%)	NC (55%) p (45%)
Alternative premise	q (100%)	$\neg p \wedge \neg r$ (100%)	NC (20%) $\neg p \wedge \neg r \rightarrow \neg q$ (80%)	NC (25%) $p \vee r$ (55%) $p \vee r \vee (p \wedge r)$ (20%)
Additional premise	NC (60%) q (40%)	$\neg s$ (35%) $\neg p \vee \neg s$ (45%) $\neg s \vee (s \wedge \neg p)$ (20%)	NC (90%) $\neg p$ (10%)	NC (10%) s (85%) $p \vee s$ (5%)

Table 3: Overall Reasoning Patterns (NC: No conclusion)

The full set of answers can be found in Appendix B.

4.1.1 MP

Suppression of MP would occur if, after applying the valid inference (concluding q) in the two-premise case, it would not be concluded in the three-premise case. 100% of the subjects concluded q in the two-premise case. Of these, 0% suppress it in the alternative case and 60% in the additional.

4.1.2 MT

Suppression of MT would occur if, after applying the valid inference (concluding $\neg p$) in the two-premise case, it would not be concluded in the three-premise case. Importantly, $\neg p \wedge \neg r$ would count as suppression, whereas $\neg s$, $\neg p \vee \neg s$ and $\neg s \vee (s \wedge \neg p)$ would not count as suppression of p, since the inference is still validly applied according to the new information. The majority of the subjects, 80%, concluded $\neg p$ in the two-premise case. Of these, 100% did not suppress MT in the additional case, whereas 0% suppress it in the alternative case.

4.1.3 DA

Suppression of DA would occur if, after committing the so-called fallacy (concluding $\neg q$) in the two-premise case, it would not be concluded in the three-premise case. The majority of the subjects - 75% - did not commit the so-called fallacy. Of those who did (3 subjects), 100% suppress it in the alternative case. Interestingly, they still try to conclude the fallacy $\neg q$, but only if $\neg r$ is additionally the case. In the additional case, 66% suppress it.

4.1.4 AC

Suppression of AC would occur if, after committing the so-called fallacy (concluding p) in the two-premise case, it would not be concluded in the three-premise case. Importantly, $p \vee r$ would not count as suppression, since the 'fallacy' is still being endorsed. The same is the case for the answers s and $p \vee s$. The majority of subjects - 55% - did not commit the so-called fallacy. Of those who did (5 subjects), 0% suppress it in the alternative case. In the additional case, 0% suppress it.

4.1.5 Suppression results

Having translated the above results into suppression figures, quite different numbers have been found to those by Byrne:

	MP	*MT*	*DA*	*AC*
Simple argument	Byrne: 96% Us: 100%	Byrne: 92% Us: 80%	Byrne: 46% Us: 25%	Byrne: 46% Us: 45%
Alternative premise	Byrne: 96% Us: 100%	Byrne: 96% Us: 100%	Byrne: 4% Us: 0%	Byrne: 13% *Us: 100%
Additional premise	Byrne: 38% Us: 40%	Byrne: 33% *Us: 100%	Byrne: 63% *Us: 33%	Byrne: 54% *Us: 100%

Table 4: Suppression Results: measured are the valid inferences in MP and MT and the 'fallacies' in AC and DA; Byrne's results from [5]

The most interesting results are marked with a *. Concerning the MT additional case, it is assumed that those subjects who answer $\neg p \vee \neg s$ would have answered 'maybe' in Byrne's experiment. This would have counted as a suppression in Byrne's experiment, whereas not in the current experiment; hence the great difference in percentages (33% vs. 100%). With regards to AC, it is assumed that those subjects who answered $p \vee r$ would again have concluded 'maybe' in Byrne's

experiment - again suppression, whereas it is in fact not. Hence the differences again in the percentages.

4.2 Per Subject Analysis

In terms of the models outlined in the research questions, it is observed that most of our subjects adopt Closed World Reasoning with strengthening: 5 of them reason either only or mainly according to CWRS. Two other subjects use it as well as a 'minor' tendency. The second main model to be observed is closed world reasoning. Only one subject uses classical logic. Probabilistic reasoning is never used as a main trend of reasoning. Table 4.2 summarises the results.

	CL	*CWR*	*CWRS*	*PR*
Subject1	+		++	
Subject2			++	
Subject3		++		
Subject4		++		
Subject5			++	+
Subject6		++	+	
Subject7			++	
Subject8	++			+
Subject9	++		+	
Subject10			++	

Table 5: Subjects' main reasoning patterns
CL: classical logic
CWR: closed world reasoning
CWRS: CWR with strengthening
PR: probabilistic reasoning
++: main trend
+ : minor trend

Following is a detailed analysis of each subject.

4.2.1 Subject 1 (Female, 22, cognitive science student)

Summary:
Subject 1's answers best fit closed world reasoning with strengthening. However,

she was quite inconsistent in her responses.

Details:
It actually appears that she was sometimes reasoning in an 'open' world; she had a tendency to think of exceptions:

> **AC2:**
> S: Well, that most probably means she has an essay to write *unless she has another reason to stay in the library.*
> E: Do you think there is enough information here?
> S: Mm, well you should say that the only reason she would be in the library is to write an essay, *because there could be another reason.*

Sometimes the extra premise would inhibit these other exceptions, suggesting application of closed world reasoning. This happened in all conditions with the extra 'exam' premise, for example:

> **AC3 Alt:**
> S: Ok, my conclusion from this is that Marian stays late in the library because she either has an essay to write or she has an exam. This card is very clear.

Generally, the exceptions stemmed from interpreting the additional case as strengthening. The subject wanted to incorporate as much information as possible (the same was the case with the fillers), thus took the 'theme' of the first conditional (what Marian might be doing in the library) and wanted to propose possibilities:

> **MP3 Add:**
> S: I guess it's necessary for the library to stay open for Marian to stay late in the library. The second condition [referring to the library condition] implies that there *may be other reasons* [other than writing an essay] for her to stay in the library til late. But *in this case*, if the library is open she's staying late to write her essay.

> **DA3 Add:**
> S: If the library is open, she stays late in the library. That's what the second condition says. That means that if the library is open, she stays late in the library and it *could be for any reason.*

4.2.2 Subject 2 (Male, 24, history teacher)

Summary:
Subject 2's answer pattern fits a model as predicted by closed world reasoning with strengthening.

Details:
Subject 2 was generally consistent in his reactions to each argument pattern. He preferred to stay close to the information given to him in the texts:

> **AC2:** You know this information; Because I was told this.
>
> **MP3 Add:** It depends on the information I have
>
> **DA3 Alt:** If this was the only information I was given

In some cases, the subject deliberated over what to put in the closed world:

> **MP3 Alt:**
> S: Ok, yeah, I think she doesn't have an essay to write; neither does she have an exam. But *because I've had information before* which suggests that the library is not open til late

The subject wants to include an exception, but only if he is supposed to take that information into account. In all the AC instances, the subject came up with other exceptions. He did dismiss them, sticking to only those exceptions indicated.

> **AC2:**
> S: Ok, it's llikely that she has too write an essay. It's also possible that she is staying late in the library because she has something else to do. So I'm not sure that she has to write an essay, but it is likely
> S: If I would say it like this, in this order, I would mean to suggest with the second sentence that she has to write an essay.

Here is an example illustrating the strengthening interpretation:

> **DA3 Alt:**
> S: There is still a possibility that she stays late in the library, because I'm not sure if it's open late or not. If it is, then she will be in the library *despite the fact* that she doesn't have an essay to write.
> E: Why do you think she might be in the library?
> S: Because it says 'if the library is open, then she stays late in the library' ... so *whenever* the library is open, she'll stay late in the library.

The subject was aware that there could be another interpretation of the premises; he went on to say:

> S: Hmm, I think so. I mean, these must be general statements, rather than specific ones for one situation, because otherwise you wouldn't have to say either of them... *The connection is not made explicitly here* - I understand that if she has an essay to write but the library doesn't open til late, then she won't stay late in the library. But here to me it seems to be two separate things.

Even in the Modus Ponens additional case, the subject stated, 'I don't think it's a very good way of putting it'. To him, the best way of incorporating the second premise would be strengthening, because otherwise the premises sound unnatural.

4.2.3 Subject 3 (Female, 20, anthropology student)

Summary:
Subject 3 reasons mainly according to CWR. Although, she did not make the so-called fallacious inferences with denial of the antecedent, she did however make the fallacious inference with the affirmation of the consequent. She does not suppress this inference; merely adds the alternative inference as a consequence.

Details:
The subject's answer suggests a form of strengthening when asked to reformulate the modus ponens:

> **MP2:**
> E: If you had to reformulate it so somebody else would understand it like you did?
> S: Well, what you might add then is.... *Always when* Marian has to write an essay she stays late in the library.

However, she then changes her mind and finally adopts CWR. From that point, she would tend to stick to CWR. In other words, after having struggled between different interpretations, the subject chooses one way of reasoning and tends to keep it.

4.2.4 Subject 4 (Female, 25, youth councillor)

Summary:
Subject 4 reasons also mainly according to CWR. She however did make the

so-called fallacious inferences with AD. And she suppressed it in the alternative premise case. She also made the fallacious inference with the AC. She did not suppress this inference but merely adds the alternative inference as a consequence.

Details:
The subject uses strengthening in the modus ponens additional case:

> **MP3 Add:**
> E: What can you conclude?
> S: That Marian stays late in the library when the library is open until late. That... so Marian will stay late in the library when it's open late.

