# How illiterates interpret syllogistic problems

**MSc Thesis** (*Afstudeerscriptie*)

written by

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## Abstract

In this thesis I have tried to find an explanation for the difference between literate and illiterate people in solving syllogistic tasks. I have formulated a list of experimental tasks designed to test a range of existing and new theories on this question. I interviewed over 23 illiterate subjects.
The results are in some sense more puzzling than expected. They provide interesting new clues compared to the existing data from earlier research, and they falsify all (my) hypotheses. In chapter 4 I therefore come up with a new hypothesis, conjecturing that illiterate people do not impose constraints on verbal information of a theoretical nature. These constraints are needed to enforce new information *beyond the information given*, when two or more pieces of information are integrated. Only a lack of such constraints can explain the explicit inconsistencies encountered in the transcripts.

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# 1 Introduction

In his well-known research in Central Asia in the 1930's, Luria (1976) revealed a stunning relation between literacy and (syllogistic) reasoning. Illiterates apparently refused to draw conclusions from even the simplest premises. By way of an example:

Exp: In the Far North, where there is snow, all bears are white.
Novaya Zemlaya is in the Far North.
What color are the bears there?
Subj: I don't know what color the bears there are, I never saw them.

Other subjects mixed up premises with world knowledge, answered from experience or made a guess. Only few subjects used the information in the premises to find an answer.
Cole and Scribner (1981) later argued that the relation of this phenomenon with literacy might actually only be indirect, as they showed that it occurs in an unschooled population as well, even if the subjects do master some written script.
In this thesis I will examine the cognitive side of the phenomenon. Thus, I do not aim to find support for either of these explanations at the level of social or educational differences, but I will try to provide these theories with a background at a more fundamental level of *individual* skills or development.

A wide range of two-premise tasks has become traditional in this field, but in this research I will focus on those tasks employing a universal quantifier, as in:

All $A$ are $B$
A certain $x$ is an $A$

followed by the question:

Is this certain $x$ a $B$?

or a WH-question asking for the same, such as "What about this certain x?"
For different technical reasons the task cannot be called a proper syllogism[1]. Moreover, the premises are often embedded in a small story or context. I will therefore refer to such a task as a pseudo-syllogistic problem, *PSP* for short.
Before engaging in test questions and judging answers, it is good to be clear about what we *expect* subjects to do with a PSP. We will have to agree on a competence answer. What is the adequate solution to a PSP?

[1] A syllogism is an argument (not a question) consisting of two categorical (not singular) premises and a conclusion.

Strictly speaking -and we will see later on that speaking strictly is a rewarding attitude in this case- a PSP is a trick question, for the answer is not in the information given. What we therefore expect subjects to do is what Bruner(1973) has called *going beyond the information given*. In this case, going beyond the information given consists in assuming the premises true, and more or less reading off further information from the resulting picture. The answer that can be found by assuming both premises true in the above example is exactly that "this x must be a B", even though this information was not in the premises.
For a logician it might be hard to accept the difference between the information given and this obvious answer, because he is trained to see that the information given *cannot* be true without the answer being true. The information 'beyond' is actually contained in the information given, because no situation is possible in which the premises are true and the conclusion is not. Yet I claim that this difference between information given and information beyond the given, is exactly what causes the trouble in the illiterate answer pattern. The impatient reader may skip to chapter 4.

### Terminology

Because in simple cases most literate people manage to find out that "this x is a B", we classify such answers as 'classical'[2]. For shortness I will use the term *cl-answer*[3]. Conversely, I will use the term *noncl-answer* for the typical non-classically logical answers as described in the work of Luria, Scribner and others. This includes all answers that do not convincingly show that the subject has *inferred* the cl-answer from the premises. A mere 'lucky shot' is thus also counted as a noncl-answer. A special kind of noncl-answer is a refusal to answer the question altogether, which will be specified as *nescio*. Subjects giving mostly noncl-answers will be referred to as *noncl'ers*, for shortness. Obviously, *cl'ers* are people giving -in general- classical answers. I will give a more detailed account of these answer categories in chapter 3.

### Positioning with respect to other research

Luria and Cole & Scribner where interested in the effect of literacy on peoples cognitive capacities. The purpose of their experiments with PSPs was to establish a relation between literacy or schooling on one side, and (pseudo)syllogistic reasoning on the other. A large group of subjects with subtly varying degrees of schooling was needed to control the first parameter. As a consequence, the boundary between classical and non-classical

[2]With slightly more difficult syllogisms the number of correct answers drops dramatically, even with educated subjects.

[3]In other than syllogistic tasks, the term cl-answer also refers to the classical, literate competence answer, even if this is not in the form "x is a B". A more detailed definition of answers types is provided in chapter 3.

answers was expected to be found *between subjects*.

My aim in this experiment was not to find the social cause of the phenomenon. The difference between the distinctions schooled/unschooled or literate/illiterate did not play a role of importance, as I was interested in explaining the phenomenon at a different level.
I took the occurrence of noncl-answer patterns in a certain category of subjects (be it illiterate, unschooled or other) for granted, and tried to understand how the phenomenon can be explained at the individual level, searching for cognitive or psychological factors. As a consequence, my research approached the group of subjects from a different angle (see table 1 below). Of course, for any theory on this phenomenon to be convincing, we expect it not only to explain the answer pattern on this level, but to fit the obvious (cor)relation with literacy/schooling as well.

My initial hypothesis was that the explanation for these answer patterns is not a lack of (learnt) reasoning skills but the unfamiliarity with certain problem types, and the conventions that they bring along. These conventions mainly regard the way the task and the problem is to be interpreted. In other words: problems arise already before the actual process of deduction takes place. This predicts that a boundary between answer types (cl versus noncl) coincides with a difference in *task types*, even when presented to *one and the same subject*. The experiment therefore consisted of a series of PSPs and other tasks of decreasing difficulty, where the criterion for *difficulty* roughly coincides with possible interpretational ambiguity.
In table 1 I have tried to visualize my approach as opposed to most other studies in this field. The vertical line represents the social or educational dimension: what exactly distinguishes cl'ers from noncl'ers? As a consequence, researchers like Scribner, Cole and Luria are mostly interested in the row left of $\Leftarrow$.
The horizontal lines represent the slight changes in presentation and formulation of tasks that were expected to ease the difficulties in regular PSPs. I am interested in the column above $\Uparrow$, and the purpose of the current experiment was to find task $i$ or -to be more precise- to find what feature of PSPs is represented by the horizontal line between task $i$-1 and task $i$.

| | **cl'er** | **noncl'er** | |
|---|---|---|---|
| **task 1(PSP)** | *cl* | *noncl* | ⇐ Scribner, Cole, Luria |
| **...** | *cl* | *noncl* | |
| **task *i*** | *cl* | *cl* | |
| **...** | *cl* | *cl* | |
| **task *n*** | *cl* | *cl* | |
| | | ⇑ | |
| | | Current experiment | |

*Table 1. Positioning of the experiment.*

As a hypothesis it is of course rather uninformative to claim that unshared conventions are the source of the problem. In fact it is not very risky to say that language, or communication in general, is *conventional* by nature. There are many conventions at play in conveying and interpreting a syllogism, and so there are as many possible sources for confusion. Which one of those is to blame for the phenomenon at hand?
I did not start from one *single* hypothesis, I had several. In the next chapter I will introduce a series of explanations, some of which I formulated myself. Others are mere thought-out common sense explanations, or hypotheses inspired by the conversations I had with different teachers of the literacy course at the Regionaal Opleidingen Centrum. Some ideas were also brought up in literature by other researchers. In the latter case I will review the evidence that is said to support the hypothesis. In almost all cases I have invented new experimental tasks to test the hypothesis.

I chose to take a rather naive stance towards all hypotheses: I think that if we want to make the most of the opportunity to interview almost 30 illiterate volunteers, we should take all possibilities into account, even very simplistic theories. Of course, I was inclined to put my hopes more on some explanations than on others. In the next chapter I saved the best ones for last.
In chapter 3 I will present and analyze the results of the experiment. We will see that most changes in tasks indeed led to slightly higher number of cl-answers, but none of them enough to enable me to identify one of the hypotheses as the obvious and undisputed cause of the noncl phenomenon. Two tasks did show a remarkable difference in percentage of competence answers: 40% for the 'daughters task' and 70% for the 'box II task'. The hypotheses that these tasks were supposed to test, had by then already been falsified by other results. However, the data are inspiring.
In chapter 4 I will therefore present a new hypothesis at a much more fundamental level of task interpretation. I will show that the results of my experiment may not exactly prove, but nevertheless strongly suggest that illiterates in certain circumstances do not *go beyond the information given.*

# 2 Hypotheses

If the explanation for noncl-answer patterns is really not a reasoning disability, then there must be some feature of the questions asked that makes noncl'ers apply their reasoning ability in a what only *seems* an illogical way. In most of the existing literature, explanations are sought in the genres, language activities and social contexts that play a role in interpreting and solving PSPs. If it can be proven that these practices are taught *exclusively* in school, this would explain the relation between schooling and answer patterns.
In this chapter I will discuss the essence of most plausible theories and the factors that are supposed to cause the seemingly illogical answer patterns. I will find what they predict and to what extent these predictions are met by existing data. On the other hand I will show that these theories are not entirely satisfying, and that new hypotheses are needed to answer some important remaining questions. To test these hypotheses I have designed new experimental tasks.

**The intelligence-factor**

We have assumed that noncl'ers do not lack a logical ability. However, most people's intuitive reaction to the fascinating phenomenon of noncl-answers is that noncl'ers are "intellectually underdeveloped", or some other euphemism for stupidity. To most literates a PSP seems so simple, unambiguous and straightforward that one starts to wonder if a noncl'er is actually capable of making the inference:

$$\begin{array}{l} \forall x(Px \rightarrow Qx) \\ \underline{Pa \qquad\qquad} \\ Qa \end{array}$$

That is: are they capable of 'transferring' a predicate $Q$ that is known to hold for the class of elements $\{x|Px\}$ to an individual element $a$ that is known to belong to that class.
Obviously, assuming that someone cannot make this inference would bring along a load of problems and questions, for it seems impossible to survive without these simplest of all simple and basic logical skills. However, we cannot rule out any explanation a priori. To make sure that noncl'ers can make the inference as such, we will have to come up with a task that presents these premises in an unambiguous way, that is, a presentation that avoids all interpretational, cultural, semantical (etc.) ambiguities that come along with any verbal presentation of the problem. I have therefore chosen to present the 'premises' visually, as a situation in the real world. (All task descriptions are marked with a ★)

**★ Box II**
I present subjects with a tray containing three red boxes, and show them that each box contains a ping-pong ball (see appendix). I close all three boxes. After that, I turn the tray around its vertical axis so as to hide the boxes behind the lid, and directly produce one of the boxes again. Thus there are two boxes out of sight but still on the table, and one box on the table in front of the subject. Since all three boxes look exactly the same, the subject is not be able to recall the contents of the individual box. Instead, she has to recall that all red boxes contained a ball, and *infer* an answer to my question: "What is in this box?".

One may object that this task does not test proper reasoning, for there are no premises: there is only a question about a situation. It is important to see that in this task, just like in a regular PSP, we provide the subjects with incomplete information. The observed situation does not suffice in itself to answer the question. In the introduction I already stated that we expect subjects to go beyond the information given. The task is to construct a picture of the situation based on the information given, and then 'read off' what must be the answer to the question.
In this case the information given is nonverbal, but nonetheless *incomplete* with respect to the question. We do not show the contents of the individual box. To arrive at a correct conclusion, the subject has to go *beyond the information given.*

**The exactness-factor**

An other somewhat simplistic but intuitively plausible theory pops up if one hears about the noncl phenomenon. What if the word 'all' simply has a different *meaning* for illiterates? It seems reasonable to assume that in an illiterate community, concepts like accuracy, preciseness and *Pünktlichkeit* are less highly respected than in academic communities. Everyone who has been outside the Western/academic world, knows that *one o'clock* can sometimes mean *afternoon* and that *50 Thai baht* may turn out to mean anything between 25 and 70 baht. Indians are well known for reducing distances when they show tourists the way to wherever.
Add this experience -not completely free from Western prejudices- to the fact that most illiterates do not even use a watch, money or other measures, and one realizes that illiterates may not necessarily use the same criteria for exactness as we do. Gordon (2004) has actually shown that there are illiterate tribes whose counting system consists of the numbers "roughly one", "roughly two" and "many".
This all shows that it is not needless to check whether illiterates have a concept of 'all' at their disposal as distinct from "approximately all". For completeness we will therefore test the subject's understanding of the nat-

ural language quantifier.

★ I present the subjects with three red boxes, and show them that each box contains a ping-pong ball. Then I close the boxes and ask them:

> **Box I**
> Is it true that all red boxes contain a ball?

I proceed with task *Box II* as explained above. When this is done, I put all blue boxes on the table. I show that two of the blue boxes contain a ball, but the third one does not. I close the lids, and ask:

> **Box III**
> Is it true that all blue boxes contain a ball?

Of course, this task cannot dismiss the possibility that noncl'ers interpret 'all' as 'approximately all', but it can show that *on a domain of three elements*, one exception is enough to discard the natural language universal quantifier.

**The memory-factor**

Many researchers working in this field have noticed that it seems very hard for illiterates to *remember* premises. Luria already showed that most subjects were not able to repeat a PSP even after having heard it up to three times. It should not come as a surprise that 'literal wording' is not a concept that illiterates intuitively understand, but it is remarkable that their answers often did not even come close to correct *paraphrases* of the logical or semantical structure of the task. Luria (1976) describes distortions of the PSP:

> Precious metals do not rust.
> Gold is not a precious metal.
> Does it rust or not?

into more or less random statements like:

> Precious metals rust. Precious gold rusts.

Of course, one cannot expect an answer to be logically consistent with the premises if somehow the starting point of reasoning was already completely different from those premises. Thus, bad (linguistic) memory could cause noncl-answers.
On the other hand we should avoid rash conclusions about the memory-factor. Let us assume that for some *other* reason yet to be found, noncl'ers do not see how the premises form one consistent system of statements. Subjects may then not be able to repeat the premises, exactly *because* they

don't see a logical structure, in stead of the other way around. Bad memory may be symptom as well as a cause. It is therefore difficult to assess the importance of this factor experimentally.

★ In case of noncl-answers I will always ask the subject to repeat the premises. If the subject appears to have reasoned from an incorrect starting point, I will try to make the original premises clear by repeating them.

**The exam-factor**

A PSP constitutes a special type of question. Following Hintikka (1975), an exam question in general can be considered *non-standard*, since it seeks information that the questioner obviously already has. Stenning and Van Lambalgen(2007) write:

> Imagine the confusion the subject gets into if he interprets the experimenters question as a sincere request for information.

I will call this possible source of confusion the *exam-factor*.
It is unlikely that this factor alone can account for noncl-answers, if it can at all. It seems reasonable to assume that despite its non-standardness, the use of this type of questions is quite natural after all. They are used in riddles and language games which are part of every culture, and it is hard to imagine raising a child and learning it to speak a language without ever using test questions.
But apart from those general considerations, even experimental data show that noncl'ers do know how to answer test questions. The simplest test questions are probably those on memory which were part of (a.o.) Kurvers' (2002) experiment. Subjects were asked to remember a short story that the experimenter would read from a book. Although not all subjects could answer all questions about the story correctly, there was no confusion about what they were supposed to do: to echo the information the experimenter had been reading to the subject just minutes before.

★ In my protocol I did not include new tasks to test this factor specifically. I expected that problems of this kind would be reflected more in the way subjects react to the questions in general, than in specific predictable answers.

**The reliability-factor**

This possible explanation of noncl-answers is related to the exam-factor. It has to do with the fact that before anything is asked, the questioner gives information (in the form of premises) that is obviously related to the question. For a schooled, this is a *clue* that she is supposed to take this information as

a given, and use it to infer an answer from[4]. The unschooled subject however may not be familiar with this convention, and she may decide that the information in the premises is just not good enough to answer the question with. I will call this ignorance of the conventions of PSP's the *reliability-factor*.
If the reliability-factor is indeed crucial in the explanation of noncl-answers, it would mean that syllogistic reasoning as such is not the problem, but hypothetical reasoning *in general* is something that illiterates don't do.
This predicts that noncl'ers cannot solve "story sums": arithmetical problems presented as an everyday problem in natural language sentences. After all, to be able to solve such problem, one has to accept such a 'story' as a given.

