Looking for logic in all the wrong places: An investigation of language, literacy and logic in reasoning
Counihan, M.E.

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Chapter 5  
Remining the Wason selection task

5.1 Introduction

Given the conclusions of the previous chapter, it might seem as though existing paradigms used in psychology of reasoning studies are ill-suited to test human reasoning. We saw that the equivocation of logical with grammatical form, and the reliance on a flawed notion of literal meaning as the basis of logical reasoning, have, amongst other things, led experimenters to substantially underdescribe the semantic structure of reasoning materials, and thereby to underestimate the complexity of performance in reasoning tasks. Thus, it can seem as though the tasks themselves are not effectively testing reasoning. This need not be seen so. This chapter is dedicated to showcasing that, even while arguing that the standard testing means have not been penetrating enough, one can still use standard experimental paradigms to investigate reasoning, albeit in a much broader sense, i.e., one that takes the meaning-making processes accompanying and resulting from it seriously.

The experimental paradigm used to achieve this is Wason’s (1968) selection task. The selection task has become a veritable cornerstone in the psychology of reasoning. This is evident in the fact that the variation in results generated by different versions of the original task – especially thematic versions (about which more later) – forms the empirical basis for social contract theory proposed in evolutionary psychology (Cosmides, 1989, Cosmides & Tooby, 1989), for the rational analysis theory of reasoning, which posits probabilistic considerations to explain performance (Oaksford & Chater, 1994), and as important input for both the adaptive rationality theory (Gigerenzer & Hug, 1992), and the dual-process theory of reasoning (Evans, 2003).

Yet, as was argued in the previous chapter, much work in reasoning relies on an oversimplistic view of the relation between logic and natural language. In this case, the view is manifested in the assumption that the so-called thematic version of the rule – often formulated as a ‘drinking age rule’ – has the same logical
form as the rule in Wason’s original task. Stenning and van Lambalgen (2001, 2004) have demonstrated why this reflects an inadequate formalisation of the two rules. In other words, the difference in subject performance across these two tasks cannot be explained merely as a ‘content-effect’, and thereby non-logical, as we saw in the previous chapter. In fact, the original task is much more complex than the thematic versions of it, and the main aim of this chapter is to extend the semantic analysis offered by Stenning and van Lambalgen (2001, 2004) of the original task, which uncovered a nest of semantic parameters which need to be set before the descriptive task can be completed successfully. However, there are clear parallels between the thematic and abstract tasks, and these might facilitate performance in the more difficult ‘abstract’ original version of the task. This is also investigated in the current chapter, although the focus remains on the ‘abstract’ versions. In addition to the original task, several experimental variations on Wason’s original rule are investigated, replicating and furthering the studies conducted by Stenning and van Lambalgen. As will become evident, university undergraduates exhibit concerns and confusions in reasoning tasks similar to those identified in less schooled groups: they are concerned to establish what the conditions for truth of the premises are; they rely on everyday usage of constructions used in the premises, and yet can under certain circumstances be prompted to take the intended ‘normative’ interpretation; they struggle to ascertain their role in the task situation. Such high-level similarities lend plausibility to the idea that universal semantic concerns drive reasoning behaviour in illiterate and highly literate subjects, as well as everyone in between.

5.2 Some background to the selection task

Inaugurated in 1968 by Peter Wason, the original selection task is presented to subjects as follows, including card graphic (Wason, 1968a)\footnote{1This is the traditional reference although the task is discussed earlier in Wason (1966).}:

Below is depicted a set of four cards, of which you can only see the exposed face but not the hidden back. On each card, there is a number on one of its sides and a letter on the other.

Also below there is a rule which applies only to the four cards. Your task is to decide which if any of these four cards you \textit{must} turn in order to decide if the rule is true.

Don’t turn unnecessary cards. Tick the cards you want to turn.