The subject also interprets the additional premise as strengthening when confronted with modus tollens:

> **MT2:**
> E: Is anything unclear?
> S: Well yes, uhmmm... It doesn't say always... it doesn't say that she will stay late in the library always when she has an essay to write. It only says if she has an essay to write she will study late in the library, that doesn't mean always. I think.

4.2.5 Subject 5 (Male, 30, computer programmer)

Summary:
Subject 5 reasons mainly according to CWRS. But, he sometimes struggles to reason for an interpretation and reports his hesitations between CWRS and probabilistic reasoning. However, even if he suggests that 'open world' reasoning might be a possibility, he always rejects it at the end.

Details:
The first argument (MP) is quite problematic for the subject, because he has really no idea on how the task should be handled. After being guided, he gives an answer according to probabilistic reasoning:

> **MP2:**
> S: Considering the fact that she has an essay to write, there are chances that she will stay late at the library

However, he then changes his mind and finally adopts a CWR. From that point, he will then tend to stick to CWR. In other words, after having struggled between different interpretations, the subject chooses one way of reasoning and tends to keep it.

Nevertheless, at some point, the subject again reports doubts about the interpretation he should give to the data. He brings up the possibility of reasoning with probability, but finally rejects it and prefers to assume that the exceptions not listed are not supposed to exist:

> **AC3 Alt:**
> S: She probably has an essay or an exam. She also can stay late for other reasons. But, I see these two sentences here, so it means to say that she has one of the two - an exam or an essay.

Finally, the subject definitely reasons according to CWR with strengthening, always discarding the first premise in the additional case.

4.2.6 Subject 6 (Female, 29, researcher in biology)

Summary:
The subject is following closed world reasoning. However, in some cases, she struggles between CWR and CWRS.

Details:
For each case, she always has a first clear and confident answer. However, when asking her motivations, she tends to give a more contrasted answers pattern. For example, for MP with additional premise, she first answers q, and then rejects this answer:

> **MP3 Add:**
> First answer: S: so, she stays late at the library
> Later on: S: well, if she has an essay and the library is closed, then she won't be able to stay at the library

She overuses CWR, taking into account only the conditions listed:

> **DA3 Alt:**
> S: If she has nothing, neither an essay, nor an exam, she won't stay late at the library

She refuses to entirely endorse strengthening, even though she is not really comfortable with interpreting the additional premise as an alternative one:

MT3 Add:
S: If we *stick to what is exactly written*, I use or (meaning if she has an essay or if the library is open, she stays late at the library). But, we know that you cannot stay in the library if it's closed, so it becomes and/or.

4.2.7 Subject 7 (Female, 22, student theatre sciences)

Summary:
Subject 7 would best be classified as reasoning according to CWR with strengthening of the additional premisse.

Details:
Here is a typical CWR example, which illustrates how she turns the conditional into a bi-conditional (only if):

AC2:
E: Is there anything you can conclude?
S: That she has to write an essay. Because she stays till late in the library when she has to write an essay, and today she stays till late in the library.
E: Could there be other reasons for her to stay late in the library?
S: That could be possible, for example may be she reads a very long book. But as I understand it she stays late in the library *only if* she has to write an essay

Here is an example of strengthening:

AC3 Add:
S: So the library is open.
E: Is that the only thing you can conclude?
S: Well, it could also be that she has an essay to write, but *she stays in the library anyhow* when it is open late, it says here, so she stays there anyway, so it doesn't matter if she has an essay or not.

4.2.8 Subject 8 (Female, 22, biology student)

Summary:
In general the subject's answering pattern can be described by classical logic, although she is often in doubt as whether to interpret the conditionals as absolutely

deterministic. The subject commits no fallacies.

Details:
In some cases her interpretation can best be described as probabilistic, as the following transcript testifies:

> **MT2:**
> S: That most likely she has no essay to write. But since it is not stated that she always stays late in the library when she has an essay to write you may not really conclude that she doesn't have an essay to write. It could be that, you know, for some other reason she can not stay late in the library. It is not a law of Meden en Persen.
> E: Could you reformulate?
> S: Normally Marian stays late in the library whenever she has an essay to write. Today she leaves the library early. ... There is a difference between the words always, or normally I suppose.

4.2.9 Subject 9 (Male, 33, magazine editor)

Summary:
The subject is alternating between CWR with strengthening and reasoning in an 'open world'. As the questionnaire develops, the subject is rejecting CWR, adding more possible exceptions and claiming for no conclusive answer.

Details:
The subject starts with trying to understand the scope of the questionnaire and to pick a reasoning method to fit. As his answer for the second test item shows:

> **MT2:**
> S: How detailed would you like my answers to be? I would also say she might be in the library for other reasons.
> E: What do you think ?
> S: That according to those statements she has no essay to write

> **DA3 Alt:**
> S: It is again inconclusive, the fact she has no essay does not mean she is not there. She may have other reasons. But if it was saying she goes to the library only if she has an essay then I would say she is not in the library

The subject reflects out loud his interpretation of the additional condition. He presents his doubts in a very clear way:

> **MT3 Add:**
> S: I can conclude that either the library is closed or she has no essay to write or there are other reasons for her not to be there. But it depends if the two first sentences are related.
> E: What do you mean by 'related'?
> S: If they both go together then I guess she has n essay to write. My question is - is it he same story or is it just two different pieces of information. So the question is would she study in the library if both conditions occur ... Or that those two are not related and she will study there if the library is open even if she has no essay to write

4.2.10 Subject 10 (Male, 32, Sales and Marketing manager)

Summary:
The subject is following closed world reasoning (with strengthening) very clearly. The exception is with DA where he consistently (in all conditions) claims for no conclusive answer. Another way to model his answers is as Classical Logic with a failure in AC.

Details:
The subject reflects on exceptions only once, in the MP additional condition (quote bellow) yet he restricts his answers to the given information even when he is asked (see the MT alternative condition)

> **MP3 Add:**
> S: ... I wonder what she would do if she has an essay and the library is closed ...

> **MT3 Add:**
> S: The conclusion is ... she has no essay or exam ...
> E: Could it be that she is in the library for other reasons?
> S: It could be but it doesn't say so. It only say she does not stay late in the library

The subject considers the additional premise as a strengthening condition. In his answers he considers the 'open library' condition as overtaking the 'essay' condition. This is consistent in all patterns.

MP3 Add:
S: ... I can conclude she has no life because she will study in the library *as long as it is open* ...

5 Conclusions and discussion

5.1 Do all subjects reason according to a formal model?

As described in section 4.2, most of the subjects' reasoning behaviour matches a CWR model with strengthening (5 out of 10). 3 subjects seem to be reasoning according to CWR, and 2 out of 10 subjects display no so-called fallacies at all; their behaviour may be best explained by classical logic. These results seem to confirm Hypothesis I, which states that most subjects can be correctly classified by any one of the formal models. Only 2 subjects showed a minor trend for probabilistic reasoning, which was the alternative hypothesis.

On the other hand, it was not always easy to classify every subject according to a single model. Subjects seem to have more than one single model available, and are flexible in alternating between models. When in doubt, they ask the experimenter to elaborate on his or her intention. They are consciously aware that their choice of interpretation directly influences their answers. All subjects clearly reason towards an interpretation, but it is less clear whether they do this in a consistent way throughout the experiment. It has been mentioned that all the subjects were academically schooled. Because of this, they may have picked up some classical logic indirectly, even though all the subjects declared that they had had no formal logic education. They also have some experience with abstract problem solving, which may have biased the results.

5.2 Does allowing for a more liberal answer set impact the results?

Concerning the second research question, the results in Table 3 demonstrate that Byrne's use of a restricted answer set has most probably distorted her results. Since Byrne did not allow answers relating to the added premise (s), she misinterpreted many of the answers given in the AC alternative premise and MT additional premise as cases of suppression. In the AC with alternative premise,, for example, it is assumed that Byrne's subjects would have chosen 'maybe p or may be not p' in cases where subjects in the present study answered '$p \vee r$'. Byrne counted this as suppression of p, but the results in this study show that this would not have been the case. The same holds for MT with additional premise. As can be seen from Table 4.1.5, which compares Byrnes results with the results obtained in this study, the suppression effect is reduced from 92-33 % to 80-100 % in MT additional, and from 46-13 % to 45-100 % in AC alternative.

So, liberalising the answers effectively cancelled any statistically significant effect of suppression of MT and AC. In fact the subjects' answers and analyses of their dialogues indicate that they used strengthening in those cases, which is

not a complete suppression of MT and AC. As explained in 1.3.3, strengthening suppresses all inferences relating to p and q (from Byrne's restricted set), but not inferences related to s.

5.3 Can we discriminate between the CWR model and mental models theory?

We now turn to the final research question, which concerned the possibility of discriminating between CWR and Mental Models Theory (MMT) based on our results and an examination of the dialogues. Although on the surface reasoning patterns of most subjects match those of CWR or CWRS, they also match MMT, because exactly the same patterns are predicted by MMT. The interesting question is therefore not what happens on the surface, but what are the underlying cognitive processes?

The impression is that in the dialogues, subjects made an effort to express the social conventions, essentially Gricean implicature, which compelled them to choose a particular interpretation. For any claim to be made about the underlying cognitive processes, however these results seem not to be very relevant. It is conceivable that social conventions such as the Gricean implicature are implemented at a higher cognitive level which imposes constraints on the lower level reasoning processes. The latter could very well be the mental models or anything else: the current experiment cannot decide on that. Stenning & van Lambalgen [6] claim, however, that CWR is applied on the lowest level (as a neural implementation) and in an automatic fashion; in other words, unconsciously. In that case, what would be the significance of the dialogue of the subjects explaining their reasoning? The dialogue evidently exposes a conscious process, and suggests that the choice is made consciously.