Data from Luria seem to confirm this. Luria presented his subjects with arithmetical problems like:

> It takes thirty minutes to go on foot to a certain village, or five times faster on a bicycle. How long will it take on a bicycle?[5]

Most solutions the subjects gave were wrong, and obvious guesses[6]. This could indeed mean that noncl'ers cannot reason from hypothetical information. But of course this result does not yet suffice to prove anything as long as we are not sure that subjects can divide 30 by 5 in a *non-hypothetical* situation. To show that subjects do not lack arithmetical ability to solve the problems as such, Luria asked them to divide thirty (real) buttons among six (real) men. Luria describes one of the subjects proceeding as follows:

> She set out six piles of four buttons each, then added one button to each (...)[7]

This seems to provide support for the importance of the reliability-factor. Apparently the subject does know how to divide 30 by 6 in real life, but refuses to do so in a verbal exercise. If it is true that her refusal is caused by the hypothetical nature of the premises, this would be a strong explanation

[4]Some authors confuse this with a more strict requirement that subjects use *only* the information in the premises. Strictly speaking, this is not required. The supposed requirement however is the focus of the closed-system-factor, explained below. The reliability-factor treated here, would be caused by ignorance of the convention to use the premises *at all*.

[5]Luria(1976), page 121

[6]Although Luria does an unconvincing attempt to show that results are better when problems are in line with practical experience.

[7]The subject comments: "If I take half a ruble from each, it still won't be enough... Can you divide a ruble? Or do you leave the ones left over?" Not only is it unclear what the subject tries to say with this -she has accomplished the task and there are no rubles left-, it is also completely unclear why Luria mentions this.

for the whole noncl phenomenon: all PSPs require acceptance of hypothetical premises.

But there are other ways to explain these data. Let us take a closer look at both tasks, starting with the verbal task. Luria makes the unschooled subject divide thirty *minutes* by five. That is, the subject has to understand that going five times faster means covering five times more distance in the same period of time, *or* covering the same distance in five times less minutes. From there, she has to decide that the latter is the appropriate perspective to solve this problem, understanding that distance is given and traveling time is asked. Finally, she has to be able to divide thirty by five.

The relation between speed, distance and time, with its duodecimal system, is a complex one, that is usually taught only in the last years of primary school. Apart from this, I claim that dividing thirty by five is certainly not something that just any unschooled can do. Of all basic arithmetical operations, division is by far the most complex. Arithmetic at primary school starts with simple additions with numbers below ten. Only after two years[8] of intensive schooling, working with basic multiplication is attainable.

It is important to note though, that humans have no intuition for multiplication with higher numbers (say: above ten). Multiplication is not learnt by *understanding* rules, nor is it *trained* by doing exercises. The only way to master multiplication tables is by rote learning, and applying them is using *knowledge* more than practice *skills*. It is very unlikely that an unschooled can acquire this arithmetical knowledge on her own[9].

This all seems to be falsified by Luria's second task, which purpose it is to prove exactly that the subject does have the knowledge to divide thirty by six. Is it convincing? Suppose that the subject does know that $30/6 = 5$. Then why would she start with six piles of *four* buttons? To me, this suggests that the subject has no idea how to solve the problem. She starts with a rough guess (four buttons each) and fine-tunes it with the remaining six buttons.

All in all, Luria's story sums do not provide an argument for the role of the reliability-factor in noncl-answers[10]. Actually, I claim that it hardly plays a role at all. Subjects do know how to reason from hypothetical premises, and they will in general accept those premises, even if they are not in line with experiences in the real world.

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[8] Information from different primary schools.

[9] To make students at Teachers Training College (PABO) aware of this lack of intuitive understanding in preschool children, they practice arithmetic lessons with a special textbook from the "Land of Oct": using an octonary system. Following this comparison, Luria's task is as difficult for an unschooled as dividing 30/6 in an octonary system is difficult for us.

[10] "Reliability-factor" is my term. Luria did not use this task to test the reliability-factor. Nevertheless, the task seems suitable for this purpose.

★ To show this, I presented noncl'ers with two story sums:

> **Basket**
> Suppose I have a basket.
> First, I put two bottles of water in it.
> After that, I put one bottle of wine in it.
> How many bottles are there in the basket?
>
> **Tram**
> A tram is driving through Rotterdam.
> Two horses enter the tram.
> A little later, two elephants enter the tram.
> How many animals are there in the tram?

I deliberately put a bottle of wine in the first question, inviting comments about alcohol (all my subjects being muslims). The horses and elephants were ingredients meant to disturb the subject's interpretation even more. Still, I expected subjects to be able to solve these problems without any difficulty. They would take the premises as given, and calculate an answer on that basis.
This would then show that the reliability-factor is *not* the explanation for noncl-answers, and that noncl'ers understand that premises have to be accepted as a given, regardless of whether these are acceptable assumptions (basket) or blatantly ridiculous (tram).

### The closed-system-factor

Most authors confuse the reliability-factor with a more strict requirement that the subject use *only* the information given in the premises. Scribner(1977) calls this the 'theoretical mode [of thinking]', as opposed to the 'empirical mode'[11]. It is obvious from transcripts that noncl'ers often employ this empirical mode, using their world knowledge, personal experience with objects and situations mentioned in the premises, and even pure imagination. Several authors notice this fact, and give it a central place in their explanations:

> [The noncl-answer] is typical of those individuals in cultures that have no writing. They tend to make inferences based on knowledge and experience rather than logical acumen. (Johnson-Laird, 2006)
>
> The conditions of the problem do not form a closed logical system within which the appropriate computational processes should be

[11] Scribner (1977), page 488-490

> carried out. Instead, the subjects either make attempts to answer the question by guesswork or appeal to concrete personal experience (...). (Luria, 1975)
>
> (...) people can and do engage in valid deductive reasoning on verbal logic problems, provided they put brackets around what they know to be true and confine their reasoning to the terms of the problems. More often than not, traditional villagers fail to do just that. (Scribner, 1977)
>
> Apparently working with a closed system of statements is something that starting readers still have to learn. (Kurvers, 2003)

Strictly speaking however, 'putting brackets' around what one knows is a superfluous requirement for solving a PSP. After all it is a property of classical logic that adding premises to a valid argument scheme cannot change its validity. Most authors fail to explain how an 'open' system of statements would invite nonmonotonicity.
For, even if there is an obvious relation between the answers given and plausible world knowledge, this leaves unexplained how noncl'ers deal with the conclusion that is *logically implied* by the premises. Accepting the premises as true has consequences. Then why do illiterates disregard these? Let us take a closer look at different answer types, and see how a failure to put 'brackets' around the premises can or cannot explain them.
In the simplest case the subjects gives a cl-answer. Theories assuming the influence of the closed-system factor allow two different pictures of the illiterate reasoning process in this case. If there is the set of given premises $\Delta$, a set of propositions of world knowledge $\Gamma$ and a correct conclusion $\phi$, the following is one possible way to picture the subject's reasoning steps:

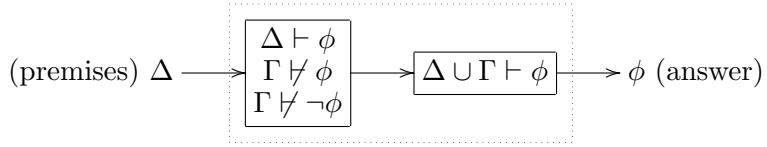


*Diagram 1. Reasoning process in case of cl-answer*

In this picture the available world knowledge $\Gamma$ is silent about $\phi$. However, $\Gamma$ allows an update/union with premises $\Delta$. Indirectly, the cl-answer is then based on the same grounds as in the literate case: because it follows[12] from the premises.

[12] I use $\vdash$ to express some entailment relation without intending to suggest that this is syntactic, semantic or otherwise.

The other possible picture is:

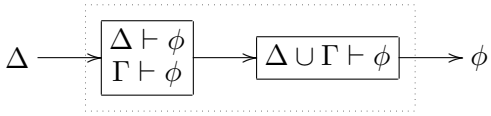


*Diagram 2. Alternative reasoning process in case of cl-answer*

In this case the subject simply adds the premises to her world knowledge, without this really changing the answer she would give without having heard the premises. Hearing her answer, we don't know if she inferred it from the premises or from experience. When we ask her, the subject will justify her conclusion with reference to either world knowledge ("I know that $\phi$") or given premises ("From what you said, it follows that $\phi$"). Thus, in case of a cl-answer the closed-system-factor provides two explanations.
However, subjects often give answers that may follow from world knowledge, but contradict the premises. In the next chapter I will refer to this type of answer as "false". The closed-system explanation explains this by assuming world knowledge to contradict the cl-answer. However, this leaves one reasoning step unexplained, since world knowledge and premises are not reconcilable:

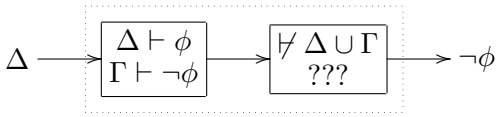


*Diagram 3. Reasoning process in case of false answer*

There seem to be basically two possible answers to the question marks in the second box of diagram 3: one possibility is that the subject *ignores* the incongruence between what follows from world knowledge and premises, and gives one of two possible answers. She (consciously or unconsciously) accepts the fact that the opposite answer is possible as well. Given the relation noncl'ers - unschooled, this suggests that avoiding contradiction is something we learn at school.
Another possibility is that world knowledge apparently *overrules* the premises: $\Gamma$ is somehow more 'entrenched' than $\Delta$, which is then dismissed as unreliable. This is not a very satisfying explanation either: it is a roundabout formulation of the reliability-factor, for it comes down to saying that noncl'ers do not accept premises if these are inconsistent with their world knowledge. It makes one wonder what criteria noncl'ers use for belief revision.
The latter question becomes especially relevant in case the subject refrains

from giving any answer at all. The only way to include the closed-system-factor into an explanation of the nescio, again leaves the second reasoning step unexplained:

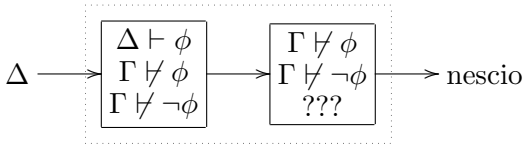


*Diagram 4. Reasoning process in case of nescio answer*

Conclusion $\phi$ does not follow from $\Gamma$, or at least not convincingly enough to base an answer on. Now how would this 'knowledge' overrule the premises, even if it remains silent on the topic? What has happened with the premises that makes ignorance overrule them? If it is true that illiterates prefer world knowledge over given information even if world knowledge is uninformative, this would mean that in all cases, premises have no influence on the answer. This means there is actually no logical or semantical relation between question and answer apart from the topic under discussion. Subjects give either an experience-based answer, or no answer at all. In this light, to speak of an 'empirical *solution*' to the problem would be rather overrating the answer as such. In fact, the subject completely disregards the problem in stead of solving it. Thus, an 'empirical' answer, in Scribner's theory, is little more than a random association with the topic under discussion. Giving world knowledge a role in our explanation of the noncl-phenomenon actually deprives the premises of their role.

Some support for this conclusion can actually be found in existing transcripts. Scribner quotes the following conversation:

| | |
|---|---|
| Experimenter: | All Kpelle men are rice farmers.<br>Mr Smith is not a rice farmer.<br>Is he a Kpelle men? |
| Subject: | I don't know the man in person. I have not laid eyes on the man himself. |
| Experimenter: | Just think about the statement. |
| Subject: | If I know him in person, I can answer that question, but since I do not know him in person I cannot answer that question. |

Here it seems that the subject indeed refuses to draw a conclusion because his world knowledge cannot corroborate it. These answers seem to support the reliability-factor or the closed-system-factor.
Yet such explanation -if it would be the whole explanation- is very unsatis-

fying. It comes down to saying that noncl'ers -in practice most illiterates- do not attach much value to what is being said, because they only believe their own senses. Such an exclusive trust in world knowledge would completely block not only belief revision but even simple belief update, as long as it is not supported by personal experience. Illiterates must then be in a communicative dead-end. It would be a justified question to ask what they use language for at all. This is certainly not the type of explanation we would like to content ourselves with.

Most authors do not realize the problematic consequences this type of explanation brings along. Moreover, most theories would -if they were correct- at most be a partial explanation of the phenomenon. As an example of this I quote from Stenning (2002). He treats two examples of noncl-answers: the famous Kpelle-answer quoted above and another well known example from Scribner and Cole (1981):

E: All people who own houses pay a house-tax.
Boima does not pay house-tax.
Does Boima own a house?
S: Boima does not have money to pay a house tax.

Stenning (2002):

> In both examples the subject construes the problem as one of expanding on the situation of the problem's words, even though the reference is known only to E. In the first case [Kpelle, see page 16], the subject points out that she cannot join in this discourse on these terms, for lack of first-hand information. In the second case [Boima, this page], the subject adds a plausible further assumption, perhaps in the spirit of telling a fictional story communally authored with the experimenter?[13]

I have already pointed out why a lack of first-hand information cannot be the reason for a nescio-answer, if we assume that illiterates can understand and accept given premises: since the answer is *contained in the premises*, first-hand information is not needed. Our task is not so much to show where subjects find their answers, as it is to explain why subjects do not use the answer that is contained in the premises.
In the second example Stenning's explanation sounds plausible, but it does not apply to the stronger type of noncl-answer: false. In that case, the subject is not merely 'expanding' on the situation, but *changing* it, by given an answer that is *inconsistent* with the premises. Our task, once again, is to explain how noncl'ers can ignore that inconsistency.

[13] Stenning (2002), page 139.

But there is even more reason to doubt the importance of the closed-system-factor. It may play a role in much later stage of reasoning than Stenning and most other authors assume. The fact that subjects often refer to world knowledge when asked to motivate their initial answers, does not necessarily mean that they don't know how to 'put brackets' around the premises. Suppose that in a first stage they do confine their reasoning to the premises, but for some reason yet to be found, *nothing follows*. Some subjects will tell the experimenter so. Others may feel uncomfortable or stupid not being able to give an answer, or they may just be unfamiliar with this type of problems and ignorant of the purposes of the experiment. They may then seek resort to imagination or world knowledge *only in a second stage*. This reaction should not surprise us too much, for I think it is a very natural thing to do. If we are being asked a question like:

> A man finds a small metal box on the sidewalk.
> He opens it.
> What does he see?

we would understand this as an invitation to make a guess, *because it is obvious that we cannot know the answer*. Now if we agree that noncl'ers do not see the answer as contained in the premises of a PSP, 'expanding the situation of the problem's words' is not so strange a reaction. In that light, I can almost agree with Stenning's claim that:

> These [noncl-]responses are not the exercise of some special logic that only members of unschooled societies possess. They are exactly the kind of responses we make in different circumstances. It is just that we rarely interpret this as the kind of discourse invited in this context by the experimenter's words.

Subjects may indeed just be 'expanding the situation' when no easy answer can be found. But that is only a partial explanation of the phenomenon. It explains the subject's reaction to a -in her eyes- unsolvable problem: it does not explain why the problem is unsolvable to her in the first place. To answer that question we might need a 'special logic' after all.

It is very hard to determine the stage in reasoning where world knowledge interferes, and in existing data there is no evidence that it either plays a role in the whole process of interpretation and reasoning, or it comes in only *after* reasoning based on premises alone has failed. We cannot tell whether it is symptom or cause of the concl phenomenon.

Suppose however that the closed-system-factor does play a role even in the first attempt to solve a problem. This would bring along certain predictions

that can be checked. One such prediction is that arithmetical problems cannot be answered. For, contrary to PSP's, arithmetical problems are non-monotonic by convention. Adding new information to the premises can alter the conclusion. The convention requires that one disregards possible abnormal situations if they are not explicitly mentioned. If illiterates are really not used to do this, as the closed-system-factor claims, this predicts that for the basket task we get responses like:

> How many bottles where there in the basket initially?