\textbf{Rule: If there is vowel on one side, then there is an even number on the other side.}

\begin{center}
\begin{tabular}{cccc}
A & K & 4 & 7 \\
\end{tabular}
\end{center}
5.2. SOME BACKGROUND TO THE SELECTION TASK

Wason saw the task as a means to investigate the extent to which people reasoned according to the normative theory of scientific reasoning then in vogue: Popper’s falsificationism. Popper’s philosophy of science concentrated on so-called ‘contexts of justification’, in which experimental results contributed to scientific knowledge not by confirming existing hypotheses but by falsifying them. Truth is approached by ruling out falsehoods, not by verifying putative truths. For Wason, this mode of scientific thinking was represented in the logic of the selection task, in which the logical subject would seek ways of falsifying the given rule, instead of seeking confirmatory evidence for it.

Student populations overwhelmingly select the A card for turning, and typically more than half also select the 4 card. These results suggested to Wason that people do not reason according to Popper’s theory, since only a scant minority select the 7 card, which could potentially falsify the rule by providing a counterexample to it. This is a startling discovery, especially when you consider that the subjects of the tests are intelligent and motivated university students, the scientists of tomorrow! Such an inimical result was not left alone for long; Wason’s task has been repeated countless times since then and in myriad variations. The results from the original task have proved extremely robust, but several variations have yielded responses analogous to the normative A, 7 choice – although, as will become clear, there are key logical differences between the original task and these variations.

The variations which yielded normative performance from subjects have been commonly characterised as ‘thematic’, making use of familiar content in various degrees (Wason & Shapiro, 1971, Johnson-Laird, Legrenzi & Legrenzi, 1972, Griggs & Cox, 1982). An example would be the rule “If a letter has a second class stamp, it is left unsealed”.\(^2\) Perhaps the most well-known among these thematic variations is the ‘drinking-age’ rule, presented in the form “If a person drinks alcohol, they must be over 18 years of age.” When presented with such a rule, subjects overwhelmingly choose the response equivalent to A and 7 in the original task (just how equivalent remains to be seen). The results from these tasks contrast with those from the original ‘abstract’ task and were understood to illustrate ‘content-effects’ – that is, subjects reason differently with materials which differ in content, but not in logical form. As was described in the previous chapter, such findings have been adduced as evidence against logic-based theories of reasoning. Cheng and Holyoak (1985) had the insight that such rules might be easier for subjects because they describe what \emph{should} be the case, and as such, the task becomes one of detecting violations of the rule, not assessing the rule itself. Cosmides formulated this in terms of social contracts and ‘cheater detection’; Stenning and van Lambalgen (2001, 2004) show that this embeds in the

\(^2\)This example also serves to illustrate that familiarity is a context-dependent notion – American students did not achieve ceiling performance on this version, perhaps because the deontic reading was not obvious to them (Stenning and van Lambalgen, 2004, p. 485).
more general notion of deontic reasoning. Deontic reasoning is concerned with the logic of obligation and permission; note the use of the modal verb “must” in the drinking-age rule. The rule doesn’t describe or purport to describe, what is the case, as a descriptive would, but rather stipulates what should be the case. Many of the rules used in variations on the selection task can be interpreted deontically even though they often don’t contain modal verbs. Crucially, the original formulation is not interpretable deontically, but rather descriptively. As the current chapter will show, the selection task is a much more complex task when dealing with descriptive rather than deontic rules.

5.3 Experiment

The experiment consisted of written questionnaires followed by in-depth tutorial interviews with ten subjects, on a selection of variations on the Wason selection task. The main aims of this study were to gather data on interpretative possibilities, thus extending the work of Stenning and van Lambalgen (2001), and to collate this to subjects’ performance across different conditions. A subsidiary aim was to engage the subject with the tasks until stable understanding of the normative competence model for the standard task was achieved, if possible, under the assumption that the transcript thus obtained would provide rich data about what the students need to learn in order to succeed at the standard task.

The written tasks preceding the interviews constitute the standard investigative tool in this area, and served as a base-line control for the rest of the experiment (a ‘no learning’ condition). The interviews were conducted over two sessions, often with a break overnight. All ten subjects were undergraduate students of Edinburgh University, and first-language English speakers. None of them had previously taken a course in logic.