The fact that subjects seem to be able to switch freely between different logical systems also does not add to the claim that CWR has a special status among the reasoning patterns. The results from the present study suggest no evidence that CWR is the default parameter setting, or that it is superior to other reasoning systems for other than superficial reasons (such as Gricean implicature).

In our opinion, there seems to be much more room for semantic content to drive reasoning than is suggested by [6]. To illustrate this, compare the following syllogisms:

> If Marian wins the lottery, then she buys an ice-cream
> She buys an ice-cream

If Marian wins the lottery, then she buys an castle
She buys an castle

At first glance, when faced with the second syllogism, one would be much more compelled to commit the so-called AC fallacy than with the first, and conclude that Marian won the lottery, even though both syllogisms have the same form.

5.4 Evaluation

Finally, an evaluation of the methodology will follow, giving some suggestions for improvement of the experimental design.

First of all, the fillers seemed to have served their purpose well. Without fillers, subjects may have confused and mixed up the different syllogisms, especially considering the fact that all the syllogisms were based on the same story. This did not seem to occur with the subjects, although occasionally they wanted to integrate information 'from the other cards' (e.g. Subject 2). The rephrasing question sometimes provided insightful extra information, but most often was not understood by the subjects.

Some problems with the syllogisms used in our method may have biased subjects to entertain CWR. Ideally, the antecedent and consequent should be completely contingent upon each other, e.g.

If Marian passes her exam, then Arsenal wins the European cup

In our setting however both the antecedent (exam, essay) and the consequent (studying late in library) suggest studying, thereby putting off exceptions and different explanations.

Another minor problem that we found with the syllogisms was with the use of the word 'late', which is a vague predicate. This could invite subjects to impose a fuzzy logic interpretation, or otherwise induce uncertainty in the subjects.

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A Materials

Alternative case: If Marian has an exam.
Additional case: If the library is open

Modus Ponens

2 premises:

If Marian has an essay to write, she studies late in the library.
She has an essay to write.

Alternative:

If Marian has an essay to write, she studies late in the library.
If Marian has an exam, she studies late in the library.
She has an essay to write.

Additional:

If Marian has an essay to write, she studies late in the library.
If the library is open, she studies late in the library.
She has an essay to write.

Modus Tollens

2 premises:

If Marian has an essay to write, she studies late in the library.
She does not study late in the library.

Alternative:

If Marian has an essay to write, she studies late in the library.
If Marian has an exam, she studies late in the library.
She does not study late in the library.

Additional:

If Marian has an essay to write, she studies late in the library.
If the library is open, she studies late in the library.
She does not study late in the library.

Affirmation of the Consequent

2 premises:

If Marian has an essay to write, she studies late in the library.
She studies late in the library.

Alternative:

If Marian has an essay to write, she studies late in the library.
If Marian has an exam, she studies late in the library.
She studies late in the library.

Additional:

If Marian has an essay to write, she studies late in the library.
If the library is open, she studies late in the library.
She studies late in the library.

Denial of the Antecedent

2 premises:

If Marian has an essay to write, she studies late in the library.
She doesn't have an essay to write.

Alternative:

If Marian has an essay to write, she studies late in the library.
If Marian has an exam, she studies late in the library.
She doesn't have an essay to write.

Additional:

If Marian has an essay to write, she studies late in the library.
If the library is open, she studies late in the library.
She doesn't have an essay to write.

B Overview of results

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S210	
MP2	q	q	q	q	q	q	q	q	q	q	100% q
MP3 Alt	q	q	q	q	q	q	q	q	q	q	100% q
MP3 Add	q	-	q	-	-	q	-	q	-	-	40% q 60 % -
MT2	¬p	¬p	¬p	¬p	ab ¬p	¬p∨ab	¬p	¬p	¬p	¬p	80% ¬p 10% ¬p∨ab 10% ab
MT3 Alt	¬p ∧ ¬r	¬p ∧ ¬r	¬p ∧ ¬r	¬p ∧ ¬r	¬p ∧ ¬r	¬p ∧ ¬r	¬p ∧ ¬r	¬p ∧ ¬r	¬p ∧ ¬r	¬p ∧ ¬r	100% ¬p∧¬r
MT3 Add	¬ p ∨ ¬s	¬ p ∨ ¬s	¬ p ∨ ¬s	¬p ∨ (p ∧¬ s)	¬s	¬s ∨ (s ∧¬ p)	¬ p ∨ ¬s ¬s	¬s	¬s	¬ p ∨ ¬s	35% ¬s 45% ¬p∨¬s 20% ¬s∨ (s ∧¬ p) or related
DA2	-	¬q	-	¬q	- ¬q	-	-	-	-	-	25% ¬q 75% -
DA3 Alt	¬p∧ ¬r → ¬q	¬p∧ ¬r → ¬q	¬p∧ ¬r → ¬q	¬p∧ ¬r → ¬q	-	¬p∧ ¬r → ¬q	¬p∧ ¬r → ¬q	-	¬p∧ ¬r → ¬q	¬p∧ ¬r → ¬q	30% - 70% ¬p∧ ¬r → ¬q
DA3 Add	-	-	-	¬q	-	-	-	-	-	-	90% - 10% ¬q
AC2	p	p	p -	-	p	-	-	p	-	-	50% - 50% p
AC3 Alt	p∨r	p∨r	p∨r ∨(p ∧ r)	p∨r ∨(p ∧ r)	p∨r	-	-	p∨r	- p ∨ r	p ∨ r	55% p∨r 25% - 20% p∨r∨(p∧r)
AC3 Add	s	s	s	s	s	s	-	s	s	p∨s s	80% s 5% p∨s 5% -

Figure 1: Overview of results of all subjects

C Transcripts

C.1 Subject 1 (Cognitive Science student, 22, female)

C.1.1 Modus Ponens Two-premise

Finds this too easy - assuming already that she's staying late in the library
S: Ok, Marian has an essay to write and for this reason she erm needs some books which are in the library and erm there's a lot of work to do so that's why she's erm probably staying late in the library.
E: [pointing to condition again] if she has an essay to write, she will stay late in the library and it says she has an essay to write; can you conclude anything from this?
S: that's the condition [pointing to first premise] - if she has an essay to write, she needs a lot of time in the library, which means she'll stay late in this library.
E: Do you find this confusing? Do you think there is enough information there?
S: No, I find it very clear.

C.1.2 Modus Tollens Two-premise

S: Ok, that would mean she doesn't have an essay to write because she would only stay late in the library if she has an essay to write
S: It's clear, especially in combination with the other card

C.1.3 Affirmation of the Consequent Two-premise

S: Well, that most probably means she has an essay to write unless she has another reason to stay in the library um, but she probably has an essay to write
E: When you say unless she has another reason do you think there is enough information given?
S: Mm, well maybe you should say that the only reason she would be in the library is to write an essay because there could be another reason

C.1.4 Denial of the Antecedent Two-premise

S: Ok, if she doesn't have an essay to write she won't stay late in the library unless of course she has other reasons to work in the library. like um an interesting book to read
E: If you were to formulate it in a way you understood it then, what might it be?
S: Um, you could add she does not have an essay to write and has no other business in the library

C.1.5 Modus Ponens Three-premise Alternative

S: Um, Marian has an essay to write, which means she stays late in the library, so I'd take condition 1 and 3 and conclude that Marian will stay late in the library
S: The second condition is not really relevant here, because she doesn't have an exam, only an essay to write
S: The second condition is not necessary, because um, she doesn't have an exam - it's just another reason why she'd stay late in the library. So if the third condition would be she stays late in the library; that could be for the reason that she has to write an essay or that she has an exam
E: If you had to reformulate this in a way that you understand it - we're thinking about rewriting this text for the next experiment - might it change?
S: I'd take out the second condition

C.1.6 Modus Tollens Three-premise Additional

S: Ok, well that can mean two thing
S: it can mean that she doesn't have an essay to write, or that the library doesn't stay open. So it could be that the library is closed that day, or closed earlier than normal
E: Is this confusing or clear? Do you think there is any information missing?
S: Um, well isn't it obvious when the library is open and when it's closed? [laughs]
E: Yeah, but you don't know
E: Again, if you had to reformulate it? Would it be different?
S: I think it's clear. Although I was thinking about the second condition - if Marian's spending so much time in the library, she should know when it's open and when it's not
E: So if you had to tell someone about Marian and her library habits, based on this information, what might you say to her/ him?
S: I might say Marian does not stay late in the library because she does not have an essay to write or that the library is not open

C.1.7 Affirmation of the consequent Three-premise Alternative

S: Ok, my conclusion from this is that Marian stays late in the library because she either has an essay to write, or she has an exam
S: This card is very clear
E: Again, if you wanted to reformulate the text, how might you do it? (That's if you would want to change it) - according to the way you understood it.
S: I would say Marian's going to stay in the library til late, for one of two reasons - either that she has an exam or she has an essay to write.