For the basket task these doubts may seem far fetched, but in the tram task a lot of world knowledge imposes itself. First of all the story is situated in Rotterdam (Amsterdam respectively), a name that will evoke all kinds memories of experiences and world knowledge in the subject's mind. The 'little later' in the premises suggests that something might have happened in between. If horses can enter a tram then why couldn't they get off as well? Do elephants fit into a tram? Is a default tram empty? The story sums thus serve a double purpose in this experiment.

Related to the closed-system factor are all explanations based on the allegedly strict distinction between 'content' and 'form'. Such theory claims that we as schooled people are better in separating form from content, and thus are able to disregard our world knowledge while solving a PSP. The strict distinction between content and form is of course questionable, but I will not go into that question here. In stead, it seems wise to invent a PSP where content does not trigger any world knowledge, and see if performance improves. It seems that the only way to do so is by using neologisms: words without any meaning. We did this in the knuf task.

★ The story sums in my protocol serve a double purpose: they check both the reliability-factor and the closed-world-factor.
Besides that, I will ask subjects to justify cl-answers, to check whether they reasoned from world knowledge or from premises.

★ The knufknuf task is a PSP with nonsense words. To avoid complete confusion and to assure ourselves that subjects do not associate any real world objects with the words, we will tell them that we have made up the words ourselves. The words are chosen such that they resemble real words (ratelaar), or are easy to recognize (knoefknoef)

> **Knuf**
> Do you know what a knufknuf is? No wonder, because it is a fantasy word that we have made up ourselves. All you have to remember is that all knufknufs have a rattler.
> All knuknufs have a rattler.

Molly is a knufknuf.
Does Molly have a rattler?

**Other logics and the exception-factor**

So far, we have been tacitly assuming that the competence answer to a PSP must be a result of applying classical logic. The assumption is that cl'ers translate the natural language PSP into some mental representation which functions as the starting point from where classical logic takes over. This intuitive picture of the process of solving a PSP is as follows:

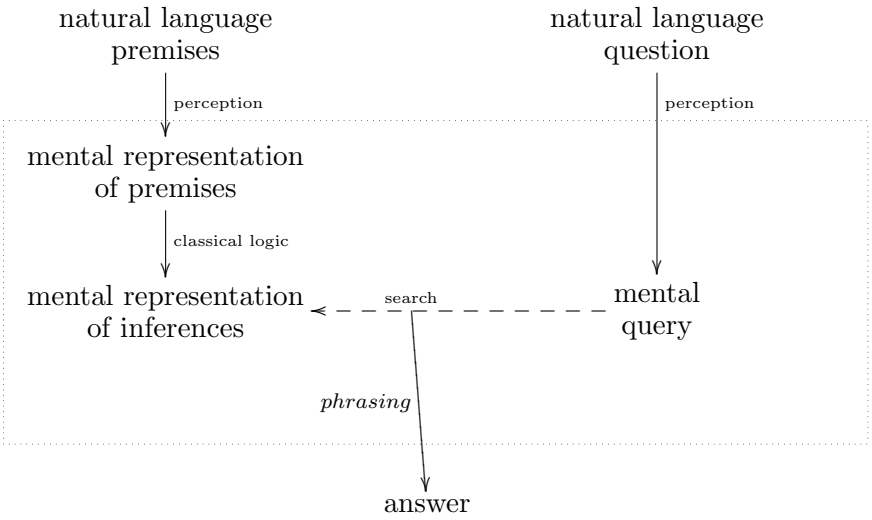


*Diagram 5. Naive picture of reasoning process*

Now we observe that noncl'ers do not give the competence answer, and we conjecture that something must go wrong in either the perception or the inferential step. We invented the box II task to ensure that the inferential step does not pose a problem for our subjects in terms of reasoning capacity. If this is true, as we expect, this would seem to leave us with only the perception step to find the noncl-er "mistake". Most of the factors treated above are indeed concerned with questions of *how does the subject understand the premises* and *do subjects know what answer is requested?*
There is however reason to doubt the picture in diagram 5, and the assumptions underlying it. Stenning and Van Lambalgen (2007) claim that classical logic is not the system most natural to human reasoning. Even worse, there may not be one single logical system modeling all human reasoning: different logics may be used for different situations / problems. This changes the character of the perception arrows drastically. Merely translating natural language into mental representations of propositions of classical logic does not suffice, for the hearer will first have to decide what logic fits the problem

best. Stenning and Van Lambalgen indeed distinguish reasoning *to* an interpretation from reasoning *from* an interpretation. Thus the interpretation is not the starting point, but rather a halfway conclusion.

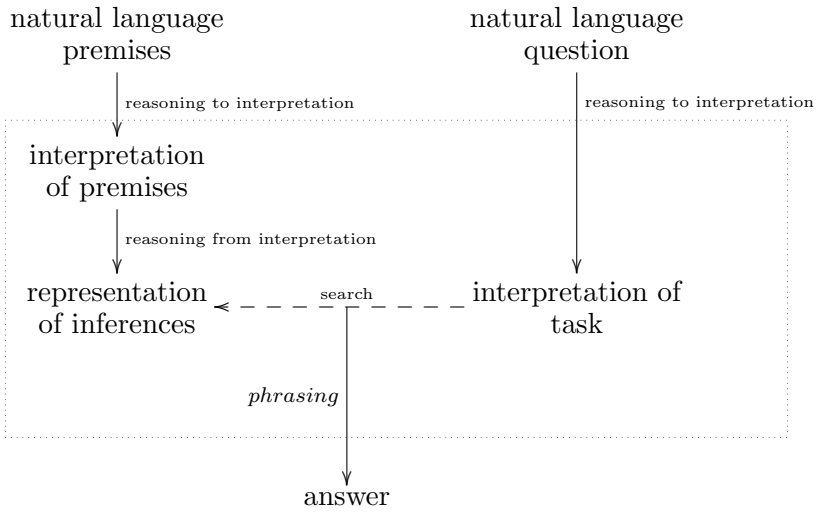


*Diagram 6. More sophisticated picture of reasoning process*

The step formerly labeled 'perception', has now been upgraded to 'reasoning to an interpretation'. The separate arrows with this name may be misleading, because in the process of interpretation they will strongly interact and influence each other. The interpretation of premises is cast in a logical form that cannot simply be extracted from the information given, but has to be *imposed* on the material on basis of context, convention, cooperation principles etc.
The arrow that represented the blind application of classical logic in diagram 5, now represents 'reasoning from an interpretation' with help of some 'suitable logic'. What is suitable is again highly dependent on the interpretation of the task at hand. Thus, in a more adequate picture of Stenning and Van Lambalgen's proposal there must be dotted arrows connecting almost all nodes, all labeled "mutual influence".
Now for most everyday discourse processing, Stenning and Van Lambalgen have modeled the logic that seems most suitable. It appears to predict roughly -or at least explain convincingly- some seemingly illogical answer patterns in empirical data.
The interesting thing for us is that the logic suitable for this 'discourse processing mode' explains why even literate subjects often appear to employ a *nonmonotonic* form of reasoning. We have seen that in theories on the noncl phenomenon that attribute a central role to world knowledge, the apparent nonmonotonicity of the phenomenon is a blank spot in the explanation.

I will therefore take some room to show how Stenning and Van Lambalgen explain *literate* nonmonotonic reasoning in, in order to see whether their explanation is applicable to our case. In the text box below I provide the description of an experimental task with *literates* by Byrne (1989) that may serve as an example case to illustrate Stenning and Van Lambalgen's ideas.

**The Suppression Task**
Byrne presented literate subjects with two premises forming a regular Modus Ponens, as in:

> Whenever Susan has an essay to write, she studies late in the library.
> Susan has an essay to write.

She then added to these premises a third premise, semantically related to the other two, like in the above case:

> Whenever the library is open, Susan studies late in the library.

When such a confusing premise was added, subjects appeared to be less confident in endorsing Modus Ponens: only 38 percent of subjects did so, against 96 percent when no confusing premise was added. From this result Byrne concluded that semantics will overrule logic as an interpretation tool when it is incompatible with it.

*Stenning and Van Lambalgen: Credulous interpretation*
Stenning and Van Lambalgen discern different attitudes a subject can take towards discourse to be interpreted. An important distinction is that between *credulous* an *adversarial* interpretation. Adversarial reasoning employs a sceptical attitude towards given information (premises) as in juridical and scientific context. In these contexts one takes into account all kinds of possible circumstances, regardless of their likeliness, to test the robustness of given information. This reasoning attitude is supposed to be available only after (school) training. We are therefore mainly interested in the other, supposedly more natural attitude: *credulous* reasoning.

> Discourse interpretation involves *credulous* reasoning by the hearer, that is to say the hearer tries to accommodate the truth of all the speaker's utterances in deriving an intended model[14].

This means that the subject will not consider all models that satisfy the information given. In stead she will try to restrict her interpretation to the model that the speaker most likely *intended*. Intuitively this already necessitates a form of nonmonotonic reasoning: the subject must be able to cancel

[14]Stenning and Van Lambalgen (2007), page 157.

early inferences from her interpretation upon getting further details about the intended model.
Stenning and Van Lambalgen introduce a logic to model these idea's. One of its features is that there is not a one-to-one translation of natural language connectives into those of classical logic. An important difference in interpretation concerns the natural language conditional:

> We claim that one meaning of the conditional that naturally occurs to the subject in the suppression task is that of a law-like relationship between antecedent and consequent.(...)We contend that the conditional is often not so much a truth functional connective, as a license for certain inferences. One reason is the role of putative counterexamples; (...) especially in the case of law-like conditionals, such a counterexample is not used to discard the conditional, but to look for an abnormality; it is thus more appropriate to describe it as an exception[15].

I think it is safe to go even a little further: in terms of cooperative conversation, the natural language conditional -when used as a proper propositional connective- *cannot* be interpreted as expressing a purely truth functional connective. That this is necessarily so can easily be explained with help of Gricean maxims (Grice, 1989).
Suppose a speaker $S$ expresses a conditional "if $\phi$ then $\psi$" in natural language, and suppose we interpret it as the truth functional connective $\phi \rightarrow \psi$. The second maxim of Quality then suggests that $S$ has adequate evidence for either $\neg\phi$ or $\psi$ (or both). But if this suggestion were right, $S$ would be flouting the first maxim of Quantity, which requires him to make his contribution as informative as possible: after all both $\neg\phi$ and $\psi$ are more informative than $\phi \rightarrow \psi$. Thus, Grice's maxims tell us that our initial interpretation must be wrong.[16]
If we interpret the statement as stating some *intrinsic relation* between antecedent and consequent, regardless of the truth values of $\phi$ or $\psi$, no maxim's are flouted. Note that this 'intrinsic relation' can be a causal or purely metaphysical, but also a logical relation if the statement is a tautology. In the latter case there is of course just as little room for exceptions as there is in case of a truth functional connective.
But since tautologies are not the kind of statements we tend to communicate with, Stenning and Van Lambalgen are right in their observation that most natural language conditionals are interpreted as general laws, possibly allowing for exceptions. These are acceptable only if one acknowledges that

[15]Ibidem, page 162-163.

[16]One of the weak spots in Grice's original theory is that he does not explain how we 'repair' the flouting of maxims. Starting from the observation that our initial interpretation was wrong, how do we arrive at an alternative, correct interpretation? In this case the law-like interpretation is the most straightforward alternative.

an infinite number of assumptions is implicitly taken to hold. In the context of example the suppression task (see text box), the general law expressed by the conditional holds *if* Susan is not ill, *if* the world has not come to an end, *if* the library is not closed, *if* it has not been transformed into a yellow submarine, etc. The conditional expresses the intrinsic relation between 'having an essay to write' and 'studying late in the library' barring unlikely circumstances. It does not mean to express a complete correlation between occurrences of the two situations.

Stenning and Van Lambalgen propose to represent these tacit assumptions by translating the natural language conditional of the form *if* $\phi$ *then* $\psi$ into a formula $(\phi \wedge \neg\chi) \rightarrow \psi$, where $\chi$ stands for any situation that may block the inference of $\psi$ from $\phi$ only. One can read the condition $\neg\chi$ as: "nothing abnormal is going on", where the definition of abnormality is fully dependent on the context.

If this formula is indeed an adequate representation of the normal interpretation of a natural language conditional, this has of course consequences for reasoning with conditionals. One of the most important consequences is that Modus Ponens is no longer available in natural language. For, as long as the truth value of $\neg\chi$ is unknown, from

$(\phi \wedge \neg\chi) \rightarrow \psi$
$\phi$

nothing follows, or it must be a rather uninformative $\neg\chi \rightarrow \psi$. If it is true that in everyday conversation we interpret the conditional with these implicit proviso's, drawing interesting conclusions on their basis becomes rather hard.
This is where a crucial aspect of credulous reasoning comes to the rescue. Stenning and Van Lambalgen:

> As we interpret the discourse, we take our task to be to construct a model of the story which is the same as the speakers intended model, and we assume that we are to use whatever general and specific knowledge we have, including the assumption that the speaker is being cooperative in constructing her discourse, to help us guess which model this is.(page 29)

In practice this means that the subject does not consider all models of the premises, but only those models in which *nothing abnormal occurs*. This means that all possible disabling conditions $\chi$ can be assumed to be untrue, as long as these are not explicitly mentioned in the discourse as playing a role in the intended model.[17]A proper formalization of the interpretation of

[17]Stenning and Van Lambalgen construct their theory on the basis of Logic Programming, suggesting that human reasoning is based on motor planning. In Logic Programming

the task would thus look like:

$(\phi \wedge \neg\chi) \rightarrow \psi$
$\neg\chi$
$\phi$
conclusion: $\psi$

The assumption that the situation is not abnormal neutralizes the assumed proviso in the conditional. With it, the argument yields (in this case) a conclusions indistinguishable from the classical logical answer.
The difference with classical logic is that reasoning has become nonmonotonic on the level of natural language. The implicit premise $\neg\chi$ is only a *default* assumption, so if we add to the premises in natural language a premise that prevents the assumption of $\neg\chi$, the formerly valid conclusion turns invalid again.
Now empirically it appears that *affirming* $\chi$ is not even needed to reach this effect: merely *mentioning* possible situation $\chi$ is enough to bring it into consideration. This is exactly how Stenning and Van Lambalgen explain the suppression effect: adding a premise $\neg\chi \rightarrow \phi'$ ("If the library is open, Susan studies late in the library") suffices to 'highlight' the possibility of exceptions to the conditional. This highlighting makes that the default assumption $\neg\chi$ is no longer an implicit part of the premises and the truth value of the antecedent cannot be calculated.

$(\phi \wedge \neg\chi) \rightarrow \psi$
$\neg\chi \rightarrow \phi'$
$\phi$
conclusion: nothing follows

Thus, credulous interpretation is a mechanism easily disturbed, and the seemingly classical logical answer is easily 'suppressed'. With this analysis, Stenning and Van Lambalgen provide an explanation of the suppression effect that leaves both logic and semantics their role.
The interesting thing is that this suppression effect also occurs when no disturbing premises are added, although less frequently.

> There are however also subjects who refuse to endorse [Modus Ponens], and in tutorial interviews we conducted we found that this was because the subjects could think of exceptional circumstances preventing the occurrence of $q$ even when $p$. Such subjects combine the enriched representations with a refusal to apply closed world reasoning to the abnormality. (Stenning and Van Lambalgen, page 172)

the frame problem is solved by applying negation as failure: if no application of Modus Ponens yields a proposition $Q$, then $Q$ is not true.

It appears that these (educated) people apply only half of the tools of closed world reasoning: they do interpret the conditional with an implicit proviso, but fail to restrict their evaluation of the premises to the intended, normal case model.
Their answers are very reminiscent of the noncl-answer pattern in Luria-style experiments, or at least of the nescio-type answer. The question imposes itself: can Stenning and Van Lambalgen's theory be used to explain noncl-answers in PSP's as well?