5.3.1 The written task

The written questionnaire consisted of four versions of the selection task, given in table 5.1.

In addition there was an immediate inference task which will not be discussed on its own here, but will be mentioned when findings from it are relevant in our discussion of the other conditions. Subjects were given as long as they needed

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3Here is a sample condition of the task with instructions (which were the same for all conditions):

Assume the sentence in bold is true. Which (if any) of the other sentences below must then also be true? Tick the circle next to the ones you judge must be true.

If there is a vowel on one side of a card, then there is an even number on the other side.

This was followed by up to five sentences, including variously phrased disjunctions, conjunctions,
## 5.3. EXPERIMENT

<table>
<thead>
<tr>
<th>Condition</th>
<th>Background rule</th>
<th>Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>original</td>
<td>On each card there is a letter on one of its sides and a number on the other side. The letters are A and K; the numbers are 4 and 7.</td>
<td><em>If there is an A on one side of the card, then there is a 4 on the other side.</em></td>
</tr>
<tr>
<td>conjunctive</td>
<td>as above</td>
<td><em>There are As on one side of the cards and 4s on the other side.</em></td>
</tr>
</tbody>
</table>
| two-rule       | Each card has a letter on one side and a number on the other side. The letters are U and I; the numbers are 3 and 8. | **Rule 1:**
|                |                                                                                 | *If there is a U on one side of the card, then there is an 8 on the other side.* |
|                |                                                                                 | **Rule 2:**
|                |                                                                                 | *If there is an I on one side of the card, then there is an 8 on the other side.* |
| arrow rule     | Each card has an arrow on one side and a symbol (+ or –) on the other side.      | *If there is an upward-pointing arrow on one side of the card, then there is a ‘+’ on the other side.* |

Table 5.1: The different experimental conditions in the written task

to complete the written tasks. Reference was made to a subject’s written answer only when a discrepancy was observed between that answer and that given in the dialogue. This gave the opportunity to match written answers with subjects’ reconstruction of their own reasoning.

The first condition was Wason’s original formulation, with almost identical instructions. They were as follows:

Below is depicted a set of four cards, of which you can see only the exposed face but not the hidden back. On each card, there is a letter on one of its sides and a number on the other side. The letters are A and K; the numbers are 4 and 7.

Also below there is a rule which applies only to the four cards. Your task is to decide which (if any) of these four cards you must turn in order to decide if the rule is true. Don’t turn unnecessary cards. Tick the cards you want to turn.

negated conditionals and quantified sentences (using only *every* as in the interview protocol).
Next the subjects were given a conjunctive formulation of the rule. As for all conditions, the conjunctive task used the instructions given above with the pertinent (background) rule. It was included because the difficulty in Wason’s selection task is often supposed to lie in its conditional formulation. Conditionals are acquired late (Bowerman, 1986); they are known to be linguistically complex (Comrie, 1986). So why not do the same task without the conditional? That thinking prompted the inclusion of a conjunctive condition in both the written and interview parts of this study. Moreover, Stenning and van Lambalgen (2004) conducted a written test both of a similar condition and subsequently of the same formulation used here. They posit a deontic reading behind the predominant choice for A and 4. By including the conjunctive condition in the dialogues the current study is able to further evaluate this claim and others that Stenning and van Lambalgen make about the conjunctive condition.

In the two-rule task both rules are conditional but here the subject must discern which cards can decide which one of two rules is true. Stenning and van Lambalgen (2001) developed the two-rule task with the aim of investigating the effect of presenting subjects with two rival hypotheses. This provides a means to assess the Bayesian explanation of performance offered by Oaksford and Chater (1994), but Stenning and van Lambalgen (2004) also present the task as a means to reduce non-classical deployment of truth-values which clearly play a role in the original task. Oaksford and Chater (1994) base their ‘rational analysis’ model of subject reasoning, on this type of behaviour. That is, subjects in Wason’s task might see their task as one of providing evidence for the rule – what Wason labelled ‘verification bias’ – in order to ‘show’ that it is true, instead of, or as well as, that of seeking potential falsifiers as a means to disprove the rule. In fact, subjects should seek to check whether the rule is false, and conclude that it is true if there is no evidence to the contrary. But subjects often do not conclude truth from non-falsity, as Stenning and van Lambalgen (2001) have also observed.