C.1.8 Denial of the antecedent Three Premise Additional

S: Marian doesn't have an essay to write, which means she would not stay late in the library, but the second condition says that if the library stays open that she will stay late in the library, but it doesn't say dependent or independent of the essay that she might have to write, so she could still stay late in the library if it's open to do something else
E: So you're saying that
S: that there could be another reason for her to go to the library and to stay late in the library
E: and the fact that she doesn't have an essay to write
S: doesn't mean that she won't go to the library and stay there til late
E: ok, so she doesn't have an essay to write, then normally you'd say she wouldn't stay late in the library
S: well, it doesn't really say because the second condition is that if the library is open, she stays late in the library; so apparently there could be another reason for her to stay in the library
E: and that being
S: a book she might want to read, some research she has to do, maybe she fancies someone there
E: and if you had to reformulate the text the way you understood it, as text for a following experiment?
S: you could give other reasons for her to stay in the library, or you could indicate whether there are other reasons for her to stay late in the library

C.1.9 Modus Ponens Three-premise Additional

S: Ok well Marian has an essay to write and that is the reason that she stays late in the library. There could be other reasons for her to stay late in the library, but in this case the reason is that she has to write an essay
E: So, you're saying she stays late in the library?
S: Yes
E: Do you think there's too much/ not enough information?
S: Well I guess it's necessary for the library to stay open if Marian wants to stay in the library, so in that sense it's not too much information
S: Apparently, or the second condition implies that there might be other reasons for her to stay in the library til late; um, but now she's staying late in the library because she needs to write her essay and she does that in the library
E: Reformulating the text.
S: Marian has several reasons to stay late in the library, but today she has an

essay to write and therefore she stays in the library

C.1.10 Modus Tollens Three premise Alternative

S: Ok, um should I say this card um independent of the other cards, or
E: Yes... just think about this one
S: Ok, Marian does not stay in the library because she doesn't have an essay to write and she doesn't have an exam. That's what I conclude from this. From solely this card.
E: When you say solely this card do you mean you want to include information from other cards?
S: Yes, because she doesn't stay late in the library could also be because the library isn't open, til late
E: Do you think there might be some missing information?
S: I think you could say whether the library is open at all; because it might be a Sunday and it's not open
E: Reformulating?
S: Marian does not stay late in the library because she does not have an essay to write and she does not have an exam

C.1.11 Affirmation of the consequent, Three-premise Additional

S: Ok, from this card I would conclude that um that Marian stays in the library and the reason for this could be several; one of which could be that she has an essay to write; um, but there could be other reasons, because the second condition says that if the library stays open she stays late in the library, meaning that she could be dong other things - as long as the library's open, she is there [strengthening]
E: Reformulation?
S: Marian stays late in the library because she might have an essay to write

C.1.12 Denial of the Antecedent, Three-premise, Alternative

S: Ok, I conclude from this card that there could be another reason no Marian could still stay late in the library for the reason that she has an exam, but she won't stay in the library to write an essay because she doesn't have to
E: Any other information?
S: Well, you could add whether the library is open or not?

C.2 Subject 2 (History teacher, 24, male)

Difference between real world and what information is given in the cards; this subject really sticks to the information given in the cards, otherwise, why would you give it? But if asked 'if you saw Marian' - so link to real life, then things about other possibilities Also said that only mentioned some things (about library being open, etc.) because it's mentioned in other cards

C.2.1 Modus Ponens Two-premise

S: Yeah, I think she will stay late in the library
E: And why's that?
S: Because it says that if she has an essay to write, then she stays in the library til late and it says she has an essay to write, so I assume she'll stay late in the library
E: Do you think there is anything unclear about it?
S: Well, you don't know if she is actually in the library, because it says she stays in the library, so possibly she's at home, so she won't stay late in the library

C.2.2 Modus Tollens Two-premise

S: Yeah, I think she probably does not have to write an essay

C.2.3 Affirmation of the consequent Two-premise

S: Ok, it's likely that she has to write an essay; it's also possible that she's staying late in the library because she has something else to do. so I'm not sure that she has to write an essay, but it's likely
E: If you had to describe this situation to someone else, would you describe it in a different way?
S: Well, if I would say it like this, in this order, I would suggest or I would mean to suggest with the second sentence that she has to write an essay, that she is writing an essay and I could leave out the second sentence. It does suggest that she is writing an essay, because otherwise why would you bother saying the first sentence? You could just say she's staying late in the library.
E: But if you were just thinking about Marian in real life you see her studying late in the library, what might you think then?
S: Oh, then I think she must have some deadlines coming up
E: But not necessarily that she has an essay to write?
S: from this? [pointing to card]
E: You know this information (someone has told you this information) and you

see Marian studying late in the library
S: Oh, then I think she's probably writing an essay
E: So, you don't think she might be doing something else?
S: Well, yeah, of course it's possible, but because I was told this, I'm more likely to take this as a first option

C.2.4 Denial of the antecedent Two-premise

S: Yeah, you can I think it's not likely that she stays late in the library this evening. Because I think with the first sentence you suggest that only if she has to write an essay then she stays late in the library; she doesn't have to write an essay so she probably isn't staying late in the library
E: Do you think it should be made clearer in any way?
S: Yeah, of course it would be clearer with an 'only if' because only if she has an essay to write, then she'll stay late in the library
E: What if it's just 'if'?
S: Yeah, then it doesn't necessarily lead to any conclusions she could be revising for a test to stay late in the library, or an exam

C.2.5 Modus Ponens Three-premise Alternative

S: That she's probably staying late in the library, but again, it doesn't really change anything, the second sentence; to me it doesn't make much of a difference; it doesn't give you any more information on this particular situation because you know that she has an essay to write, so the information about the exam doesn't help you; but no I mean she has an essay to write, so that's what she's doing now; so it's likely that she stays late in the library tonight because she's writing an essay - it says in the first sentence
E: Why do you say likely and probably?
S: Mmm good question no I think it is let me see
E: Think about meeting Marian and she says she has an essay to write
S: Then I would presume that she's staying until late in the library because I know that if she has an essay to write, then she's staying late in the library
E: If we were doing this experiment again text clearer, etc.
S: I would say Marian has an essay to write, so she is staying late in the library. That would make it clear. [Saying the exam information is not necessary - not thinking about real-world here, but information on cards]

C.2.6 Modus Tollens, Three-premise, Additional

S: Mmm yeah, there are two possibilities I think mmm either the library does not stay open til late, or she does not have an essay to write
S: Should I explain it?
S: I don't know I mean it gives two reasons why she might stay late in the library [strengthening?] The first statement says she does not stay late in the library so then I assume that neither of the first to cases is the case
E: Again if you wanted to reformulate this in the way you understood it?
S: I would say mmm for example, although Marian has an essay to write, she's not staying late in the library because open anymore something like that, might be possible

C.2.7 Affirmation of the consequent, Three-premise, Alternative

S: I think Marian either has an essay to write or she has an exam; yeah, because it says she does stay late in the library and again it gives you two cases as to why she might stay late in the library, it's giving two likely reasons as to why she's staying so late.
E:
S: You still don't know if she's writing an essay or revising for an exam. So again, you give the listeners some information because I mean you suggest that she's doing either of these two things; but she might even be doing something different. I would simply say: Marian is staying late in the library; she is revising for an exam. And then you can leave out the whole essay thing because it wouldn't be relevant.
E: But if you wanted to explain to someone why Marian is going to stay late in the library; if you wanted to tell someone about Marian
S: I would simply say Marian is staying late in the library tonight because she's revising for an exam
E: But if you don't now if Marian is in the library or not, and you wanted to tell somebody about Marian's library habits
S: So I don't know if she's staying late in the library tonight? Something about her and her library habits?
E: Oh, then I would say that always when Marian has an exam or she has an essay to write, she stays late in the library

C.2.8 Denial of the antecedent, Three-premise, Additional

S: Ok, well, still I think there is a possibility that she stays late in the library, because I'm not sure if it's open late or not [strengthening]; if it is, then she will

be in the library, despite the fact she doesn't have an essay to write
E: why do you think she might be in the library?
S: Because it says 'if the library stays open, then she stays late in the library' so whenever the library is open, she'll stay late in the library
E: Ok
S: Hmm I think so; I think so; I mean, these must be general statements, rather than specific ones for one situation; because otherwise, you wouldn't have to say either of them that's what I think
E: You mean, you could see it as if Marian has an essay and the library stays open, then she stays late in the library
S: Yeah, but I mean the connection is not made explicitly here - I mean they don't I understand that if she has an essay to write but the library doesn't stay open til late, then she won't stay late in the library, I understand that, but here to me it seems to be two separate things

C.2.9 Modus Ponens, Three-premise, Additional

S: Ok yeah I think it is likely that she stays late in the library tonight, but it depends if the library is open.. so perhaps I think [pauses]. yeah, in a way I think hmm what does it say to me? I mean the fact that you first say that she has an essay to write then she stays late in the library, but then you add to it if the library stays open she stays late in the library so perhaps she's not actually in the library tonight, because the library's not open. I don't think it's a very good way of putting it.
E: how might you put it?
S: I would say, if Marian has an essay to write, and the library stays open late, then she does stay late in the library. That's how I would state it [this time, he's not strengthening] but then I haven't even included that she has to write an essay so, . I don't know, it depends on the information I have; otherwise I would say something like oh, Marian has an essay to write tonight and the library's staying open, so she's staying in the library late tonight

C.2.10 Modus Tollens, Three-premise, Alternative

S: Ok, yeah I think she doesn't have an essay to write; neither does she have an exam. But because I've had information before that she only stays late in the library if the library is open, which suggests that the library is not always open til late [so maybe that's why she's not staying late in the library]
E: Ignoring that other information, might you have thought of that information yourself?