It can, but there is a difference. The major premise of a PSP is of course not a conditional, it is a universally quantified sentence. Since the most straightforward way to represent such premise is:

$$\forall x(Px \rightarrow Qx)$$

we can insert the 'restriction to normality' exactly the same way we did it in propositional logic:

$$\forall x((Px \wedge \neg ABx) \rightarrow Qx)^{18}$$

For the insertion of such non-abnormality condition the same argument applies: in everyday natural language quantification many conditions are left implicit. Let us take for an example the universally quantified first premise of the PSP:

> All bears on the north pole are white.
> Teddy is a bear on the north pole.
> (What color is Teddy?)

We can easily imagine an occasional melanic bear not immediately falsifying the general rule. The universal quantifier according to Stenning and Van Lambalgen's theory is understood as licensing an inference, *given normal circumstances*. The credulous interpretation of a PSP is now:

$$\forall x((Px \wedge \neg ABx) \rightarrow Qx)$$
$$Pt$$
$$\neg ABt$$

where the subject assumes that as long as the speaker does not mention possibly exceptional elements, Teddy is intended to be a prototypical bear: $\neg ABt$.
Now if not applying closed world reasoning to the abnormality in a conditional is really the explanation for educated people who refuse to endorse Modus Ponens, we can imagine that the same happens with PSPs. The interpretation of the above PSP is then

[18] The important difference is of course that here the abnormality is not a proposition, but a predicate: $ABx = x$ is an abnormal element.

$\forall x((Px \wedge \neg ABx) \rightarrow Qx)$
$Pt$

from which nothing follows. We can imagine that this is what illiterate subjects do. I will call this the *exception-factor*.
To sum it up: the exception-factor could provide an explanation for noncl-answer patterns if noncl'ers do interpret the conditional with the implicit proviso that it applies only under normal circumstances, and they fail to compensate this with the assumption that the singular premise is actually true under the same normal circumstances.
There are some questions we need to answer if the exception-factor proves to be important. Why would illiterates interpret some sentences credulously (major premise) and other with a more sceptical attitude (minor premise / question)? Even if it is true that some educated people seem to do this, it is not trivial to find a reason why illiterates would do it more often, and more stubbornly.
And: if it is true that noncl'ers fail to apply closed world reasoning to abnormalities, this predicts that they will perform at least equally bad on a standard Modus Ponens task. Counihan (forthcoming) however has found that with 50% of cl-answers, Modus Ponens appears somewhat easier for illiterates (30% cl-answers)[19]. For completeness I will include a Modus Ponens task in my protocol.

*New tasks*
Now to the tasks. We will have to devise a task similar to a standard PSP, but with the exception-factor neutralized, to see whether this yields more cl-answers. There are two strategies to anticipate possible exceptions to the major premise, based on two slightly different assumptions about where these exceptions really come from.
The naive idea is that illiterates take exceptions into account to the extent that they can *think of* exceptions in the task at hand. If the topic is polar bears, they can imagine or remember melanic bears on the north pole, and therefore they refuse to draw conclusions. The remedy is then to choose a topic such that the subjects cannot think of exceptions, simply because they are not familiar with it. Data from Tulviste(1991) seem to confirm this. Tulviste presented his subjects with two types of PSP's: one with very familiar content and one with material that was completely unknown to the subjects. Among Tulviste's problems were:

Saiba and Nakupte always drink tea together.
Saiba drinks tea at three in the afternoon.
Does Nakupte drink tea at three o'clock or not?

[19]Source: personal correspondence. Exact figures will appear in Counihan (forthcoming)

All precious metals do not rust.
Molybdenum is a precious metal.
Does molybdenum rust or not?

Since noncl'ers were supposed not to be able to think of any exceptions to the premises in the latter case, it was expected that they performed better with this type.
Tulviste's data show that noncl'ers perform slightly better in the second task type. Although Tulviste used these date to prove a somewhat different point[20], they could be seen as weak[21] support for the exception-factor.

The other strategy to neutralize the exception-factor assumes that illiterates will take exceptions into account even if they cannot imagine actual exceptions themselves. Here, the exceptions are a more formal consequence of the law-like interpretation: to each law there can be exceptions. To neutralize such weak-law-like interpretation, more drastic measures are needed than just using unknown topics.
It is important to notice that there is an important difference between Modus Ponens and the syllogism. We have seen that the conditional is necessarily interpreted non truth functionally on the basis of Gricean cooperation maxims. The natural language universal quantifier on the other hand, *can* express a truth functional statement. The following example (from Goodman, 1947) proves that the universal quantifier is not susceptible to the Gricean reductio ad absurdum outlined above:

All the coins in my pocket are copper.

Here, the speaker certainly does not want to state an *intrinsic* relation between being a coin in Goodman's pocket and being made of copper. The universal quantifier does not express a relation, but a mere correlation between two properties. Still no maxims are flouted, because it is far more efficient to quantify over these unnamed elements than to name them one by one.
Thus, the natural language universal quantifier can have a truth functional meaning and interpretation. Now of course if the universal quantifier is truth functional, exceptions are not possible. This could help us design a test for the exception-factor. If we can make sure that the quantifier in the major premise is interpreted as truth functional, according to this explanation the exception-factor should be neutralized. The interpretation of the task is then

[20]Tulviste claims that children acquire a new mode of thinking in school, which they will earlier start to apply to 'school' material than to everyday problems.

[21]Figures: 81 out of 110 cl-answers for known topics, 90 out of 110 for unknown topics. Subjects were from a 'transitional', half-literate group, which explains the high average scores. The difference however is certainly not enough to explain the whole noncl phenomenon with.

$\forall x(Px \rightarrow Qx)$
$Pa$

which justifies the classical answer $Qa$. Here we see the essential difference between the exception-factor and the exactness-factor: the latter is about being sloppy with words, or having a different understanding of the universality of the universal quantifier. The exception-factor on the other hand, leaves the universality of the quantifier intact, but inserts a negated disabling condition in the implication that the quantifier ranges over. If the exactness-factor would explain noncl-answers, it would apply in all interpretations, either truth functional or law-like.

A PSP with a truth functional major premise would therefore be a perfect test for the exception-factor, if not the problem is that we don't know how to *enforce* a truth functional interpretation and rule out a law-like interpretation. It is very hard to come up with sentences that do not allow for a law-like reading. Even Goodman's example can be interpreted as law-like. The solution to this problem is as simple as it is graceless. We simply emphasize that the truth functional reading is intended by explicitly excluding all possible exceptions to the relation. This was done in the daughters task and the animals task.

★ To control the exception-factor we explicitly deny all possible exceptions. This is doable only with a small number of elements. The tricky bit is to predicate $Q$ of all $Ps$ in the domain without using the name or other unique reference that is needed to single out an individual in the minor premise. This was done in the daughters task and the animals task.

**Daughters**
There is a mother who has three daughters: Sofia, Laura and Lisa.
All three of her daughters have blue eyes.
Sofia has blue eyes.
Laura has blue eyes.
Lisa has blue eyes.
One of them is the eldest.
What color of eyes does the eldest have?

**Animals**
A farmer has three animals: a cow, a goat and a sheep.
The cow lives in a stable.
The goat lives in a stable.
The sheep lives in a stable.
All of his three animals live in a stable.

One of the animals is called Blacky.
Does Blacky live in a stable?

★ To see how noncl'ers deal with conditionals in a simple case of Modus Ponens, I added the Susan task. The word 'blue' was meant to distinguish the rough guess from the exact inference.

**Susan**
Susan lives in a cold country.
If Susan feels cold, she will put on her blue sweater.
Today, Susan feels cold.
What will Susan do?

### The domain-factor

The last factor to be treated elaborates on the idea of a strictly truth functional interpretation of the universal quantifier. A truth functional universal quantifier states a *correlation* between two properties, regardless of whether there is in fact a *relation* between the two. As already stated above, for a truthful expression of a purely contingent correlation, an observation of all elements is required. Of course, the term 'observation' has to be taken in a broad sense here. It can be a superficial or rough observation. The information can be second hand. But in all cases, a complete correlation must have been established by checking all elements, for any *extrapolation* over elements beyond the observation would in fact imply a relationship.
Intuitively, this restricts the possible domain of discourse that a truth functional universal quantifier is applied to. The suggestion of a real observation makes quantification over *all* elements of some sort in a truly *universal* domain rather implausible, even if the number of elements is limited. One expects 'all' to range over a limited, known, or at least surveyable domain of objects. For the unambiguous expression of a universal quantifier, it would thus be recommendable to specify its domain beforehand.
Counihan (forthcoming) actually found that in spoken language, the word 'all' is often used anaphorically. These anaphora do not function as a simple quantification over undefined elements, but rather

> [perform] a summarizing function, acting as a kind of fishing net for aforementioned or contextually given referents, about which something further can then be said. Its almost like a group pronoun.[22]

Of 67 occurrences in a mixed corpus, only 8 where straightforward quantifiers, and most remarkably these quantifications almost all appeared in juridical, scientific or religious contexts. These findings make Counihan actually

[22] Counihan, 2007, page 14.

(...)speculate that the whole idea of a universal domain is a literate idiosyncrasy.[23]

One of the typical features of a PSP is of course that the major premise starts with the universal quantifier, without specifying its domain. In this light it is remarkable that traditional tasks in most experiments in this field, the predicate $P$ in the premise refers to a large and indefinite set $\{x|Px\}$.

All bears in the north are white.

All stones on the moon are blue.

All women in Markia are married.

All the stores in Kpelleland are in a town.

Counihan suggests that illiterates are not familiar with this kind of out-of-the-blue universal quantification. It would be hard for them to asses the truth conditions of such a premise, it being unclear what the 'all' refers to. But even if the subject accepts the unusual use of the quantifier, she can only draw a conclusion if she *knows* that the individual element in the minor premise is an element of the *observed group* of elements in de major premise. To be more precise, the domain-factor appears to be a stronger version of the exception-factor. Again, the universal quantifier is interpreted with an implicit proviso. But this time the proviso is that the element belongs to the observed group. Slightly more formally, we use the predicate $O$ to express this. The statement "All P's are Q's" is then interpreted as:

$$\forall x(Ox \rightarrow (Px \rightarrow Qx))$$

When in the minor premise an individual element is introduced which satisfies predicate $P$, it is not obvious that this element also satisfies $O$. Upon hearing the minor premise, the subject has no reason to neutralize the implicit condition in the major premise, contrary to the what is the case with the exception factor. The interpretation of the premises is thus simply:

$$\forall x(Ox \rightarrow (Px \rightarrow Qx))$$
$$Pa$$

from which nothing follows.
To see how interpreting universal quantifiers *non law-like* immediately has this result, we may consider the following extension of the Goodman example:

All coins in my pocket are silver.
I put a coin into my pocket.
What material is the coin made of?

[23]Counihan, 2007, page 22

After having read this task, we as schooled subjects are inclined to reinterpret the first premise as a law, because the task does not make sense otherwise. If we stick to the more plausible coincidental reading of the major premise, we will choose a nescio answer or an open-system answer like "Coins are either copper or nickel(?)". Of course, any predetermined 'competence answer' here is questionable, but the example serves as an illustration of how even a truth functional interpretation can be ambiguous if it is unclear whether the individual element in the minor premise is part of the observed group.

The domain-factor as an explanation for noncl-answers suggests that noncl'ers are somehow inclined to interpret the universal quantifier as applying only to a predefined domain. To check this, I will add to the protocol a PSP where the domain is not only carefully introduced, but also where the individual element in the minor premise is necessarily part of this domain.

**★Brothers**

> I have three brothers and one sister.
> All three of my brothers live in Rotterdam.
> Jan is one of my brothers.
> Where does Jan live?

Notice that in the daughters task and the animals task, the domain is also small (3 elements) and explicitly introduced beforehand. These tasks thus serve a double function.

In the appendix a complete list of tasks is provided.

## Setup of the experiment

Subjects were selected from literacy courses at the Regionaal Opleidingen Centrum in Amsterdam and Zadkine in Rotterdam. Teachers Marjoke de Roos and Cees Breuer very kindly helped me to select approximately 30 unschooled students. Since some of the subjects were somewhat reluctant to participate, I promised to use fictitious names in the transcriptions.
The interviews took place during seven days in an office in the two schools. For the first sessions I got help from a Moroccan-Arabic interpreter. Most subjects were female muslims, and it appeared that being interviewed by two men was a barrier for participation. For the other sessions I therefore hired a female Moroccan-Arabic and a female Turkish interpreter.
A total of 23 interview sessions yielded useful material. Of the 23 transcriptions of these interviews, 7 were excluded from analysis because the subjects gave mostly cl-answers. Most of these subjects appeared to have had some schooling or literacy training in Quran schools.

# 3 Results

## Result patterns

In the interview transcriptions, different answer types are discernable. The most important categories are of course noncl and cl. In the subcategories I distinguish the different kinds of answer justifications and noise in the data.

### Cl-answers

I classify an answer as *classical* if it answers the question, it follows from the premises and the subject at least seems to have inferred it from these premises. An indication for the latter requirement is the justification subjects give for their answer. For all cl-answers, I asked "Why do you think so?". Cl'ers are expected to refer to the premises. I have been rather lenient at this point, counting as classical answers like:

> -Because you just told me.
> -If really all P are Q, then this P must be Q, too.
> -Well, all P are Q, isn't it?

In only a few cases I did not ask for a justification, because the subject's self-confidence in answering, intonation, etc, made clear that she got the point.
For convenience I used the same categories for answers in non-PSP tasks. In the basket task, the tram task and the three box tasks I counted as a cl-answers: 3, 4, *yes*, *a ball* and *no* respectively. (See appendix for a complete list of tasks.)

### Noncl-answers

The typical 'illiterate' response as reported by other authors actually comes in different versions.

*nescio*
I classify as a 'nescio' both a refusal to answer the question, as well as all answers that amount to "I don't know". In fact, it is not always possible to distinguish between these two. Sometimes subjects only gave a shrug or a shake of the head.

*false*
This answer plainly contradicts the cl-answer.
Notice that with the Susan task it is hard to give a false answer: strictly speaking only explicitly denying that Susan puts on her blue sweater qualifies as such. Nonetheless I count as *false* all answers that do *not* mention Susan putting on her blue sweater.

*cl-os*
This is a cl-answer, but the subject justifies it with reference to world knowledge (*os* for *open system*).
This is a tricky category, because such justification does not exclude the possibility that the subject actually inferred her answer from the premises. Of course, we asked subjects to justify their answers. Unfortunately some subjects interpreted this question not as the epistemic 'why do you think that p?' but as the factual 'why p, do you think?'[24]. Since the answer to the latter question was not entailed by the premises, it seems only natural to take resort to world knowledge or imagination. An example from the interview with Vivian:

**1.**

| | |
|---|---|
| Exp: | [daughters task] |
| | What color are the eyes of the eldest girl? |
| Vivian: | Blue |
| Exp: | Why do you think so? |
| Vivian: | Because they are all sisters, they all look alike. |

Vivians justification of the (correct) answer seems to be an explanation of the logics of inheritance rather than syllogistics: because all sisters have blue eyes, it is only natural that the eldest has blue eyes too. The question of *how* Vivian *knows* this, remains unanswered.

*cl-g*
This is a cl-answer, but it appears to be just a lucky guess. When asked to justify the answer, the subjects come with answers like:

> -That is what I think.
> -I do not really *know*, I just give an answer.

*noise*
This is the collective term for all noise. This ranges from real noise (subject answers cell phone) to translation problems (subject is not familiar with the concept of a bear).

## Quantitative data

Table 2 gives the 16 interviews that are useful for our purposes, represented according to the categories above. Other subjects gave mostly cl-answers or the interview/transcript was not useful. The figure for 'Standard PSP' in table 3 gives the average results for 'bears', 'moon' and 'Markia'.