By presenting subjects with two rules, and told one is true – and in fact, given the current set-up, only one can be true, although it’s not clear subjects see this immediately – Stenning and van Lambalgen hoped to background the issue of other available truth-values for either rule. The classical normative choice is for the single card 3, which falsifies one or other of the two rules, depending on which letter is on the other side. The idea is that the potential for subjects to view their role as seeking ‘verifiers’ should be minimised by such a set-up.

In the ‘arrow-rule’ condition, instead of letters and numbers, cards had arrows and symbols (‘+’ or ‘−’) on them. The motivation for including this condition was to try to minimise the possibility that subjects would choose cards simply by ‘matching’. Evans (see for instance Evans, 1998) has suggested that the A, 4 choice is the result of superficial processing of the rule in which the subject simply chooses cards which ‘match’ the possibilities mentioned in the rule, and that deeper interaction with the material is hindered because it is so abstract, and there is no thematic link to make between antecedent and consequent. If
5.3. EXPERIMENT

matching does indeed lie behind card choices, subjects should be insensitive to, for instance, negations, in the conditional clauses. Although it has been already shown that matching bias cannot explain the full range of responses to negated conditionals (Oaksford & Stenning, 1992), the idea behind matching bias, namely that subjects resort to engaging with the materials at a superficial level, is still an interesting one, especially given the results garnered in thematic versions of the task – where conceptual associations between antecedent and consequent are strong.

The purpose of the arrow rule condition was to see if matching bias would be reduced by a version of the rule in which a thematic link can be thought up about the two sides of the card. In the arrow rule, it is easy to make a conceptual association between upward-pointing arrows and plus signs, both stereotypically signalling some kind of positivity. This kind of natural alignment might aid subjects’ processing of the material at a deeper level, and thereby increase the choice for an upward arrow and a minus sign, the equivalent to the A, 7 choice in the original task. In contrast to previously investigated ‘thematic’ materials, an effort was made here to engender a thematic link without provoking a deontic reading of the rule. However, to anticipate slightly, as the results show (see table 5.4), this did not happen – the only subject to choose the combination of upward arrow and minus sign, was also the only subject who had chosen ‘A, 7’ already in the original task. Because of this result, the arrow rule condition will not be discussed further in this chapter. It was also not returned to in the dialogues with all students.

The failure to improve performance is nevertheless informative. It could be the result of two things. First, the conceptual association between the upward-pointing arrow and the plus sign was not independently verified, so it might be that these materials did not achieve their aim. This seems unlikely. The second possibility is that matching bias is simply not a good explanation of what motivates the A and 4 choice. If the subjects processing was indeed so superficial because they could not construct a conceptual association between the antecedent and consequent situations, then material which does engender a conceptual association between the antecedent and the consequent should result in different choices to the original material. Since this was not the finding in the current study, it undermines the claim that the choice of A and 4 is the result of this shallow ‘matching’ behaviour. The finding corroborates Stenning and van Lambalgen’s (2004) claim that the reason that other thematic material has aided performance is because the rule is interpreted deontically – not simply because it contains familiar material. Moreover, as we will see in the transcripts, in the overwhelmingly majority of cases the choice for A and 4 reflects full semantic engagement with the material, generating a coherent and stable interpretation of the conditional rule. It is thus not the result of superficial processing.
5.3.2 Interview materials and protocol

Once subjects were finished with their written form, the interview began. The interview protocol was as follows: the subject was presented with a rule, typed up on a sheet of paper, and actual cards, which were laid out on the table in front of the subject and interviewer. The rules were dealt with in the order given below. The subject was asked for their choice of cards, and then the interviewer prompted the subject to consider the possibilities for the back of each card in turn, and the consequences of each of these on the truth of the rule. Finally, the subject was asked to turn each card and asked for their response on turning. The subject was allowed to change their choice of card at any point, but they were always asked to restate their choice at this point. At all times, the interviewer sought to elicit and elucidate the subjects’ responses without indicating approval or disapproval at specific choices. Of course this is difficult to achieve in practice, especially with the aim of tutoring the subject to insight. It is however important, because, as the results will show, subjects might achieve the classical normative analysis without, for example, selecting cards on the basis of this – see further discussion in section 5.4 and especially section 5.4.2. The interviews were filmed and transcribed.