S: mmm [thinks] No, I think then my reaction would be oh, then probably she doesn't have an essay, or an exam; because otherwise she would stay late in the library. Because these are the two given examples and with the third piece of information telling me she does not stay late in the library, then I think none of these things are taking place

C.2.11 Affirmation of the consequent, Three-premise, Additional

S: OK, well I'm sure that the library is open and it's likely that she's writing an essay. But I'm not sure.
E: Why not?
S: She might be doing something else - she might be socialising or she might be working on something else. Yeah, so the main conclusion is that the library is open tonight til late.
E: And about the essay?
S: Yeah, again if I would say these three things to someone, then I would mean to say that Marian is writing an essay in the library at the moment; I would say Marian is staying late in the library tonight because she is writing an essay
E: If you did want to tell somebody when she might be studying late in the library?
S: Ok, Marian is always studying late in the library if the library is open til late and if she has an essay to write
E: So, you don't think there may be any other reasons?
S: The way I interpreted this I would probably say it the other way round Marian is always staying late in the library if she has to write an essay, and of course if the library is open til late
E: So, do you think there may be any other reason she might stay late in the library?
S: I do

C.2.12 Denial of the antecedent, Three-premise, Alternative

S: Yeah, that if she's staying late in the library, then in this case it's not because she has to write an essay but perhaps she has an exam; so no, you don't know where she is; she might go to the library anyway, especially if she has an exam; so that's what I would conclude - if this was the only information I was given, I would conclude that Marian is possibly in the library, and if she is, then it's because she has an exam. If I would give this information to someone then I would actually mean Marian is in the library because she has an exam to revise for.

C.3 Subject 3 (Female, 20, anthropology student)

C.3.1 Modus Ponens Two-premise

E: Wat kun je hier uit concluderen?
S: Dat ze tot laat in de bibliotheek blijft.
E: Kun je je argument verklaren.
S: Elke keer als ze.volgens die zin elke keer dat zeeen voorwaarde voor laat in de bibliotheek blijven is een werkstuk moeten schrijven. Nah ze moet een werkstuk schrijven dus
E: Ontbreekt er nog informatie?
S: Nee
E: Dan zou ik je willen vragen het experiment te herformuleren zodat een ander het precies zo zou begrijpen als jij.
S: Nou wat je zou kunnen toevoegen i
S: Altijd als Marian een werkstuk moet schrijven blijft ze laat in de bibliotheek.

C.3.2 Modus Ponens Three-premise Alternative

E: Wat kun je concluderen?
S: Dan blijft ze tot laat in de bibliotheek.
E: Zitten er onduidelijkheden in.
S: Nee
E: Is het dubbelzinnig ergens?
S: Nee
E: Is elke zin nodig om tot je conclusie te komen?
S: Nee, de tweede niet
E: Als Marian een werkstuk moet schrijven, dan blijft ze tot laat in de bibliotheek. Ze moet een werkstuk schrijven.

C.3.3 Modus Ponens Three-premise Additional

S: De tweede zin is niet nodig om tot je conclusie te komen. Als ze een werkstuk moet schrijven. Ze moet een werkstuk schrijven dus blijft ze tot laat in de bibliotheek. Dus lijkt me dat de bibliotheek open is.
E: Kun je het herformuleren.
S: Als Marian een werkstuk moet schrijven, dan blijft ze tot laat in de bibliotheek en is de bibliotheek open. Ze moet een werkstuk schrijven.

C.3.4 Modus Tollens Two-premise

S: Ja, dan moet ze geen werkstuk schrijven.
E: Dan moet ze geen werkstuk schrijven?
S: Ja, ja
E: Kun je nog iets anders concluderen.
S: Nou, nee, ik zou alleen als zeg maar bij bepaalde.als er een andere factor er bij was waardoor het zeg maar.
E: Als je het zou moeten herformuleren?
S: Als Marian een werkstuk moet schrijven, dan blijft ze tot laat in de bibliotheek. Ze blijft niet tot laat in de bibliotheek.

C.3.5 Modus Tollens Three-premise Alternative

S: Ze heeft en geen tentamen en ze hoeft geen werkstuk te schrijven.
E: Zijn er tegenstrijdigheden?
S: Nee
E: Heb je elke zin nodig om tot je conclusie te komen?
S: Ja
E: Zou je het kunnen herformuleren?
S: Als Marian een werkstuk moet schrijven, dan blijft ze tot laat in de bibliotheek. Als Marian een examen heeft, dan blijft ze tot laat in de bibliotheek. Ze blijft niet tot laat in de bibliotheek.

C.3.6 Modus Tollens Three-premise Aditional

E: Wat kun je concluderen?
S: Dat de bibliotheek niet tot laat open is en dat ze geen werkstuk moet schrijven maar dat de bibliotheek dan niet open is dat is logisch. Ze kan niet in de bibliotheek als die niet open is. Dus als ze niet tot laat in de bibliotheek blijft is die in ieder geval niet tot laat open. Enaltijd als ze een werkstuk moet schrijven blijft ze laat in de bibliotheek.
E: Kun je het herformuleren?
S: Als Marian een werkstuk moet schrijven, dan blijft ze tot laat in de bibliotheek. Als de bibliotheek tot laat open is, dan blijft ze tot laat in de bibliotheek. Ze blijft niet tot laat in de bibliotheek.

C.3.7 Affirmation of the consequent Two-premise

S: Nou dan moet ze een werkstuk schrijven. Ja er kunnen ook best wel andere redenen zijn waarom ze tot laat in de bibliotheek blijft. Oh ja bij die andere was

het wel zo dat ze dan dus geen werkstuk moest schrijven in ieder geval. Anders zou het een keuze tussen die twee blijven. Maar nu is het: Ze moet of een werkstuk schrijven of ze wil gewoon heel graag in de bibliotheek blijven.
E: Als je het zou moeten herformuleren?
S: Als Marian een werkstuk moet schrijven, dan blijft ze tot laat in de bibliotheek. Ze blijft tot laat in de bibliotheek.

C.3.8 Affirmation of the consequent Three-premise Alternative

S: Dan heeft ze ofwel een werkstuk ofwel een tentamen of allebei.
E: Kun je het herformuleren?
S: Als Marian een werkstuk moet schrijven, dan blijft ze tot laat in de bibliotheek.Als Marian een examen heeft, dan blijft ze tot laat in de bibliotheek. Ze blijft tot laat in de bibliotheek.

C.3.9 Affirmation of the consequent Three-premise Additional

E: Wat kun je concluderen?
S: Wat was de eerste zin? Als Marian een werkstuk moet schrijven, dan blijft ze tot laat in de bibliotheek. Als de bibliotheek open blijft, dan blijft ze tot laat in de bibliotheek. Ze blijft tot laat in de bibliotheek. Dan moet ze misschien een werkstuk schrijven. Het lijkt me dat hij open is.

C.3.10 Denial of the antecedent Two-premise

E: wat kun je hieruit concluderen.
S: Dat ze ofwel niet tot laat in de bibliotheek blijft en als ze dat wel doet het om een andere reden is dan dat ze een werkstuk moet schrijven.
E: Zijn er onduidelijkheden?
S: Nee
E: Kun je het herformuleren.
S: Als Marian een werkstuk moet schrijven, dan blijft ze tot laat in de bibliotheek. Ze hoeft geen werkstuk te schrijven.

C.3.11 Denial of the antecedent Three-premise Alternative

S: Als ze dus laat in de bibliotheek zou blijven is dat omdat ze een examen heeft. Het kan zijn dat ze niet een examen heeft. Dan blijft ze niet tot laat in de bibliotheek. Tenzij ze in de bibliotheek blijft omdat die laat open is. Maar dat staat er niet. Ik weet het niet als ze geen werkstuk heeft is in ieder geval dat niet de reden dat ze tot laat in de bibliotheek blijft.

C.3.12 Denial of the antecedent Three-premise Additional

S: Als Marian een werkstuk moet schrijven, dan blijft ze tot laat in de bibliotheek. Als de bibliotheek open blijftZe hoeft geen werkstuk te schrijven. Nou dan kan het zijn dat ze tot laat blijft als de bibliotheek inderdaad open is. Het kan ook zijn dat ze vroeg naar huis gaat. Nee wacht als ie niet tot laat open blijft. Dan gaat ze vroeg naar huis maar als ze blijft als ie tot laat open blijft dan blijft ze tot laat maar dan is het niet omdat ze een werkstuk moet schrijven.

C.4 Subject 4 (Female, 25, youth councillor)

C.4.1 Modus Ponens Two-premise

E: Wat kun je hier uit concluderen?
S: Dat blijft ze tot laat in de bibliotheek.
E: Dan zou ik je willen vragen het experiment te herformuleren zodat een ander het precies zo zou begrijpen als jij.
S: Marian moet een werkstuk schrijven dus ze blijft tot laat in de bibliotheek.

C.4.2 Modus Ponens Three-premise Alternative

E: Wat kun je concluderen?
S: Ze blijft tot laat in de bibliotheek.
E: Kun je nog iets anders concluderen?
S: Dat ze zowel laat in de bibliotheek blijft als ze een werkstuk..en als ze een examen heeft dus..dat je niet altijd kan zeggen wat ze aan het doen is als ze tot laat in de bibliotheek is. Ja

C.4.3 Modus Ponens Three-premise Additional

E: Wat kun je concluderen?
S: Dat Marian tot laat in de bibliotheek blijft als de bibliotheek tot laat open is. Datdus Marian blijft tot laat in de bibliotheek als die tot laat open blijft.