[24] in some cases this may have been a translation problem

| | **Aisha** | **Elham** | **Fatma** | **Khawla** | **Lahcen** | **Med** | **Nadia** | **Omaya** |
|---|---|---|---|---|---|---|---|---|
| Moon | nescio | nescio | cl-g | nescio | cl-g | cl-os | false | false |
| Markia | cl-g | cl-g | nescio | false | CL | nescio | CL | CL |
| Bears | false | false | false | false | false | CL | false | nescio |
| Basket | CL | CL | CL | CL | CL | CL | cl-os | CL |
| Knoef | - | - | - | - | nescio | nescio | false | nescio |
| Brothers | cl-g | nescio | nescio | nescio | nescio | CL | false | CL |
| Suzan | - | - | - | - | CL | CL | CL | CL |
| Daughters | false | cl-g | cl-g | false | CL | CL | cl-os | CL |
| Animals | - | - | false | noise | nescio | cl-os | false | cl-g |
| Tram | - | - | - | - | CL | cl-os | CL | CL |
| Box I | - | - | - | - | CL | CL | CL | CL |
| Box II | nescio | CL | CL | CL | CL | nescio | false | CL |
| Box III | - | - | - | - | CL | CL | CL | CL |

| | **Petra** | **Rachida** | **Sanae** | **Touria** | **Ulla** | **Vivian** | **Warda** | **Zina** |
|---|---|---|---|---|---|---|---|---|
| Moon | false | cl-os | CL | CL | cl-os | false | false | cl-os |
| Markia | nescio | false | nescio | cl-g | false | cl-os | cl-os | nescio |
| Bears | nescio | false | false | nescio | false | false | nescio | false |
| Basket | CL | CL | CL | CL | CL | CL | CL | CL |
| Knoef | nescio | false | nescio | nescio | noise | CL | false | nescio |
| Brothers | CL | cl-os | CL | nescio | false | cl-os | cl-g | nescio |
| Suzan | CL | noise | CL | nescio | CL | false | false | false |
| Daughters | cl-os | CL | false | CL | CL | cl-os | false | CL |
| Animals | CL | false | cl-g | false | false | cl-os | false | CL |
| Tram | CL | false | CL | CL | CL | CL | false | CL |
| Box I | CL | CL | CL | CL | CL | CL | CL | CL |
| Box II | nescio | CL | nescio | CL | CL | CL | CL | CL |
| Box III | CL | CL | CL | CL | CL | CL | CL | CL |

Table 2. *Categorization of initial answers. Names are fictitious.*

| | **%CL** | nescio | false | cl-os | cl-g | noise |
|---|---|---|---|---|---|---|
| Bears | 6 | 25 | 69 | 0 | 0 | 0 |
| Knoef | 8 | 58 | 25 | 0 | 0 | 8 |
| Moon | 12 | 19 | 31 | 25 | 12 | 0 |
| Animals | 14 | 7 | 4 | 14 | 2 | 7 |
| *Standard PSP* | 14 | 25 | 30 | 12 | 5 | 0 |
| Markia | 19 | 31 | 19 | 12 | 3 | 0 |
| Brothers | 25 | 38 | 12 | 12 | 12 | 0 |
| Daughters | 44 | 0 | 25 | 19 | 12 | 0 |
| Suzan | 58 | 8 | 25 | 0 | 0 | 8 |
| Box II | 69 | 25 | 6 | 0 | 0 | 0 |
| Tram | 75 | 0 | 17 | 8 | 0 | 0 |
| Basket | 94 | 0 | 0 | 6 | 0 | 0 |
| Box I | 100 | 0 | 0 | 0 | 0 | 0 |
| Box III | 100 | 0 | 0 | 0 | 0 | 0 |

table 3. *Percentage of CL answers, round figures.*

## Qualitative results

I will now pass all factors of the previous chapter in review to see to what extent they can be blamed for the noncl phenomenon.

### Intelligence

The intelligence-factor hypothesis doubts the ability of illiterates to infer properties of one individual object from information about a class of objects. We used the box II task to check this.
Eleven out of sixteen subjects had no trouble inferring the contents of one individual red box after having seen that all red boxes contained a ball. Two of the remaining five did mention the ball as a possibility, but were not sure enough.
It should be noted that the whole exercise could have made the impression of a magical trick. This might have been confusing, also because it is such a silly question that one may think it is a trick question. Med, for example, seemed to be just suspicious about everything that was out of sight.

**2.**

Exp: [box II task]
What is in this box?
Med: I don't know. A ball.
Exp: Do you think there is a ball in it? Or not?
Med: I don't know. If you put them back next to each other again, then maybe I know.
Exp: [puts the two other boxes next to the one under discussion.]
What is in here?
Med: Well, I don't know if... A ball.

Conclusion: From this near-perfect performance it seems safe to conclude that subjects were in general able to carry over predicates from a class of objects to an individual object.

### Memory

The memory-factor describes the inability to remember the premises properly.
Memory is an important factor, if only because the subjects themselves feel very insecure about it. Many apologized for their bad memory before any question was asked.
First of all, weak memories cause a lot of noise in the data. It appeared that especially colors are hard to remember and easily mixed up. This was not only surprising, but also a setback. We had imagined colors to be relatively safe ground for illiterate people. It appears that some berber dialects do not

even distinguish blue from green. According to my interpreters, Moroccans who have learnt to speak Arabic as a second language often cannot tell these colors apart. Other colors also caused similar problems.
As an example I quote from the interview with Nadia. Though all premises were translated in Berber, Nadia was eager to bypass the interpreter in her answers. This worsened the problem, because she mixed up the Dutch names of the colors blue and brown.

**3.**

Exp: [Susan task]
What does Susan do?
Nadia: [in Dutch] She puts on her brown sweater.
Exp: Can you remember what I told you about Susan?
Nadia: [in Dutch] An other country. It is cold, the country. She puts on a brown sweater.

Notice that Nadia does not remember the conditional as such, but the consequent ("wears sweater") that necessarily holds given that the antecedent holds ("it is cold"). In this case I decided to forgive the change of color and I counted the answer as classical because the sweater has the same color in her answer *and* the premises she remembers.
In other cases, it was not so obvious that memory was the only hurdle. From the same interview:

**4.**

Exp: [brothers task]
Where does Jan live?
Nadia: [in Dutch] Maybe Den Haag, maybe Amsterdam.
Exp: Ok. All three of my brothers live in Rotterdam, ...
Nadia: [in Dutch] ... one brother doesn't. You had two sisters, isn't it?
Exp: I have three brothers and one sister. All three of my brothers live in Rotterdam.
Nadia: [in Dutch] And your sister?
Exp: ...and my sister lives in Amsterdam. Jan is one of my brothers. Where does he live?
Nadia: [in Dutch] In Rotterdam!
Exp: Why do you think so?
Nadia: [in Dutch] It's ok, that's where the family lives, isn't it?

Here it is difficult to tell whether Nadia's bad memory is symptom or cause. The fact that she remembers two sisters where only one was given, points to the latter. But her claim that one brother does not live in Rotterdam can hardly be attributed to forgetfulness, for it really comes out of the blue. It seems that she has interpreted the premise about Jan as the introduction of a new (fourth?) brother. This may point to the domain-factor, that claims

the subject does not understand the individual to be a part of the domain of the universal quantifier. I will come back to this example later.
Anyhow it would be inaccurate to attribute the noncl-answer pattern to memory failure alone. Subjects regularly give false answers even when they can recall the premises almost literally. An example from the interview with Ulla:

**5.**

Exp: [animals task]
Does Blacky live in a stable?
Ulla: No, maybe at home.
Exp: Can you remember what I told you about the animals?
Ulla: You told me about a farmer who has three animals, a cow, a goat and a sheep. You told me that all three animals live in a stable. One of the animals is called Blacky. You asked me where Blacky lives.

Ulla's answer makes clear that there is nothing wrong with her memory, not even with interpretation. The blatant inconsistency in her answers points to a much deeper cause. I will come back to this interview in the section on exceptions.

Conclusion: Memory is an important source of noise in experimental data. However, it is not the all-explaining factor that we are looking for. Subjects who did remember the premises correctly, still gave typical noncl-answers.

**Exactness**

The exactness-factor captures the (cultural) difference in respecting the universality of the natural language universal quantifier. We presented the subjects with a minimal pair of situations in the box I and the box III task, to see if their understanding of the universal quantifier allows for exceptions. Nearly all subjects agreed with the statement that all red boxes contained a ball (box I), and actually all subjects denied that all blue boxes did (box III). Most subjects justified their conclusion -without being asked to- with comments like:

-No, one box is empty. (Nadia)
-No, only two. (Med)

These results clearly show that noncl'ers do disqualify a universal quantifier for one exception. This may seem trivial in this case, since 'two thirds' is pretty far from 'all'. Notice however that in half of our PSPs, no more than three elements were involved, so that the Box II task suffices as a check for the understanding of the universal quantifier.

Conclusion: The subject's general interpretation of 'all' as a quantifier is

exact enough to enable her to solve our PSPs. Now that the box I and III tasks have proven that one empty box can disqualify a universal quantifier, it is a justified question to ask why one brown eyed daughter does not. This question will be the main focus of chapter 4.

**Exam questions**

None of the subjects made the impression to be confused by the type of questions, that is: by the fact that we would ask for *known* information. The answers to the basket task and the tram task were given without hesitation or doubt. The same holds for the question "Do you remember what I told you about [task]?". All subjects understood that they had to repeat information that the experimenter had just given them.

Conclusion: non-standerd question do not seem to pose a problem to noncl'ers anymore than to schooled people.

**Reliability**

The reliability-factor hypothesis says that illiterates cannot reason about hypothetical situations. We used the story sums to check this.
The basket question was the only question getting 16/16 correct answers. No subject showed even the least hesitation. Most of them justified their answer -without being asked to- by repeating the numbers of different bottles. The mentioning of alcohol did not evoke religious admonitions. Only Nadia asked if the basket was large or small, thus revealing an 'open system' interpretation.
Nine out of twelve subjects obediently added up the animals in the tram, notwithstanding chuckling and amazement. All nine correct answers were given immediately and with confidence.
Rachida was the only one who stubbornly refused to consider the premises altogether[25]:

**6.**

Exp: A tram drives through Rotterdam.
First, two horses enter the tram.
After that, two [ elephants enter the tram.
Rachida: [in Dutch] [ No, no. Tram: people. No horses in tram.
Exp: How many animals are there in the tram?
Rachida: No animals in the tram. [in Dutch] A dog: yes. Only a dog.
Exp: Imagine there are two horses in the tram anyway.
Rachida: [in Berber] In my head it says that in a tram there are only people.

[25] Apparently, the fact that in European countries dogs are allowed in public transport (and goats are not) is one of the things that amazes and shocks Moroccan immigrants most. It is the cause for many a Moroccan joke about the Europeans.

[in Dutch] In my head... tram: people. [explains by summing up] Woman, man, woman, man, girl, boy: yes. Animals: no. Only people.

Here, Rachida obviously refuses to think about "what would be true if..." because she cannot imagine the situation to be true. Med also wondered:

**7.**

Med: Should I answer this question? Animals can not get on the tram.
Exp: *Imagine* two horses do enter the tram, [ and two elephants.
Med: [ Four.

Another case of a noncl-answer occured in the interview with Warda. This case is particularly interesting because we managed to pinpoint her reasoning error exactly.

**8.**

Exp: [tram task]
How many animals are in the tram?
Warda: Two.
Exp: How many animals are there?
Warda Two.
Exp: How many elephants?
Warda: Two.
Exp: How many horses were there?
Warda: Also two.
Exp: And in total?
Warda: Oh..., four.

It is obvious that Warda has no problem remembering and accepting the premises. Her problem seems to be that she does not properly *combine* the information into one larger picture, and actually adds two animals plus two other animals. I will come back to this example in chapter 4.

Conclusion: Though the reliability-factor *can* play a role in interpreting a PSP, these answers show that it does not in all cases. Apart from the high cl-score for the story sums, the confidence with which correct answers were given shows that noncl'ers do not have trouble taking (purely) hypothetical premises as a given, and reasoning on their basis. We can therefore not attribute the whole phenomenon of noncl-answer patterns to this factor.

### Closed system

The closed-system-factor says that illiterates give noncl-answers because they include world knowledge in their reasoning.
As was expected, all subjects somewhere came up with their own knowledge

and experience with the world. They gave anecdotes for an answer, took over the stating of premises before the PSP was finished, or referred to world knowledge when asked to justify the initial answer. This is nothing new. It seems to support the finding that noncl'ers do not confine their reasoning to the premises. We used the knoef task and the story sums to test this.

As expected, the knoef task was an outright disaster. All subjects struggled with the idea of having to deal with 'new' words. They were not able to talk about something that 'does not exist' and complained that the words were very difficult to remember. The complete confusion it caused, made this task the most awkward part of each interview, and we would be relieved when we could go on to the next question (brothers).
The utter failure on the knoef task does not dismiss the closed-system-factor. It does show that illiterates have no idea how to solve a problem purely on the basis of its 'form'. We can not rule out the idea that with normal PSPs, noncl'ers are distracted from their reasoning process by 'obtrusive' world knowledge, and that in the absence of world knowledge an underlying crystal clear reasoning comes to the surface. It appears impossible to avoid world knowledge all together.
More telling answers were triggered by the story sums. It is remarkable that none of the subjects introduced new animals in the tram task, and none of them imagined extra bottles in the basket. Apparently, they knew perfectly well how to leave out disturbing possibilities of the real world in this case. They do know how to separate the information given from other information.
But there is more evidence that the noncl-phenomenon cannot be attributed to world knowledge overruling the information given. Over 30% of the noncl-answers was a nescio. In all those cases, subjects apparently did not have enough information or evidence to base an answer on, even though the premises *did* entail this information. As I already claimed in chapter 2, this cannot be explained by world knowledge overruling premises, for such explanation would predict an answer based on this world knowledge. Instead, there is no answer at all. Apparently even world knowledge does not provide enough information either in this case. In these cases, there *is* nothing to overrule the premises.
The fact that some *answers* contain world knowledge, does not imply that the attempt to *solve the PSP* was based on it. My hypothesis is that world knowledge from 'outside the brackets' only comes in after a first attempt to find an answer has come to a dead end. This finds support in the fact that it is often not *knowledge* but mere *imagination* that seems to have influenced the answer. We already saw in quote 4 that Nadia came up with different possible residences for my brother Jan, even when it is certainly not world knowledge that made here think that Jan lives in The Hague or Amsterdam. In the following sample from the interview with Touria we also see how the

subject comes up with random facts when reasoning gets her nowhere.

**9.**

Exp: [animals task]
Where does Blacky live?
Touria: The animals are in the stable, but Blacky is upstairs.
Exp: Can you remember what I told you about the animals?
Touria: You told me about a farmer who has three animals, a cow, a goat and a sheep, and all three animals live in a stable. You asked me: "where would he be?" And I say: no, he takes care of those animals, he feeds them and the animals are in the stable downstairs and he is upstairs in the house.
Exp: One of the three animals is called Blacky. Blacky is an animal.
Touria: Is it a goat or a sheep?
Exp: I don't know.
Touria: Yes, they all live in the stable.

We know that Touria cannot answer the question, because she has understood 'Blacky' to be the farmer's name. Her description of a farmer's job may be from world knowledge, but the fact that 'Blacky' lives 'upstairs' springs from her imagination. According to the interpreter, the standard farm in Morocco is definitely not a multiple storey building. It looks more as if Touria is filling in details according to her imagination, much like Nadia named random Dutch cities in the brothers task (see quote 4).

Conclusion: even though noncl-answers often contain a lot of world knowledge or imagined information, this cannot explain the noncl-answer itself. It leaves unexplained how world knowledge could enforce a nescio answer, let alone how imagination would overrule premises. We cannot even be sure whether world knowledge influences reasoning at all.

### Domains

The domain-factor hypothesis says that illiterates cannot handle out-of-the-blue quantification. If the 'domain of observation' is not specified, they cannot judge whether the individual in the minor premises belongs to the observed group. We used the brothers task.
For one or two subjects the topic of this PSP posed a problem as they felt insecure about Dutch topography.