The order of conditions in the interviews was as follows:

1. The subject was presented with the original rule. Once the subject had considered each card, and had been given the chance to change their card selection, we moved onto the next condition.

2. The conjunctive rule. Here the same procedure was followed. At this point, depending on what choice the subject had made in the original task, the subject was presented with the following three conditions, interspersed with a return to the original task:

3. The universally quantified condition: same instructions, but with the rule phrased thus:

   Every card that has an A on one side has a 4 on the other side.

4. The ‘split anaphor’ conditions. The instructions in these conditions were the same as those for the original condition; the rules were

   If there is an A on the face of the card, then there is a 4 on the back of the card.
   If there is an A on the back of the card, then there is a 4 on the face of the card.

5. The two rule task – as described above.

6. The drinking age rule. Here the instructions were:
Below is a set of cards. These cards represent drinkers in a bar. On one side is written the drinker’s drink, and on the other, their age. The bar has the following rule about drinking:

*If a person drinks alcohol, then they must be over 18 years of age.*

Determine for each card whether you have to turn it in order to check whether or not the drinkers in the bar are complying with the rule.

7. The original task with compliance instructions as used in the drinking-age rule (although this was only conducted with two subjects.)

The reasons for this order of conditions are discussed in greater detail in section 5.4.2 on the impact of the tutorial engagement with subjects.

### 5.4 Results and discussion

A cursory observation of the results, given in tables 5.4 and 5.3, already makes it hard to ignore interpretational variability; for many subjects their performance across tasks within the written work is inconsistent, in the sense that no single interpretation of, for instance, a conditional rule, can explain their choices. The only subject to give the intended normative response of A and 7 for the original rule also answers ‘8’ in the two rule task; the only subject to get this latter task right is one of the many who chose A and 4 in the original task. Moreover, three subjects give discrepant answers for the original version and the arrow-rule versions.5

Comparing written answers with final answers in the interview shows that performance for the original task tends towards the intended norm as the interview progresses: eight of ten subjects settle on A and 7 by the end of the interview, whereas only one subject had originally answered ‘A and 7’ in the written task. The same thing happens in the two rule task: seven of the ten subjects settle on the equivalent to A and 7, the 3, by the end of the interview, compared with one subject in the written work.

I will now further analyse the results as follows. Firstly, observe the astonishing range of card choices made by subjects in the written task. In most reasoning studies, effort is made to explain the most common choice, with the rest being more or less ignored. However, the approach here is that we should operate from the assumption that subjects have engaged with the task and have good reasons for their choice; as such, *every* selection should be sought to be explained, preferably by reference to different settings of a limited set of semantic parameters. So for each condition, a range of interpretations is considered which can explain card choices.

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4 Subjects’ names have been changed.

5 As noted, these two conditions most probably have the same underlying logical form, unlike other thematic versions of the task, such as the drinking-age rule.
selections, and the relations between these various interpretations are considered. Evidence for each interpretation is sought in the justifications for the turnings offered by subjects in the tutorial dialogues. At the end of this section, it should be clear what interpretations plausibly lie behind the various responses in each condition and how they are related to each other. This makes it much easier to analyse data across conditions in future quantitative work.

Secondly, I discuss the responses of subjects over the course of the interview. This cleaves into two approaches. In section 5.4.2, an attempt is made to convey the extent of consistency and variety within individual subjects’ responses. In the subsequent section, 5.4.3, higher-level semantic issues which play out in all subjects’ transcripts over all conditions are described and analysed. In this section I follow up on the taxonomy of semantic concerns identified in Stenning and van Lambalgen’s (2001) quantitative study. The focus will be on new findings which bear on our understanding of the original condition.