C.4.4 Modus Tollens Two-premise

E: Wat kun je concluderen?
S: Marian hoeft geen werkstuk te schrijven dus blijft ze niet tot laat in de bibliotheek.
E: Zit er nog een onduidelijkheid in?
S: Ja, want uhm.het is niet er staat niet dat ze altijd tot laat in de bibliotheek blijft als ze een werkstuk schrijft er staat alleen: als ze een werkstuk schrijft dan

blijft ze tot laat dus dat hoeft niet altijd te zijn. Denk ik
E: Als je het zou moeten herformuleren?
S: Altijd alshoe heet ze Marian. Marian blijft altijd tot laat in de bibliotheek als ze een werkstuk moet schrijven.

C.4.5 Modus Tollens Three-premise Alternative

E: Wat kun je concluderen?
S: Dan heeft ze geen werkstuk en geen examen tenzij de bibliotheek tot laat open.oh dat is weer wat anders he? Mag ik dat wel noemen. Tenzij de bibliotheek vroeg dicht gaat want dan kan ze het weer wel hebben. Maar dat is weer een ander voorbeeld toch.

C.4.6 Modus Tollens Three-premise Additional

E: Wat kun je concluderen?
S: Dat ze of geen werkstuk moet schrijven of dat de bibliotheek niet tot laat open en ze wel een werkstuk moet schrijven.

C.4.7 Affirmation of the consequent Two-premise

E: wat kun je hieruit concluderen.
S: Nou dat ze een werkstuk moet schrijven. Dus blijft ze tot laat in de bibliotheek. Maar het kan ook zij dat ze niet een werkstuk moet schrijven en tot laat in de bibliotheek blijft. Dat is niet uitgesloten.
E: Waarom niet?
S: Omdat er niet altijd.er staat niet bij dat ze altijdder staat: als Marian een werkstuk moet schrijven dan blijft ze tot laat in de bibliotheek maar het kan ookder staat niet bij dat het altijd zo is.

C.4.8 Affirmation of the consequent Three-premise Alternative

E: Wat kun je concluderen?
S: Ze heeft een werkstuk of een examen. Marian blijft tot laat in de bibliotheek want Marian moet een werkstuk schrijven of ze heeft een examen of ze heft allebei.

C.4.9 Affirmation of the consequent Three-premise Additional

E: Wat kun je concluderen?
S: Marian moet een werkstuk schrijven en de bibliotheek is open. Dus ze maakt haar werkstuk daar dus ze blijft tot laat in de bibliotheek.

C.4.10 Denial of the antecedent Two-premise

E: wat kun je hieruit concluderen.
S: Dus ze blijft niet tot laat in de bibliotheek. Omdat ze geen werkstuk hoeft te schrijven.
E: Kun je nog iets anders concluderen?
S: Nee, maar dat is weer hetzelfde als toen net. Het hoeft niet dat ze een werkstuk hoeft te schrijven. Of tenminste, ik bedoel het hoeft niet dat ze altijd tot laat in de bibliotheek blijft als ze een werkstuk moet schrijven. Er staat niet altijd weer bij.
S: Als Marian een werkstuk moet schrijven, dan blijft ze tot laat in de bibliotheek. Ze hoeft geen werkstuk te schrijven.

C.4.11 Denial of the antecedent Three-premise Alternative

S: Marian kan nog steeds tot in de bibliotheek blijven omdat ze een examen heeft. Maar dat weet je dus niet. Ze hoeft geen werkstuk te schrijven dus daarom blijft ze niet tot laat in de bibliotheek maar als ze een examen heeft dan blijft ze wel tot laat in de bibliotheek.

C.4.12 Denial of the antecedent Three-premise Additional

S: Marian kan nog steeds tot laat in oh ze hoeft niet een werkstuk te schrijven dus ze blijft niet tot laat in de bibliotheek.
E: Kun je nog iets anders concluderen?
S: Nee

C.5 Subject 5 (Male, 30 years old, computer programmer)

C.5.1 Modus Ponens Two-premise

E: Can you conclude anything from this
S: ... the essay must be soon... If she has an essay, it certainly means that she must be in high school or university
E: yes, but concerning..
S: and that she is already at the library, ...well, that's not sure
E: they say: If M has an essay to write
S: ok, but why, below, do they say: she has an essay to write
E: in fact it's done in two times. You've got: if she has an E to write, she goes to the L
S: ok, so, considering the fact that she has an essay to write, there are chances that she will go to the L

E: here you are. So can you conclude...?
S: she will definitely go to the library
E: ok, so you conclude that she will stay late at the L
S: yeh (without conviction)
E: ok

C.5.2 Modus Tolents Two-premise

E: Can you conclude anything from this?
S: She doesn't have an essay to write. She did not stay late. And if she has one, she stays, so she does not have any essay

C.5.3 Affirmation of the consequence Two-premise

E: Can you conclude anything from this?
S: no, she might have an essay to write, but it is mybe not the cause, she maybe has sth else to do
E: ok, it's not sure that she has an essay? why?
S: because when she has an E, she stays late. But sometimes, she can stay for sth else
E: can you add sth to the story to be able to conclude sth?
S: she stays at the L, only when she has an essay. Then you can conclude that that she has an E to write.

C.5.4 Denial of antecedent Two-premise

E: Can you conclude....?
S: oh, lala, this is the story... no, no, she has not an essay, but she still can stay at the L for another reason. One cannot conclude anything.

C.5.5 Modus Ponens Three-premise Alternative

E: Can you conclude....?
S: yes, she stays late at the L
E: redondant infos?
S: yes, 2d sentence
E: missing infos?
S: no
E: conclude sth else?
S: no, she has an essay to write, that's all, so she stays late at the L. That's all I can conclude.

C.5.6 Modus Ponens Three-premise Additional

S: she always stays late at the library....
E: can you conclude sth from this? But if it is closed, she won't be able to stay, but a priori, she has planned to stay at the library. One can conclude that she will stay at the library if it stays open.
E: can you conclude sth else?
S: yes, that even though she had no essay to write, she would have stayed late at the library, if it was open. Each time that the library is open, she stays late at the L, so one doesn't know exactly when she has a essay to write.
E: can you rephrase it in a better way?
S: I would say for example...
S: on the other hand, she can stay at the L, without writing her essay, because they don't say that if M has an essay to write, she stays late to write it....No, It's ridiculous
S: ... The second sentence breaks the link between the first and the last one. If one takes the first sentence and the conclusion, one can conclude that she will stay at the library, but the 2d Sentence makes that at the end, we don't care about all the others.
E: You don' care about the first one
S: the first and last ones go together. the 2d one goes alone.
S: .... if one wants to know if she goes to the L or not, well, the L needs to be open. One assumes that it is open. And then we can completely leave out the 2d one.

C.5.7 Modus Tollens Three-premise Alternative

E: can you conclude..?
S: she has no essay and she has no exam
E: can you rephrase it?
S: each time that M has an essay or an exam, she goes to the library

C.5.8 Modus Tollens Three-premise Additional

E: can you conclude...?
S: if she does not stay late, it means that the L is closed
E: can you conclude sth else?
S: if the L is open, I can conclude that she has no essay. I think it's right. Because, in fact, if the L is open, she stays there late; and tonight, she does not stay late. So either, the L is closed, or she has no essay . That's not clear what I'm saying. She does not stay at the L, so the L is obligatory closed, since each time it's open,

she stays there. So, tonight, the L is closed, that's all I can conlude.
E: so, first sentence is unnecessary?
S: yes
E: could we suppress it?
S: well, we can use the last sentence to conclude sth
E: so..
S: when you tell me that she stays late at the L, without the 2d sentence, I conclude that she has no essay. But if one adds the fact that when it's open, she stays late, then... and that one tells me that tonight, she does not stay late, then I conclude that the L is closed. So the first sentence is no longer useful. (strenghtening)
E: but before you were saying...
S: I was wrong
E: either the L is closed and thus she does not stay at the L or she has no essay.
S: no, but I mixed up things
E: so, you consider that the first one is wrong
S: yep

C.5.9 Affirmation of the consequence Three-premise Alternative

E: Can you conclude...?
S: we've already seen this one?
E: non
S: she stays late at the L, so she probably has an essay or an exam. She also can stay late for other reasons
E: so, she cannot stay late, because she has an essay?
S: because she has an essay, or an exam or sth else. But, if these two sentences are here, it's certainly to make us ask whether she has this or that.

C.5.10 Affirmation of the consequence Three-premise Additional

E: Can you conclude...?
S: she stays late at the L, so the L is open, that's all we can conclude
S: it only means that she stays late at the L, may she or not have an essay.

C.5.11 Denial of the Antecedent Three-premise Alternative

E: can you conclude...?
S: so, if tonight she stays late at the L, therefore she has an exam
E: here, it is said, she has no essay to write. Can you conclude sth from it?
S: I cannot say, because she might have an exam
E: so, information is missing?

S: yes
E: cannot conclude anything?
S: no.. Given the fact that she has no essay, she might stay late at the L. If she has an essay, she stays; but if she has no essay, no clue.

C.5.12 Denial of the Antecedent Three-premise Additional

E: Can you conclude..?
S: if the L is open, she will still stay at the L
E: so, we cannot conclude anything
S: in fact, if she stays at the L, it will not be to write her essay.
E: unnecessary infos?
S: no, bec the last sentence and the first one are linked, but the 2d one alllows to say...well, in fact the one in the middle might be unneccessary, bec she has no essay to write, but, she still might stay at the L. The sentence of the middle is completely alone in fact. But with it, one can know that we don't care about the fact that she has an essay or not, she will stay anyway at the L.