**10.**

Exp: [brothers task]
Zina: I am a stranger in Holland.
Exp: Can you remember what I told you about my brothers?
Zina: You told me you have three brothers and one sister, and the

place you mentioned I don't know, and I cannot remember.
Exp: Do you know in which city we are now?
Zina: Yes, Rotterdam, Vierambachtenstraat.
Exp: All three of my brothers also live in Rotterdam.
Jan is one of my brothers. In which city does Jan live?
Zina: I don't know.

Apart from this problem, only 4/16 subjects solved the brothers task classically. This is surprising, because the domain was not only surveyable and defined beforehand, it was also very small. Moreover brotherhood as a property is quite a rigidly delineated concept, so that there could be no confusion about the group of elements that the word 'all' referred to, nor about the fact that Jan must be part of that very same group.
The family appeared to be a good choice of content. Most subjects could remember that there were three brothers and one sister. Still it seemed very hard to see Jan as a part of the group of brothers, witness the conversation with Lahcen:

**11.**
Exp: [brothers task]
Where does Jan live?
Lahcen: [long pause] You did not tell me where Jan lives. You told me that your brothers live in Rotterdam, but not where Jan lives.
Exp: All three of my brothers live in Rotterdam, all three. Jan is one of my brothers. Where does Jan live?
Lahcen: Those three brothers of yours live in Rotterdam, he may be one of them.
Exp: Jan is one of my brothers.
Lahcen: Then they all live in Rotterdam.

We can see how Lahcen tries hard to find the answer *within* the two premises given. It is interesting to see that the idea to *combine* the information in the premises only occurs to him after repeating the PSP. We will look at this quote in more detail in chapter 4.
In other tasks however, we can find more evidence that explicitly assigning the individual object to the group of objects is not enough to make subjects give cl-answers. From the interview with Warda:

**12.**
Exp: [daughters task]
What color are the eyes of the eldest girl?
Warda: Dark eyes, or black.
Exp: Can you remember what I told you about the three daughters?
Warda: You told me that there is a mother who has three daughters, and all three have blue eyes and you told me that one is the eldest.
Exp: The eldest, is that one of the three?

Warda: The eldest of the three. You asked me what color of eyes she had, and I said black.
Exp: How many daughters are there in total?
Warda: Three.

Notice especially the 5th and 6th turn, where Warda explicitly recognizes the eldest sister as one of the three daughters. However she still refuses to transfer the predicate "has blue eyes" from the group of daughters to the individual.
A similar thing happened in the interview with Aisha. Notice that in the first session we used a different version from the daughters task, where all daughters had *red hair* in stead of *blue eyes* and there was one *prettiest* girl instead of the *eldest*. We later changed these predicates so as to avoid answers based on personal judgement in stead of facts.

**13.**

Exp: [daughters task]
What color is the hair of the prettiest girl?
Aisha: It could be blond.
Exp: Ok. Why do you think so?
Aisha: Because she is, I mean, she [inaudible] children, she resembles a bit, but she is a little bit different from them. Or maybe it is due to her father has black hair, and mother has red hair, and they mix and give this.
Exp: And could you repeat to me what I told you about the color of the hair of the three girls?
Aisha: [tries to remember names] Don't remember. I forgot. There is a woman, a mother has three daughters, Sofia, Laura, and then I don't know... Two of them have red hair, but the third has a different color of hair.

Aisha does understand that the prettiest girl is one of the three girls. To reconcile her initial answer with this fact, she simply maintains that only two of the girls have red hair.
A last example to conclude this section:

**14.**

Exp: [animals task]
Does Blacky live in a stable?
Ulla: No, maybe at home.
Exp: Can you remember what I told you about the animals?
Ulla: You told me about a farmer who has three animals, a cow, a goat and a sheep. You told me that all three animals live in a stable. One of the animals is called Blacky. You asked me where Blacky lives.

Ulla explicitly recognizes Blacky as one of the animals, but refuses to acknowledge that Blacky must live in the stable.

Conclusion: At least we can say that the manageable domain of three brothers has not provided a spectacular improvement of interpretation of the PSP. The fact that a domain was carefully introduced, as in the daughters and animal tasks, did not help much either. Still there seems to be much truth in Counihan's observation that illiterates do not consider the individual object as being part of the class of objects in the major premise. In chapter 4, I will propose a new hypothesis that can explain both this fact and the disappointing results for the brothers task.

**Exceptions**

The hypothesis based on the exception-factor says that language users generally interpret a universal quantifier as expressing a law, not a truth functional statement. Since laws allow for exceptions, the individual in the minor premise cannot be attributed the predicate that the major premise predicates of the class of objects. We used the daughters and animals tasks to neutralize the alleged exception-factor.

The way to neutralize the exception-factor was to cancel possible exceptions by summing up all elements satisfying predicate $P$, and predicating $Q$ of them. The number of cl-answers for this type of questions was only slightly higher than for regular PSPs. The conversations around these questions however provide very interesting clues.
From the interview with Khawla for example it appears that canceling exceptions is needed, but not enough:

**15.**

Exp: [daughters task]
What color of hair does the eldest girl have?
Khawla: It could be any color. It could be red, white, black because now they paint their hair.
Exp: Ok, and can you remember what I told you about the hair of the daughters? The color of the hair?
Khawla: (to interpreter) You told me that it is a red color, that she has three daughters and that the color of the hair is red. But the eldest has black hair.
Exp: Ok. That's what you remember I told you?
Khawla: Yes.

In her first turn, Khawla brings up exactly the kind of exception the exception-factor intends to pinpoint: although the daughters have red hair *originally* and *in general*, they may have other colors *occasionally*. Remarkably, explicitly stating that each and every daughter has red hair does not take

away the possibility of this exception. This brings Khawla to give a near-contradictory answer to the second question.
We have already seen that for Ulla (see quote 5), the exclusion of exceptions did not help much either. Surprisingly, Ulla and Khawla were not the only subjects to approach inconsistency so dangerously close. From the interview with Sanae:

**16.**

Exp: [daughters task]
What color are the eyes of the eldest girl?
Sanae: Maybe black or pale brown.
Exp: Why do you think so? Can you repeat what I told you?
Sanae: You told me that there is a woman with three daughters, and all three have blue eyes. But one daughter does not have blue eyes.

These answers are all the more astounding if we recall the results of the box tasks. All subjects agreed there that *one* exceptional empty box is enough to disable a universal quantifier. Why don't they see that one brown eyed girl would be an exception too?
With the daughters task, we seem to be able to force the subject into a *reductio ad absurdum*: no consistent interpretations of her answers remain. The inconsistencies that some researchers already found between the lines, can now be pointed out in the transcript; the inconsistencies are explicit.
There is one very far-fetched escape if one assumes that illiterates use a different interpretation of scalar implicatures. They may not understand that with '*three* daughters' we mean '*exactly* three'. Consider in that light again the interview with Warda:

**17.**

Exp: [daughters task]
What color are the eyes of the eldest girl?
Warda: Dark eyes, or black.
Exp: Can you remember what I told you about the three daughters?
Warda: You told me that there is a mother who has three daughters, and all three have blue eyes and you told me that one is the eldest.
Exp: The eldest, is that one of the three?
Warda: The eldest of the three. You asked me what color of eyes she had, and I said black.
Exp: How many daughters are there in total?
Warda: Three.

This conversation leaves very little room for mild theories about interpreting semantic ambiguities in the premises. Summing up what we know about Warda's interpretation of the premises:

> There are exactly three girls. (from quote)
> All of these girls have blue eyes. (from quote)

'All' means: no exceptions. (from box task)
One of the girls has black eyes. (from quote)

The animals task yielded similar answers, that is: even the subjects who understood Blacky to be one of the three animals mentioned, sometimes refused to acknowledge that Blacky must live in a stable. Unfortunately we must be reluctant to use these answers because there was a lot of noise in them. In Morocco it is very uncommon to give animals a proper name. Subjects were consequently confused by the name of Blacky, which made it even harder to consider Blacky as *one of the animals*.

Conclusion: although it seems that explicitly excluding exceptions does make the PSP somewhat easier, it is certainly not the magical factor that explains the difference between noncl- and cl-answer patterns. Subjects still give noncl-answers, even if they can remember the premises well, including the cancelation of exceptions.
This is surprising. It seems that the explanation of the noncl phenomenon lies at a much deeper, fundamental level of perceiving logical structures. More about this in the next chapter.

# 4 Discussion

Quite to our disappointment, none of the factors considered in chapter 2 has proven to be the all-explaining cause for the noncl phenomenon. Even worse, none of them seems crucial for triggering the illiterate's deviation from the straightforward route to a solution. The good news is that the experimental results provide us with some important clues as to where to look for other explanations.

The most important result in this light is the contrast between the almost perfect performance on the box II task on one side, and near inconsistencies in the answers to the daughters task on the other. This result is important first of all because the contrast is striking: if we leave out the non-syllogistic tasks (Suzan, tram, basket and other box tasks) we see that the difference in performance between these tasks forms the biggest leap in percentages by far (see table 3, page 35). Daughters: 44% cl-answers, Box II: 69% cl-answers, with no other (syllogistic) task in between.

But above that, these tasks can serve as an almost minimal pair, for at first sight they seem similar in complexity and structure. In both cases there are three elements in the domain, all having one or more very salient properties in common. The question to be answered in both tasks is whether one particular element inherits the property that the three elements have.

For convenience I repeat both tasks:

**Daughters**
There is a mother who has three daughters: Sofia, Laura and Lisa.
All three of her daughters have blue eyes.
Sofia has blue eyes.
Laura has blue eyes.
Lisa has blue eyes.
One of them is the eldest.
What color of eyes does the eldest have?

**Box II**
I present subjects with a tray containing three red boxes, and show them that each box contains a ping-pong ball (see appendix). After that, I turn the tray around its vertical axis, thus hiding the boxes behind the lid. I then directly produce one of the boxes from behind the lid. Since all three boxes look exactly the same, the subject is not able to recall the contents of the individual box. Instead, she has to recall that all red boxes contain a ball, and *infer* an answer to my question: "What is in this box?".

Of course it is not so much the (good) performance on the box task that strikes us, as it is the inconsistency in the answers to the daughters task. The formulation of the daughters task was meant to leave the subject no escape: all possible exceptions to the major premise were canceled beforehand, so that if a subject would be able to recall the premises, giving a *nescio* answer would be close to contradicting herself. After all, it seems impossible to know that "all A are B" and "one A may not be B" at the same time. Yet several subjects had no trouble entertaining, or at least expressing such (near) inconsistent thoughts.
The mechanism that Stenning and Van Lambalgen identify as underlying the answer patterns in the Suppression Task, does not apply as an explanation for these inconsistencies. In the case of the Suppression Task, the seemingly illogical answer pattern could convincingly be attributed to a cooperative conversational attitude, where the listener considers the model the speaker most likely intended. But in this case, assuming such 'credulous' interpretation does not help us much. First of all there is the problem already mentioned above: we would need a further explanation of why illiterates do interpret the major premise in the "discourse processing mode"[26](i.e. barring unlikely circumstances) and yet interpret the minor premise and the question with a sceptical attitude (in all circumstances).
But apart from that, we now see that a credulous interpretation, at least in the form Stenning and Van Lambalgen propose, does not justify the answers found in our experiment. We made explicit that in our 'intended model' there were no exceptions to the universal quantifier by naming all daughters and predicating blue eyes for each of them individually. Still more than half of our subjects would maintain that one element was (possibly) different from the rest. Classifying this as a 'credulous' interpretation would be stretching the term too far.
The problem must lie at a deeper level than the credulous or otherwise interpretation of logical constants.

Nonetheless, Stenning and Van Lambalgen's ideas provide a promising framework for understanding the alleged illogical answers of illiterates. The main point of their book is not so much to establish what kind of logic subjects use to solve the Wason Selection Task, the Suppression Task or other unnatural laboratory exercises. Their point is to show that part of the process of problem solving is exactly determining what kind of logic should be used, be it Closed World Reasoning based on a credulous interpretation, classical logic based on adversarial interpretation *or otherwise*. Though making inferences is certainly a part of reasoning, another part of the process consists of setting parameters needed for making the most useful inferences given the task and context at hand.

[26]Stenning and Van Lambalgen, 2007, page 299.

My idea is that the noncl answer pattern is the result of just another 'parameter setting'; be it one at a much deeper level of interpretation, and above that one that we as literates find hard to see as something else than a failure to reason. For illiterates however, as I will show in this chapter, their interpretation might not be such an illogical choice after all.

**Searching sentential data versus integrating premises**

To start with one clear example of a noncl-answer that is not illogical at all, I repeat Lahcen's answer to the brothers task.

**1.**
Exp: I have three brothers and one sister.
All three of my brothers live in Rotterdam.
Jan is my brother.
Where does Jan live?
Lahcen: [long pause] You did not tell where Jan lives. You told me that your brothers live in Rotterdam, but not where Jan lives.
Exp: All three of my brothers live in Rotterdam, all three. Jan is one of my brothers. Where does Jan live?
Lahcen: Those three brothers of yours live in Rotterdam, he may be one of them.
Exp: Jan is one of my brothers.
Lahcen: Then they all live in Rotterdam.

Now before expressing our amazement about the lack of deductive ability, we should take a pause and listen carefully to what Lahcen says. In his initial answer he states that the experimenter *did not tell him* where Jan lives. It is hard for us to ignore our own answer to the PSP because it pops up immediately while reading the premises. But if we do ignore this, we will realize that Lahcen is actually right. No one *told him* where Jan lives. None of the premises contains the answer to the question, nor does a conjunction of the premises. In other words: Lahcen's *nescio* is perfectly reasonable if we interpret the question in a PSP as:

> What do you remember that I told you about x ?

Confronted with this question, the subject tries to recall the premises as a *list of statements*, perhaps even verbatim. He searches them for an answer to the question and concludes: "You didn't tell me".
We now realize that the cl-answer is not so much a better answer to the same question, but an equally adequate answer to a different question:

> What would be the case with respect to x *if the premises where true?*

To answer this question some more work is needed than just searching a list of premises in our memory. We may have different mechanisms at our disposal: in a context where credulous interpretation is appropriate, we may construct the one model that we think is intended, and read off the answer from that model. In another case we might adopt a more sceptical attitude and check all possible models in which the premises are true, or we may apply whatever mental rules of deduction that are available and needed to prove that either "not x" or "x".
For the moment I will not go into the question of how we would arrive at such models, what mental language would be used for deduction or other questions in the traditional 'rules versus models' debate in general. The important thing is that in all cases we are using the information of *all* premises to 'construct' new information that lies *beyond the information given*: be it in the form of a model, as a new sentence or even otherwise. I will therefore call this method of solving the problem not 'drawing inferences', which would suggest that one standard (classical) logic can do the job, but simply 'integrating premises' (IP). On the other hand, the noncl'er interpretation of the task as recalling sentences I will refer to as 'searching sentential data' (SSD).

The above extract from the interview with Lahcen is a perfect example of this distinction, because in his subsequent turns Lahcen starts to apply the other, more 'literate' technique (IP):

> Lahcen: Those three brothers of you live in Rotterdam. *He may be one of them.*

In this second turn we witness Lahcen almost literally integrate the premises. He realizes that the brother in the minor premises must be one of the brothers mentioned in the first. He then discovers that this insight actually yields *new information*, and in his final answer he concludes that "they all live in Rotterdam".[27]
This example thus suggests that before any reasoning can take place, a choice must be made between two types of information that may serve as the basis of a correct answer: the information given alone, or all information that follows (necessarily, or based on credulous interpretation or otherwise).

My conjecture is that for noncl'ers, it is this choice for SSD in stead of IP that causes the noncl phenomenon. In diagram 7 I have given a rough picture of the different steps of syllogistic problem solving in the illiterate case, as opposed to the literate process in diagrams 5 and 6 (see chapter 2).

[27] As a final answer this may not seem very satisfying to the reader because it can be seen as a mere repetition of the major premise. However, nonverbal aspects of the answer clearly showed a sudden insight. Whereas the second answer was more an expression of his inner thoughts, Lahcen presented the third answer as a definitive and satisfying answer to the question.

The natural language premises are cast into some mental representation, but without integrating them into one consistent model. The question then makes the subject directly search these premises.