Finally, the implications of the foregoing analysis for the significance of the selection task in theories of reasoning is briefly considered.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Condition</th>
<th>original</th>
<th>conjunction</th>
<th>two rule</th>
<th>arrow rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peter</td>
<td>A, 4</td>
<td>none</td>
<td>8</td>
<td>up, +</td>
<td></td>
</tr>
<tr>
<td>Ted</td>
<td>A, 7</td>
<td>none</td>
<td>8</td>
<td>up, -</td>
<td></td>
</tr>
<tr>
<td>Stuart</td>
<td>A, 4</td>
<td>A, 4</td>
<td>8</td>
<td>up*</td>
<td></td>
</tr>
<tr>
<td>Molly</td>
<td>A</td>
<td>none</td>
<td>8</td>
<td>up</td>
<td></td>
</tr>
<tr>
<td>Oona</td>
<td>A, 4</td>
<td>A, 4</td>
<td>8</td>
<td>up*</td>
<td></td>
</tr>
<tr>
<td>Barbara</td>
<td>A, 4</td>
<td>none</td>
<td>3</td>
<td>up, +</td>
<td></td>
</tr>
<tr>
<td>Christopher</td>
<td>A, 4</td>
<td>A</td>
<td>8</td>
<td>up*</td>
<td></td>
</tr>
<tr>
<td>William</td>
<td>A, 4</td>
<td>none</td>
<td>8</td>
<td>up, +</td>
<td></td>
</tr>
<tr>
<td>Rochelle</td>
<td>A, 4</td>
<td>A, 4</td>
<td>8</td>
<td>up*</td>
<td></td>
</tr>
<tr>
<td>Philippa</td>
<td>A</td>
<td>K, 7</td>
<td>8</td>
<td>up</td>
<td></td>
</tr>
</tbody>
</table>

* indicates discrepancy between responses for Wason’s rule and the novel arrow rule condition

Table 5.2: Responses to the written questionnaire
<table>
<thead>
<tr>
<th>Condition</th>
<th>original</th>
<th>conjunction</th>
<th>split anaphors</th>
<th>two rule</th>
<th>drinking age</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>A on face</td>
<td>A on back</td>
<td></td>
</tr>
<tr>
<td>Subject</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peter</td>
<td>A, 7</td>
<td>–</td>
<td>A, 7</td>
<td>7 → 4,7</td>
<td>8 → U,I,8 → 3</td>
</tr>
<tr>
<td>Ted</td>
<td>A, 7</td>
<td>–</td>
<td>all</td>
<td>A, 4, 7</td>
<td>8 → all → 3</td>
</tr>
<tr>
<td>Stuart</td>
<td>A, 4</td>
<td>A, 7</td>
<td>A, 7</td>
<td>A, 4, 7</td>
<td>3</td>
</tr>
<tr>
<td>Molly</td>
<td>A</td>
<td>A, 7</td>
<td>none</td>
<td>A, 4, 7</td>
<td>3</td>
</tr>
<tr>
<td>Oona</td>
<td>A, 4</td>
<td>A, 4</td>
<td>A, 4</td>
<td>A, 4</td>
<td>8 → 3</td>
</tr>
<tr>
<td>Barbara</td>
<td>A, 7</td>
<td>–</td>
<td>none</td>
<td>A, 4, 7</td>
<td>8 → U,I,8 → U,I,3</td>
</tr>
<tr>
<td>Christopher</td>
<td>A, 7</td>
<td>–</td>
<td>K, 7</td>
<td>A, 4 → 4,7</td>
<td>8 → any → 3</td>
</tr>
<tr>
<td>William</td>
<td>A, 4</td>
<td>A, 7</td>
<td>none</td>
<td>A, 4, 7</td>
<td>8 → all</td>
</tr>
<tr>
<td>Rochelle</td>
<td>A, 4</td>
<td>A, 4</td>
<td>all</td>
<td>A, 4, 7</td>
<td>U,I,3 → all → U,3</td>
</tr>
<tr>
<td>Philippa</td>
<td>A, 7</td>
<td>–</td>
<td>none</td>
<td>A, 4, 7</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 5.3: Responses in the interview
5.4.1 Explaining the modal choices in the written task