C.6 Subject 6 (Female, 29, researcher in biology)

C.6.1 Modus Ponens Two-premise

E: Can you conclude anything from this?
S: yes, she stays late at the L
E: why
S: because If M. has an essay to write, she stays at the L

C.6.2 Modus Tolents Two-premise

E: Can you conclude anything from this?
S: ..She doesn't have an essay to write
E: why
S: because if she had one, she would stay at the L
E: can you conclude sth else
S: no, I don't see

C.6.3 Affirmation of the consequence Two-premise

E: Can you conclude anything from this?
S: she maybe has an E to write, but not obligatory
E: maybe?
S: because she can also have sth else, that makes her stay at the L

C.6.4 Denial of antecedent Two-premise

E: Can you conclude....?
S: one can't conclude anything
E: what could you add to be able to conclude sth?
S: to know if she stays at the L or not? well, I don't know
S: if she does something else and for this, you tell me that she has to stay late at the L... otherwise, I cannot conclude anything

C.6.5 Modus Ponens Three-premise Alternative

E: Can you conclude....?
S: yes, she stays late at the L
E: unnecessary infos?
S: yes, 2d sentence
E: missing infos?
S: no
E: rephrase it?
S: If M has an essay or an exam, she stays late at the L.

C.6.6 Modus Ponens Three-premise Additional

S: so, she stays late at the library. (no suppr)
E: conclude sth else?
S: that the L is open..if she stays late
E: rephrase it
S: if M has an E and that the L stays open, she stays late at the L
E: does it mean the same?
S: no, because she can have an E to write and willing to stay at the L. But if the L is closed, she won't stay at the L. She needs both.

C.6.7 Modus Tollens Three-premise Alternative

E: can you conclude anything from this?
S: she has no essay, she has no exam
E: she has no essay AND she has no exam?
S: she has no essay AND/ OR she has no exam

C.6.8 Modus Tollens Three-premise Additional

E: Can you conclude anything from this?
S: she has no essay and/or the library is closed

E: so..
S: If we stick to what is exactly written, I use " or ". But, we know that you cannot stay in the library if it's closed, so it becomes and/or.

C.6.9 Affirmation of the consequence Three-premise Alternative

E: Can you conclude anything from this?
S: so she has an essay and/or an exam
E: how would you rephrase it?
S: if M has an essay or an exam, she stays late at the library

C.6.10 Affirmation of the consequence Three-premise Additional

S: so, she has an essay to write and/or the library is open (fallacy + processes as if alt)
E: ok..
S: I realise that if she has an essay to write, she stays late at the L, IF the L is open (realise that it's add. and that L closed is an abn for the first one). If it is closed, she cannot stay in there. So, in fact, only the 2d sentecne is suficient
E: first S is unnessecary?
S: yes
E: so, you conclude that L is open
S: yes
E: so, we don't know why she goes there
S: no, if she has an E, she will stay late at the L, but she can have sth else to do at the L (no more fallacy), and since the L is open, she stays late.
E: so you don't conclude that she has an essay to write
S: I conclude that S1 is included in S2. S1 is one detail of S2.

C.6.11 Denial of the Antecedent Three-premise Alternative

E: Can you conclude?
S: nothing, because she has no essay, she has no reason to stay at the L; However, if she has an exam, she will still stay late, it will be a sufficient reason to stay late. If she has no essay and no exam, she won't stay late at the L. So, we cannot know if she stays late or not.
E: wait.
S:if she has no essay, she's not supposed to stay late, but if she has an exam, she will stay late, so one don't know.

C.6.12 Denial of the Antecedent Three-premise Additional

S: well, if the L stays open, she stays late at the L
E: so
S: since she has no essay to write, the 1st sentence doesn't hold, and only the 2d one applies
E: why can't you say: she has no essay to write, so she doesn't stay late
S: no, bec if the L is open, she will stay late at the L, even though she has no essay.
E: so, for you she won't stay late at the L if she has no essay and if the L is closed
S: yes

C.7 Subject 7 (Female, 22, student theatre sciences)

C.7.1 Modus Ponens Two-premise

S: she must write an essay, therefore she sits till late in the library
reformulate: today she must write an essay.

C.7.2 Modus Ponens Three-premise Alternative

S: yes, that she stay late in the library. because either if she has an essay to write or if she has an exam she stays late in the library. in any case she stays in the library till late.

C.7.3 Modus Ponens Three-premise Additional

S: so, she stays till late in the library, unless the library doesn't stay open.
S: so you may conclude that, even though she has an essay to write, may be the library doesn't stay open till late, so then after all she cannot stay in the library till late.
S: so first you conclude that in any case what she wants is to stay late in the library, but then still it depends on the library's will if she can stay there till late.
reformulate: if Marian has an essay to write, she stays in the library till closing time.

C.7.4 Modus Tolents Two-premise

S: that either she has a very short essay to write or no essay. may be she had to write an essay but didn't feel like going to the library, or that it was so short that she finished it on time, so she didn't have to stay.
E: But if you look again at the first sentence...

S: So she doesn't have to write an essay today, because she doesn't stay in the library till late.
reformulate: Marian doesn't stay late in the library today because she has no essay to write.

C.7.5 Modus Tollens Three-premise Alternative

S: no, nothing actually. she probably doesn't have to write an essay, otherwise she would stay there till late, and she doesn't have an exam, otherwise she would stay late as well. but she doesn't stay late in the library. I see, so you may conclude that she doesn't have to write an essay or make an exam. or, the opening times of the library have changed, but then that sentence about the opening times should be here.
reformulate: today Marian she is not in the library at all, that makes it a lot clearer.

C.7.6 Modus Tollens Three-premise Additional

S: That it is not correct. because it says ... o, so then the library is closed.
E: can you also conclude something about the essay?
S: no, because, let me think, she stays late in the library in any case, so she stays if she has an essay to write, but in any case (sowieso) if the library is open. and she doesn't study late in the library so the only thing you can conclude is that the library is closed.
reformulate: ehhh, I would remove the first sentence.

C.7.7 Affirmation of the consequence Two-premise

S: that she has to write an essay. because she stays till late in the libray when she has to write an essay, and today she stays till late in the library.
E: could there be other reasons for her to stay late in the library?
S: That could be possible, for example may be she reads a very long book. But as I understand it she stays late in the library only if she has to write an essay

C.7.8 Affirmation of the consequence Three-premise Alternative

S: yes, that she has either an essay or an exam. which one? one of them. you don't know which of them.
E: could there be another reason?
S: Yes, if she is reading a book, or if she fell asleep.

reformulate: Therefore you could better say: only in case Marian has an essay to write but also if she has an exam, she stays late.

C.7.9 Affirmation of the consequence Three-premise Additional

S: so the library is open.
E: is that the only thing you can conclude? Yes
S: Well, it could also be that she has an essay to write, but she stays in the library anyhow when it is open late, it says here, so she stays there anyway, so it doesn't matter if she has an essay or not.
reformulate: it depends what you want to say. if you want to say that she has an essay, I would leave the second sentence out. otherwise I would leave the first sentence out, either get rid of the first or of the second sentence. It is logical that you cannot be in there when it is closed.

C.7.10 Denial of antecedent Two-premise

S: nothing. because may be this time she stays till late in the library but she is reading a book. or, if Marian is someone that only stays late in the library when she has to write an essay, then today she does not stay till late.
reformulate: only in case Marian has to write an essay she stays late in the library
She does not have an essay to write

C.7.11 Denial of the Antecedent Three-premise Alternative

S: that the essay is not the reason why she stays late in the library. but it could still be that she has an exam. But in fact you cannot conclude a thing. because she doesn;t have an essay to write. so suppose she is in the library, then that is not the reason. but the reason can be that she has an exam.
E: so can you conclude that? no. it doesn't say that. if it would have been but

C.7.12 Denial of the Antecedent Three-premise Additional

S: she is almost always in the library. unlesss it is closed. Actually you cannot conclude anything. o you can. that , let me see, she doesn't have an essay to write, so she needs not stay late in the library, but she always stays late if the library stays open. so you cannot conclude anything, except for that she is probably in the library even though she has no essay to write.
E: so you can conclude that she is in the library?
S: yes, unless it is closed

reformulate: throw the sentence with Marian out. I would say: Marian always stays in the library, but when the library closes she goes home.

C.8 Subject 8 (Female, 22, biology student)

C.8.1 Modus Ponens Two-premise

S: You may conclude that she will stay in the library till late. If she always does so.
reformulate? I would say, always when she has an exam she will stay in the library. She has an exam now.

C.8.2 Modus Ponens Three-premise Alternative

S: Well, you only have to consider the first sentence. So she'll probably be in the library. I would have been clearer if it had said: whenever Marian has an essay to write, etc. The fact that she has an exam has nothing to do with it.
reformulate? I would leave the exam out. And whenever she has an essay to write, etc.

C.8.3 Modus Ponens Three-premise Additional

S: The second sentence again has no function. If you suppose that it is always the case that when she has an essay to write, she studies late in the library, then of course she now stays late in the library.
reformulate: the 2nd premise should go out.