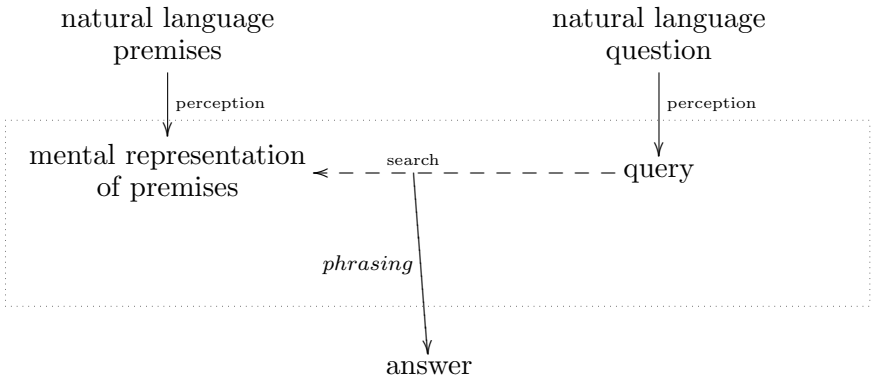


*Diagram 7. Using SSD in stead of IP*

**So... they can't reason after all?**

In the introduction we stated that the reasoning required to solve a PSP is to 'go beyond the information given'. If my conjecture comes somewhere near the truth, and what noncl'ers do is exactly *stick with* the information given, we might be inclined -however much to our regret- to conclude that illiterates *cannot reason* properly.
There is reason to nuance this qualification. Even if it appears that noncl'ers *do* not reason, we don't have evidence to say they *cannot*. Actually, our experiment proves that they *can*, and this is where the other half of our minimal pair comes in: the box task. Let us re-examine it.
The information given in the box II task consist of two observations:

> Three open boxes, all containing a ball (and, subsequently)
> One of the same three boxes, closed.

Notice that these observations do *not* include the fact that the isolated box contains a ball. The answer to the question, therefore, is no more contained in these "premises" than information about the third girl's eyes is in the daughters task. Still, almost 70% of the subjects managed to *infer* from the information given that the isolated box contained a ball.
The only way to reach this conclusion is the following. First we'll have to realize that the isolated box is actually identical with one of the three boxes observed earlier. Then a basic constraint on identity tells us that an object inherits all properties of the objects it is identical with. This insight, combined with a reasonable assumption of object permanence, then leads to three possible models of the situation. For all three models (that is:

whichever one of the three boxes is presented) the box must contain a ball. Thus, integrating these visual premises into one consistent model and reading off new information requires a lot of brainwork. The good performance on this task shows that noncl'ers are able to do so.
This sheds new light on results of the daughters task. Since the box II task shows that noncl'ers do know how to integrate information, from the daughters we must conclude that they do not integrate information *in all cases*. Apparently the daughters task -or a PSP in general- is of a task type that does not trigger the IP mechanism in illiterates. The box task does trigger this solving strategy.

Now why would they perform so differently on tasks that seem so similar in complexity? Here, the dissimilarities of the tasks are important, and especially the way the information is presented. For of course, the tasks have one important difference: in the box task, the premises are presented as a *situation* in the real world, whereas the daughters task is more like a regular, *verbal* syllogistic problem. Constructing a picture of the situation requires a completely different use of the information given in both cases. In the box task it seems that the required information can be constructed more or less "bottom up", whereas the sentential information only allows a "top down" construction. To make clear what I mean with this, and why it has consequences for the choice between SSD and IP, I will make a slight detour saying something about representations in general.

*Indirect versus direct representation systems*
The sentences describing the daughters, the color of their eyes, etc., constitute what Stenning (2002) has called an 'indirect representation'. With *indirectness* he means that the representation system (natural language) employs 'abstract syntax' to represent relations. This means that not all significant relations between symbols of the system correspond to relations between elements represented: the syntax decides which relation is meaningful and which is not. By way of an example: the spatial relation of concatenation is significant in natural language. The concatenation of "Lisa" and "has" in the daughters task is meaningful, making Lisa the subject of the sentence. But the concatenation of "eyes." (at the end of the sentence) and "Lisa" (at the beginning of the next) is not meaningful: we can change the order of sentences without changing the meaning.
In a *direct* representation on the other hand, all relations that are significant in the system are meaningful. Formulated more precisely, quoting Stenning[28]:

> A system of representation $\Sigma$ is *direct* iff: for any relation R between symbols of $\Sigma$, where R is significant in $\Sigma$, there is a

[28]Stenning, 2002, page 24

> relation **R** such that it is always the case in Σ that in any complete well-formed representation in the system, a's standing in R to b signifies that the denotation of a (in Σ) bears **R** to the denotation of b (in Σ).

Examples of direct representations can be found in diagrammatic systems such as Euler circles, Venn diagrams, city maps and models.
Although this distinction between representation systems is useful, and Stenning's ideas on its consequences are very relevant to us, in my opinion the above definition does not suffice to grasp the essential difference between sentential systems and models, at least not for our purpose. Stenning's definition leaves too much room for direct representations that do not have the nice properties that we need if we want to understand the difference between SSD on the one hand and IP on the other.
As an example consider three circles A, B and C, where A properly includes both B and C, and B properly includes C:

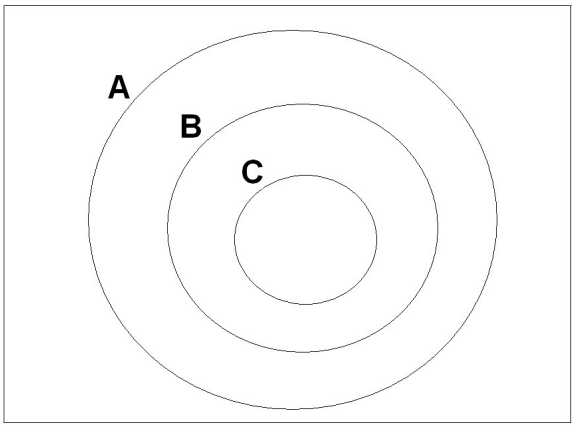


*Diagram 8. Map of the Netherlands*

Now if we take proper inclusion to stand for the real world relation "accessible by train from", and A,B and C to refer to Amsterdam, Rotterdam and The Hague respectively, we obtain a map of the Netherlands which satisfies Stennings definition of diagrammaticality: all proper inclusions stand for a railway connection. Note that Stenning only later mentions a saturation requirement $\forall x, y(\neg xRy \rightarrow \neg x\mathbf{R}y)$. Without it, this 'map' of the Netherlands is actually correct.
Of course, as a map this diagram is not very useful because it does not provide an insightful picture of Dutch railway connections. This is because an important spatial *constraint* that governs the proper inclusion relation of circles on a two dimensional plane (dissymmetry) is not in line with the *symmetric* accessibility relation on a railway network. In the real world, a connection from A to B necessarily means that there is a reverse connection from B to A. Using circle inclusion as a means of representing railway

connections is a bad choice. In fact, it makes a saturated diagram of the railway system impossible.
On the other hand we know that for all dissymmetric, transitive and irreflexive relations in the real world, such as proper set inclusion, Euler diagrams are an excellent means of representation.

I therefore propose to add an essential condition to our definition of directness. The crucial distinction is that in indirect representations the relevant constraints that govern real-world relation **R** do not necessarily or meaningfully govern representing relation *R*. Or, conversely:

> A representation system is *direct* IFF: the *means* of representing relation *R* is governed by the same constraints as represented relation **R** itself AND it satisfies Stennings condition.

The similarity in constraints is important because it is exactly these constraints that give direct representation systems the distinctive property that is interesting in view of our experiment. Direct representations have the nice habit of what Stenning calls 'enforcing' the representation of certain classes of information. This enforcement is actually a result of the specific constraints on the means representation. On a (regular) map, where railways are represented by lines, it is *impossible* to represent a railway connection from city A to city B without representing a reverse connection from B to A. This is exactly *because* we cannot connect one dot with another dot without also connecting the second with the first. Thus, the symmetry of railway connections is a inherent in our representation system.
As Stenning rightly points out, this feature of direct representations is particularly important for the 'agglomerative' mode of reasoning, where information in indirect representations is integrated into one new representation. Stenning: "When two representations are merged into one spatial field, all their symbols become spatially related to each other, and in directly interpreted representations, these new relations will be interpretable as expressing new relations."
Here it is especially important that the constraints on representing relation *R* mimic the constraints on represented relation **R**. We can easily see that adding a new circle *D* for 'Utrecht' to diagram 8 would yield new information, but too little: whatever position we give the new circle, it only adds new one-way connections. This no surprise, since the original diagram was already quite imperfect.
But even in correct and saturated diagrams combining information can go terribly wrong if we don't use the appropriate means of representation. Consider the following diagram of friendship relations, where closeness of symbols represents intensity of affection:

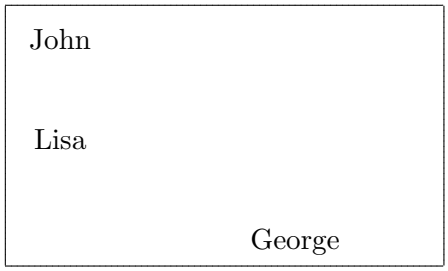


*Diagram 9. Friendship relations*

This diagram then shows that John likes Lisa more than he likes George. Now first of all the diagram is misleading because it suggests that degrees of friendship are symmetric. We could repair this, for instance by somehow distinguishing horizontal from vertical distances. Thus, this particular diagram could be made to represent a certain situation perfectly. Real problems however arise when we integrate new information into the diagram. Suppose we learn that John and Mary get on very well together:

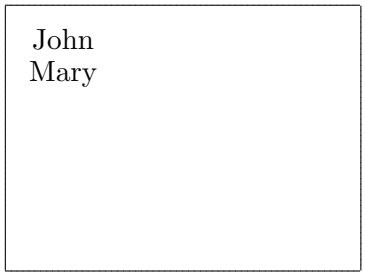


*Diagram 10. Friendship relations*

Integrating this information in diagram 9 would automatically fix Mary's friendship with Lisa and George. But in real life, Mary and George could still be good friends, regardless of the relation between Mary and John. Apparently spatial relations between symbols on a two dimensional plane are a bad choice as a means of representing friendship relations, because the constraints on these spatial relations enforce *more* information than wanted.

One important aspect of a means of representation is the choice between type referentiality versus token referentiality. In the latter case, one object can only be represented by one symbol in the representation. In a type referential system, different tokens of one type of symbol can refer to one and the same object.
Because identity is an important relation that brings along strong constraints, most direct representation systems are useless without token referentiality. Transitivity, for one thing, can only be enforced on a token referential representation.
Our definition of diagrammaticality however, does not disallow type refer-

ence. We can think of a diagram:

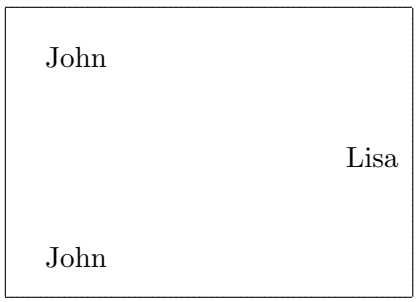


*Diagram 11. Friendship relations*

representing John's self esteem as compared to his esteem for Lisa. From our exercise with diagrams 9 and 10 we know that this means of representation is a bad choice for other reasons, but other representation systems may employ type referentiality to everyone's satisfaction. As Stenning rightly points out, certain flow charts may very well need type referentiality.
Type referential representations however, are not reliable for integrating information. The fact that one and the same object may be represented by more than one symbol, makes that there are possibly different ways to merge the information, yielding ambiguous results. Consider the following emergency information flow charts and try to integrate them.

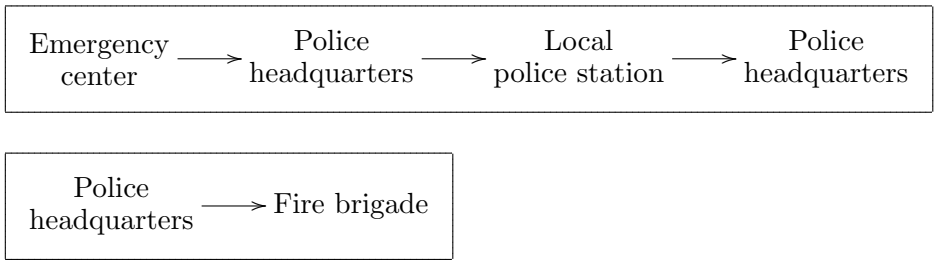


*Diagram 12. Emergency information flow charts.*

Probably, the reader understands that at least one question cannot be answered: is the fire brigade to be informed in all cases, or only after feedback from the local police station? But in fact, the problem is much worse. Since the representation is type referential, there is no *need* to answer this question. Different occurrences of one symbol can remain separated. In this case, "integrating" the two charts may result in nothing more than a conjunction of unconnected charts, without enforcing any new information.

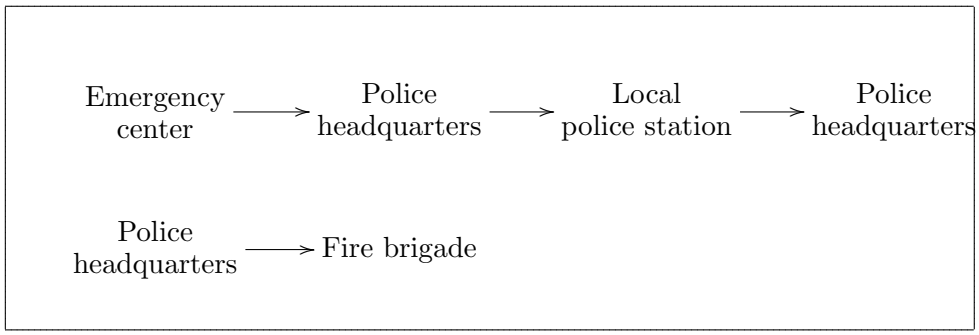


*Diagram 13. Integrated information flow charts.*

Our extended definition says that relations in direct representations must be governed by the same constraints as represented relations. We now see that in practice, token referentiality is a minimum requirement. For integration of information to be useful, the *means* of representation must at least obey constraints on identity.

Now sentences of natural language are of course type referential. By 'integrating' them, information is therefore not necessarily enforced. Merely conjoining sentences does not necessarily lead to true new information. The combination of "John is taller than Ben" with "Ben is taller than Peter" does not make clear that John must be taller than Peter. Even if the subject knows that the first Ben is identical with the second, an indirect representation system will not give away the new information *automatically*. The only way to integrate sentential premises to the same result, is to add transitivity as a premise and 'calculate' new information.
The same holds for sentences with a universal quantifier. The conjunction of sentences:

> All my brothers live in Rotterdam.
> Jan is one of my brothers.

does not 'enforce' the symbol *Jan* to inherit the predicate(s) of the symbol representing the element that the denotation of *Jan* must be identical with. Language is to a large extent free of constraints.

This leads to another important corollary of the distinction between indirect and direct representations pointed out by Stenning: the *expressiveness* of indirect representation systems. The lack of constraints in indirect representations opens the way to representing the logically impossible. It is easy to state: "John is taller than John", because the syntactic relation of 'being concatenated to both ends of the expression *taller than*' is not irreflexive, whereas the relation 'being taller than' obviously is. In any useful diagrammatic system *directly* representing tallness, the means of representing tallness must be irreflexive too, so as to make this nonsense impossible.

*Back to illiterate reasoning*

All this talk about representations may have given the impression that I want to describe the inner processes of (illiterate) thought in terms of these representations. After all, the age-old split between mental model theories and mental rules theories seems to parallel the indirect/direct distinction nicely.