C.8.4 Modus Tolents Two-premise

S: That most likely she has no essay to write. But since it is not stated that she always stays late in the library when she has an essay to write you may not really conclude that she doesn't have an essay to write. It could be that, you know, for some other reason she can not stay late in the library. It is not a law of Meden en Persen.
reformulate: Normally Marian stays late in the library whenever she has an essay to write. Today she leaves the library early. ... There is a difference between the words always, or normally I suppose.

C.8.5 Modus Tollens Three-premise Alternative

S: That most likely she has no essay to write and no exam to do. Because she doesn;t stay late in the library: she has the habit that whenever she has an essay

or an exam, she will then stay late in the library.
reformulate: I would change it into always when.

C.8.6 Modus Tollens Three-premise Additional

S: thinks longer. There can be 2 reason
S: either the library closed for some strange reason. May be there was a fire, or SainteClaus passed by. Or indeed she has no essay to write. ... You may normally assume that the library stays open, may you not? Unless some strange reason occurs. So either this, or she has no essay to write anyway. The second sentence is a bit confusing.
reformulate: ... I wouldn't know how to formulate it better.

C.8.7 Affirmation of the consequence Two-premise

S: No. Because, (repeats premise 1), but may be normally she also stays late in the library if she has a test or so. If there is one reason to stay late it doesn't mean there are no other reasons.
reformulate: I would formulate it the same.

C.8.8 Affirmation of the consequence Three-premise Alternative

S: You cannot really conclude anything from that. May be she is eager to read a certain book. Those are 2 reasons for her to stay late in the library, but there could be 20 more like those. So you cannot conclude anything.
reformulate: it's ok like this.

C.8.9 Affirmation of the consequence Three-premise Additional

S: Well, that the library is open, and further nothing. What she is doing there you won't know. She could be writing an essay but she could also read a book, or something.
E: You concluded that the library is open. So why can you not conclude that she has an essay to write?
S: Well, this is one reason for her to stay late in the library, but there might be 10 other reasons.
reformulate: the second sentence is a bit strange. you could perhaps make it longer: if Marian has an essay to write, she stays till late in the library but only if it is open. Of course the library should be open if you want to stay there till late.

C.8.10 Denial of antecedent Two-premise

S: No. Because you don't know where she is. There might be many reasons why she could be in the library till late. And besides, you have no idea where she is, she could be in the playing ground.
reformulate: I would leave it like this.

C.8.11 Denial of the Antecedent Three-premise Alternative

S: Completely nothing. She might as well stay late in the library for some other reason. Or she might be at the playing ground.
reformulate: no need.

C.8.12 Denial of the Antecedent Three-premise Additional

S: no. She could be late in the library anyway, provided it is open. It doesn't say anything about what she is doing.
reformulate: whenever Marian has an essay towrite she stays late in the library, provided it is open. She has no essay to write. What is Marian doing now? So I made one sentence out of the first two.

C.9 Subject 9 ((Male, 33, magazine editor)

C.9.1 Modus Ponens Two-premise

S: She is now in the library and it's late
E: Why
S: Because she has an essay to write so she is late at the library

C.9.2 Modus Tolents Two-premise

S: She has no essay to write
E: why
S: because she is not in the library, it says that if she has an essay to write she will stay late and since she not there she has no essay. How deep in details would you like me to go? I would also say she may be in the library because of other reasons.
E: what ever you think about it
S: that according to those statements she has no essay to write.

C.9.3 Affirmation of the consequence Two-premise

S: she probably has an essay to write (tough she may be there for other reasons). But there is nothing conclusive you can conclude
E: Why?
S: Because she may have also homework in algebra.
E: And from the data?
S: if t was saying she in the library only if she has an essay I would say so but it is not conclusive

C.9.4 Denial of antecedent Two-premise

S: there is no limitation here that says only if she has an essay. Maybe she is there studding something else.
E: if you should base only on the information here?
S: then she would probably not be late in the library.

C.9.5 Modus Ponens Three-premise Alternative

S: The second statement is redundant. She is probably in the library but it is not decisive.
E: why not decisive?
S: they give another statement so it just prove there may be other reasons for her to be in the library
E: and assume this is all the information there is?
S: then she is probably there. But there are also missing information, they don't say what day is the exam and what day is today. So it might be that if she has an exam she studies there in the days before. They don't say the exam is tomorrow.

C.9.6 Modus Ponens Three-premise Additional

S: assuming those are all the details then only if the library is open she will be there late.
E: so this is what we can conclude ?
S: again, there is nothing conclusive. I don't know if the library is open today. There is no relation between the two sentences.
E: which sentences has no relation between them?
S: the two conditionals. But I don't know if the library is open now. If it was open today then she will be in the library.

C.9.7 Modus Tollens Three-premise Alternative

S: she has no exam and no essay to write.
E: why is it so?
S: there are two conditions and a conclusive fact. So she is not there. But, maybe she goes there for other reasons, and if I know them I could say more but we can be sure she has no essay or exam.

C.9.8 Modus Tollens Three-premise Additional

S: I can conclude that either the library is closed or she has no essay to write. Or there are other reasons for her not to be there. But it depends if the two first premises are related.
E: what do you mean by related?
S: If they both go together then I guess she has no essay to write. The question is it the same story or is it just two different premises. So the question if she studies in the library if both are happening, if she has an essay and the library is open. Or that those two are not related and she will study there if the library is open even if she has no essay.

C.9.9 Affirmation of the consequence Three-premise Alternative

S: she may have an essay or exam but she may be there for other reasons.
E: If those are the only reasons for her to go there?
S: then she either has an exam or essay for tomorrow.

C.9.10 Affirmation of the consequence Three-premise Additional

S: maybe she also has an assay and may be she is there for other reason, but the library is open anyway.
E: So can you conclude something here?
S: Well, if she is in the library then the library is open. So it adds no information.

C.9.11 Denial of the Antecedent Three-premise Alternative

S: There is nothing you can conclude. She may have an exam and if so she is in the library. So if those are the only premises then I can conclude there is some chance she is there (because of an exam).

C.9.12 Denial of the Antecedent Three-premise Additional

S: It's again inconclusive, the fact she has no essay does not mean she is not there. She may have other reasons. But if it was saying she goes there ONLY if she has an essay then I would say she's not there.
E: what about the second sentence?
S: it depends if they related or not.
E: so how do you read it?
S: that's really depends if it an additional premises or as alternative.
E: and if those are just three facts about Marian.
S: then I would say if the library is open then she is there, no matter if she has an essay.

C.10 Subject 10 (Male, 32, Sales and Marketing manager)

C.10.1 Modus Ponens Two-premise

S: she will study late in the library.

C.10.2 Modus Tolents Two-premise

S: I can conclude she does not have an essay to write.
E: why?
S: because she has an essay to write then she should be in the library. And she is not. If the first sentence is 100

C.10.3 Affirmation of the consequence Two-premise

S: She studies late in the library so she has an essay to write. Should I look for more conclusions?
E: if there are any more.
S: no. this is my conclusion.

C.10.4 Denial of antecedent Two-premise

S: I cannot conclude anything from this. The only certainty is that if she has an essay to write. But it does not say what she do if she has no essay to write.

C.10.5 Modus Ponens Three-premise Alternative

S: she has an essay to write so she is late in the library. I don't care about the second sentence because nothing is said about the exam. If the thirds sentence

would have been 'she is late in the library' I could say she either has essay or an exam. But it only given that she has an essay so I can conclude that I can find her late in the library.

C.10.6 Modus Ponens Three-premise Additional

S: She is late in the library. Actually I can conclude she has no life because she will study late in the library as long as it is open. I wonder what she should do if she has an essay and the library is closed.
E: and providing these are the only given premises.
S: that since she has an easy to write she will be in the library (assuming the library is open).

C.10.7 Modus Tollens Three-premise Alternative

S: the conclusion from this is - since she does not study late in the library she has no essay or exam. Because, if she had either one she would be late in the library.
E: Could it be she is in the library for other reasons.
S: It could be but it doesn't say here. It only say she does not stay late in the library.

C.10.8 Modus Tollens Three-premise Additional

S: that could mean that the library is close. It cannot mean she has no essay to write.
E: what do you mean by that?
S: I cannot conclude she has no essay to write. Could be she has an essay but the library is closed. But I guess Can I conclude she has no essay to write? I cannot say she has no essay to write.
E: is there anything you can say?
S: The structures of sentence guide me to the conclusion she has no essay to write but I cannot say so. It could very well mean that library is closed. Without the extra information I would say she has no essay to write but not that sentence. Unless she only has an essay to write when the library is open.

C.10.9 Affirmation of the consequence Three-premise Alternative

S: so she either has an essay or an exam or both.
E: is there anything else you would like to add.
S: no.

C.10.10 Affirmation of the consequence Three-premise Additional

S: I can conclude that the library is open. But it does not necessarily mean she has an essay to write. Because she will be late in the library anyway if it's open. It could be she has an essay but it is not a definite conclusion.

C.10.11 Denial of the Antecedent Three-premise Alternative

S: that could still mean she is late in the library because she may have an exam but we cannot be sure about it.
E: so is there anything that can be concluded?
S: no. I cannot conclude anything for 100

C.10.12 Denial of the Antecedent Three-premise Additional

S: I cannot conclude anything from this because it might be that the library is open and there for she is there late. The only thing that is given is that she has no essay to write. It does not say if the library is open or not and it does not say if she is there late so there is no conclusion to be drown from it.
E: so how do you consider the second sentence?
S: I cannot do anything with the second sentence. If it was saying that the library is open now I would say that she would be there late but it does not say so.