But if direct representations employ constrained means of representation, we should wonder wether such means of representation exist in the human brain. Do we have an inner 'mental drawing board'? If not, what means of representation is available in the human brain that brings along the nice directness properties? The automatic 'information enforcing' property of Euler diagrams for instance, is derived from the necessary physical constraints on circle inclusion on a two dimensional plane. We as logicians do not impose the constraints on circles: they are already there and we only decide to give them a meaning. The question is thus: are there necessary constraints in the human brain that can be given a meaning in mental representations? The fact that we can reason with a wide variety of constraints, makes it unlikely that these constraints are derived from necessary *physical* neuronic constraints. It is more likely that constraints on mental direct representations are in the end soft-coded: mental constructs somehow *underlying* the mental representation one level up. Presumably we will have to consider what Bruner (1973) has called "coding systems"[29]:

> ...formal schemata that may be fitted to or may be used to organize arrays of diverse information.

For example we can think of basic schemata of space and time underlying and organizing our information processing. In processing new information we choose the appropriate set of constraints to interpret the information in. I will not go into the neuronic implementation of these coding systems or other more neuropsychological questions.

Fortunately, we don't need to know exactly what goes on in our heads while we solve a syllogism for my indirect/direct distinction to be useful. Two important differences between direct and indirect representation systems treated above, will prove very useful in our search for an explanation of the performance gap between the tasks at hand:

- Expressiveness of representation: the (im)possibility to express the impossible
- The (im)possibility to integrate premises: enforcing true, new information when combining premises.

[29] Bruner, 1973, page 220.

We have already seen that noncl'ers obviously do not integrate premises. We don't know what goes on in their heads, but we do know what the input is: two premises in sentential form, i.e. in an indirect representation. Without deciding in what form the premises are represented in the mind, we can safely conclude that these subjects have not enriched that representation with the necessary constraints. For if they would have done so, combining the premises would enforce the cl-answer.
Apparently, understanding premises does not automatically involve constructing a model on their basis. It is possible to interpret sentences only superficially, retaining the words more or less verbatim.
Another important observation corroborates this: noncl-answers show remarkable traces of inconsistency[30]. This adds to our idea that the noncl'er's interpretation of the premises has not developed very far from the sentential form they were presented in. After all: only an *indirect* representation such as the sentential form makes it possible to describe the impossible: all daughters have blue eyes and one of them hasn't. Would the subject have added the necessary constraints that govern identity[31], this would not have been possible. Again: noncl'ers seem to interpret premises at face value, without taking much trouble to picture the intended model.
With this is mind, let us review Nadia's answers to the brothers task:

**17.**

Exp: [brothers task]
Where does Jan live?
Nadia: [in Dutch] Maybe Den Haag, maybe Amsterdam.
Exp: Ok. All three of my brothers live in Rotterdam,...
Nadia: [in Dutch]... one brother doesn't. You had two sisters, isn't it?

Nadia seems to interpret the minor premise as the introduction of a new brother, different from the brothers in the major premise. But if we now try to follow the illiterate strategy, we see that Jan is not necessarily a fourth, different brother. The question of how 'Jan' relates to the brothers earlier mentioned is simply not relevant. There are two isolated pieces of information:

All brothers live in Rotterdam (no names mentioned)
One brother is called Jan (place of residence not mentioned)

Now if we get a question about Jan, it is natural to look at the second piece of information, and realize that it doesn't say where he lives. He might therefore actually *not live in Rotterdam.* The question of how Jan fits in the

[30]I choose to write 'traces of inconsistency' because crystal clear contradictions are rare, but most answers strongly indicate that the subjects conclusions are not derived from one consistent model.
[31]Such as: an element inherits all properties from elements it is identical with.

group of brothers is not relevant: the question is where he lives.
Nadia's answer is of a recurrent type in these experiments. Counihan (2007) rightly remarks that for some subjects, "singling one out suggests exception before exemplification." This seems to capture exactly what happens in these cases, but where Counihan tries to save a place for consistency in her picture of the noncl-interpretation, I am inclined to conclude that noncl'ers can break a rule while leaving it intact.

In its essence, the challenge of a PSP is to find the information behind the information given. We see that SSD as a strategy for solving problems in general never yields anything but the information given. Using SSD in solving PSPs thus always leads to a nescio answer. The nescio answer is the noncl-answer in its purest form.
Often subjects may try to obscure their ignorance with all kinds of world knowledge or rough guesses. The essence of their struggle remains the fact that without adding necessary constraints and integrating premises, they will never be able to *infer* an answer. This is the basis of the hypothesis I propose.

The contrast in performance between the daughters task and the box II task completes my argument. In the latter case information is *not* presented in indirect premises, and constraints on relations and identity are a physical reality. When integrating this information into one larger picture, subjects *do* take aboard these constraints and consequently don't get entangled in inconsistencies. The constraints governing the relevant relations in the box task can be 'read off' from the information given. Integrating premises in this case automatically yields new, correct information.

**What about world knowledge?**

How about the closed-system-factor? In the above conjecture it does not play a role. Don't we need something like an 'empirical mode of reasoning' to account for the tendency of most subjects to inject their world knowledge in their answers? After all, even if the fact that Jan lives in Rotterdam cannot be found in a sentential representation of the premises, the fact that he *may live in Den Haag* (see quote 17) is certainly not in the premises either. Where does it come from, and what is its role?
In chapter 2 I already hinted at the possibility that what Scribner (1970) calls the "empirical mode" could be rather symptom than cause if we acknowledge that for noncl'ers, the premises alone do not contain a satisfying answer. Let us put ourselves in the position of the subject for a moment. We face a question about a fictional situation, say:

> John's father is a bricklayer.
> The bricks are red or blue.

The world is full of water.
Is John thirsty at the moment?

Although we recognize some overlapping between the topic of the question and what the experimenter has told us, the answer is definitely not in the premises. Feeling somewhat embarrassed to be ignorant and above all, being unfamiliar with this type of questions, we may come up with something we 'know' about this topic:

Well, people doing physical labour often sweat more, so... but I don't know about his son of course...

Seeing it from this side we can understand that the open-system answers to syllogistic problems are so remarkable only *to us* because *we see* the classical answer. For someone who does not see the answer automatically, and who interprets the syllogistic problem as some sort of open question, it is not that strange to start telling anecdotes or inventing facts. The fact that most illiterates have never done anything like this before, makes it obvious that open-system answers are to be expected when one starts asking unanswerable questions.
So after all, the 'empirical mode' does not influence the reasoning process itself. If there is a reasoning process at all, then world knowledge interferes only in a later stage, when reasoning has not generated satisfying results.

**What about the story sums?**

Now how can we square this explanation with performance on the story sums? After all, the premises in the story sums were presented verbally. The story sum is an indirect representation too, where the listener has to *integrate* the different premises into one model to get a picture of the described situation as a whole. We have seen that only one subject had difficulties doing so. Warda did accept *and* remember the premises of the tram task, but she did not merge them into one larger picture. As a result, she answered the question for one of the premises at a time:

**18.**
Exp: [tram task]
How many animals are in the tram?
Warda: Two.
Exp: How many animals are there?
Warda Two.
Exp: How many elephants?
Warda: Two.
Exp: How many horses were there?
Warda: Also two.
Exp: And in total?

Warda: Oh..., four.

Nevertheless, almost all other subjects seem to have no trouble constructing a model, regardless of the indirect representation. This asks for an explanation.
Maybe they only *seem* to have constructed a model. Unfortunately in story sums where only addition is required, the difference between direct and indirect representation dissolves almost entirely, since it suffices to simply conjoin premises. Counting the animals in the sentences yields the same answer as carefully picturing the intended situation does.

**What about the relation with literacy?**

In the introduction I already indicated that for a theory on noncl-answer patterns to be convincing, we would require it to fit the relation with literacy or schooling in general. Can we relate the tendency to search sentential data in stead of integrating premises to illiteracy?
If this question is important for the soundness of my theory, some related questions are even more pressing: what problems do noncl'ers encounter in daily life, not being used to integrate premises? How can illiterates *survive* if they do not reason properly? And, more dramatic: is reasoning not a defining characteristic of humanity?

In the re-analysis of the box II task I have already shown that reasoning is not something that occurs in syllogisms only. Reasoning is what happens in all situations were available information needs to be integrated to arrive at knowledge that goes beyond the information given. But contrary to what is the case with the box task, solving *verbal* syllogistic problems requires a very specific type of reasoning, of which the following two characteristics are important:

- The solution requires integration of different pieces of information from the same source;
- Both the information given *and* the requested conclusion are in verbal form, and of theoretical nature.

With 'theoretical' information I mean information that really has no consequences for everyday life in the real world. Theoretical knowledge is the kind of knowledge you only need to pass an exam. My guess is that reasoning with this type of information is not very common in everyday life. It is very hard to think of everyday situations were different pieces of *theoretical* information have to be integrated to arrive at a purely *theoretical* conclusion. There is a reason why such situations are in fact very unnatural. Following

Stenning and Van Lambalgen we can safely assume that integrating our perceptions of the real world into one consistent (credulous) model of reality is what we do all the time. There is of course a limit to calculating the consequences of all we know: our rationality is bounded. Apparently we have an intuition about what consequences need to be thought out and which not.
For verbal information, Gricean maxims can be regarded as rough description of this intuition. The maxims predict that if one needs to convey that some brother lives in Rotterdam one simply *says so*, rather than giving roundabout premises that only *imply* the intended information. Information beyond the information given is seldom the most crucial part of theoretical information. Apart from more sophisticated figures of speech where Gricean implications play a role, it seldom happens in normal discourse that two pieces of theoretical information from the same source are intended to make clear some theoretical fact that lies *behind* them. We may even say that understanding that two odd sentences about brothers in Rotterdam are meant as a 'syllogistic task' is a Gricean implicature. For illiterates outside literate contexts this implicature is obviously out of reach. Purely theoretical reasoning is not something we often need to do, let alone illiterate people.
However as soon as the information concerns the subject herself, and it has consequences in the real world, her interpretation must also take into consideration the *constraints* of the real world.
This brings us to another important effect of not being schooled. It is unlikely that illiterate people have a very developed conception of what *theoretical knowledge* is. The naive idea of school learning is a one-to-one relation between input and output: learning as information storing. That an important part of school learning is gaining insight in the things *behind* given facts, is in itself an insight that may not naturally occur to uneducated people. If they are presented with some hypothetical premises, storing them in sentential form is the most natural thing to do, in anticipation of possible need in the future.
In such a picture of theoretical knowledge, SSD seems a suitable strategy for information *recovery*. Constructing a model is only an unnecessary detour from sentential premises to sentential solution.

# 5 Conclusion and further research

## Conclusion

The data of my experiment are valuable in two ways. First of all because they falsify most of the prominent theories of the noncl-phenomenon. Predictions of some common sense explanations did not prove correct, other theories already collapsed under closer analysis. Notably the wide-spread idea that noncl-answers are the result of mixing up world knowledge with premises has lost its intuitive plausibility.
The other important result is the fact that we brought the inconsistency, already hidden in data from Luria, Scribner and others, to the tape-recorded surface. So far there was always a possibility that the noncl-answer pattern could be explained by a possibly different, but nonetheless consistent reasoning model: by assuming exceptions to a general law, a different interpretation of the natural language universal quantifier or otherwise. But in the daughters task we managed to enforce a *reductio ad absurdum*: we witnessed noncl'ers give explicitly inconsistent answers. This justifies the step to a deeper level of analysis.

My hypothesis is that *going beyond the information given* in purely theoretical contexts is not a thing that noncl'ers are used to do. Unfamiliar with the syllogistic type of these tasks, they take the premises at face value, and store them as relatively unprocessed sentences in their memory. This information is thus available to them as an indirect interpretation: without the necessary constraints that govern the real world that is represented. The fact that combining premises in this form does not enforce new information, enables the noncl'er to overlook the answer that is so obvious for anyone who does interpret the premises with the necessary constraints.
A corollary of this analysis is that nescio is the typical noncl-answer. Only subjects who feel obliged to give some answer run the risk of contradicting the cl-answer that never occurred to them in the first place. The *expressiveness* of language as a means of representation makes it possible to entertain inconsistent thoughts, or at least formulate inconsistent answers.

Of course I do not pretend to give any proof of this theory with my data. My hypothesis does however allow some strong predictions which should be part of further research.

## Further research

The PSPs that I used in this experiment are only one type of problem where integrating premises is needed. To test the new hypothesis we can introduce other types of problems, for example by replacing the important role of the universal quantifier by a focus on identity:

**1.**
Beatrix is the queen of the Netherlands.
The queen of the Netherlands loves dogs.
Does Beatrix love dogs?

Another interesting field to take tasks from is that of immediate inferences. Starting from only one premise, the problem of integrating premises does not arise. However, to make immediate inferences one still needs to impose constraints on the relations involved. Without these constraints, nothing follows. I expect illiterates to give nescio answers to simple conversion tasks like:

**3.**
Some Dutch people are astronauts.
Are there astronauts who are Dutch?

But there are yet simpler models to construct. We can think of the kind of spatial models that Mani and Johnson-Laird (1982) used in order to find out about mental representations, but simpler:

**4.**
The cat is on the mat.
Is the mat under the cat?

Without taking aboard constraints on identity (the cat = the cat) and on spatial positions (on, under) it is not possible to answer this question.
In view of my remarks on everyday language use of illiterates, it would also be interesting to test their performance on a verbal task that concerns the actual world or the interview situation:

**5.**
*(Show all boxes.)*
In all boxes there is a ball.
*(Show one box.)*
What is in this box?

In the first stage of my experiment I used this task, but I abandoned it in later sessions. Although unfortunately numbers are small, it is remarkable that three out of four subjects answered this question classically.
One of the questions that my theory does not answer is why performance on the conditional task is better. Although the difference in percentages of cl-answers was considerable in my experiment, my protocol did not contain enough conditional tasks to say anything valuable on this matter. It would be very interesting to include more conditional tasks in further research.

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## Appendix: List of tasks

**Moon**
On the moon, all stones are blue.
A man goes to the moon.
He finds a stone.
What colour is that stone?

**Markia**
Markia is a country.
All women in Markia are married.
Fatma is a woman who lives in Markia.
Is Fatma married?

**Bears**
All bears in the far north are white.
Nova Zembla is a land in the far north.
What colour are the bears on Nova Zembla?

**Basket**
Suppose I have a basket.
First, I put two bottles of water in it.
After that, I put one bottle of wine in it.
How many bottles are there in the basket?

**Knoef**
Do you know what a knufknuf is?
*(Subject: "no")*
No wonder, because it is a fantasy word that we have made up ourselves.
All you have to remember is that all knufknufs have a rattler.
All knuknufs have a rattler.
Molly is a knufknuf.
Does Molly have a rattler?

**Brothers**
I have three brothers.
All three of my brothers live in Amsterdam.
Karel is one of my brothers.
In which city does Karel live?

**Susan**
Susan lives in a cold country.
If Susan feels cold, she will put on her blue sweater.
Today, Susan feels cold.

What will Susan do?

**Daughters**
There is a mother who has three daughters: Sofia, Laura and Lisa.
All three of her daughters have red hair.
Sofia has red hair.
Laura has red hair.
Lisa has red hair.
One of the girls is the eldest.
What color of hair does the eldest girl have?

**Animals**
My neighbour is a farmer, who has three animals: a goat, a sheep and a cow.
The goat lives in the stable.
The sheep lives in the stable.
And the cow lives in the stable.
All of his three animals live in a stable.
One of his animals is called Blacky.
Where does Blacky live?

**Tram**
A tram is driving through Rotterdam.
Two horses enter the tram.
A little later, two elephants enter the tram.
How many animals are there in the tram?

**Box I**
*Present the subjects with three red boxes, and show them that each box contains a ping-pong ball. Close the boxes.*
Is it true that all red boxes contain a ball?

**Box II**
*Put the three red boxes back into the tray. Show them that each box contains a ping-pong ball (see Box I task). Close all three boxes, turn the tray around its vertical axis so as to hide the boxes behind the lid. Produce one of the red boxes again. Thus there are two boxes out of sight but still on the table, and one box on the table in front of the subject.*
What is in this box?

**Box III**
*Put all blue boxes on the table. Show that two of the blue boxes contain a ball, but the third one does not. Close the boxes.*
Is it true that all blue boxes contain a ball?

I used a wooden tray containing 9 boxes in three different colors. All red boxes and two of the blue boxes contained a white pingpong ball.