In the following we look at the range of choices made in the written work, suggest interpretations which support these choices, and then seek evidence for these interpretations in the transcripts of the dialogues. Connecting interpretations to choices does not mean a blanket presumption of logicality on the behalf of the subjects, since the logical forms need still to be motivated, but it helps to connect behaviours across tasks and gives insight into difficulties with the task as intended. The following describes and provides evidence for the various logical forms which would yield modal answers on the original, conjunctive and two rule tasks.

Original task

The normative answer with a classical logical reading of the original task is the choice of the A and 7 cards. Yet in countless studies this is chosen by a very small minority of reasoning subjects. What are the commonly occurring choices, and what interpretation of the rule would justify them? This is what we now consider, before turning to the dialogue data to assess whether such readings are evident in the subjects’ considerations.

As can be seen in the above tables, seven of the ten subjects in this study chose A and 4 for the original rule in the written questionnaire preceding the tutorial dialogues. A fairly typical result is that around half the subjects chose this option (e.g. Wason and Johnson-Laird 1970, Stenning and van Lambalgen, 2001). As Stenning and van Lambalgen (2001, p. 291) have pointed out, the choice of A and 4 can be motivated by decomposing and normalising the conditional.

The rationale behind this is as follows. Conditionals with known consequents are very odd, maybe even downright unacceptable – as evidenced in the examples “If polar bears are difficult to hunt, then polar bears are white”. Fillenbaum (1978) found that subjects paraphrase conditionally phrased threats and promises by reversing the clauses, a phenomenon he termed ‘pragmatic normalisation’. Might subjects do the same thing with conditionals with consequents which are known to be true, while the antecedent is unknown?

If subjects, in the process of interpreting the anaphor ‘one side . . . other side’, decompose the anaphor in the original conditional into two separate conditionals, viz:

(1) If there is an A on the (visible) face then there is a 4 on the (invisible) back and
    if there is a A on the (invisible) back, there is an 4 on the (visible) face.

and normalise it, as Fillenbaum describes, then they would generate:

(2) If there is an A on the face, then there is a 4 on the back, and
if there is a 4 on the face, there is an A on the back.

The reading of the original rule, generated by this split and normalise procedure, as given above, will be referred to as a normalised conditional reading\textsuperscript{6}— and although it is a biconditional of sorts, it is not the same as an anaphoric biconditional “there is an A on one side if and only if there is a 4 on the other side”, which would require all cards to be turned. On this interpretation, the K card is irrelevant, and the 4 card can serve as a falsifier of the second condition. Similarly to Stenning and van Lambalgen, in my data many subjects did make this distinction between the K and 4 card. Importantly, the 7 card is also irrelevant on this reading—because the normalised rule specifies nothing about the situation in which there is an A on the back of the card. There was direct and indirect evidence that the anaphor decomposition as described above does occur. For instance, in the below transcript, the subject reverses the direction of the conditionality when they come to discuss the 4 card.\textsuperscript{7}

\textbf{Rochelle in the original task:}

E: OK. So a K here on the back of the 4 would make the rule not true?
S: Yeah.
E: But you said a K and a 4 here (indicating the K) wouldn’t matter.
S: Yes. Because . . . yeah no that doesn’t seem to make any sense. But. It’s because, it’s saying if there is an A on the other side then there has to be a 4 on the other. But this is a K, so it doesn’t really matter what’s on the other side of it. But if it’s a 4 on this side there has to be an A on the other side of it for it to actually work. So if I had a K there then that would be wrong.

The other possible resolution of the problem of a conditional with an unknown antecedent and known consequent would be to simply reduce the anaphoric ref-

\textsuperscript{6}I use this terminology although it is inconsistent with Stenning and van Lambalgen (2004, p. 509), who use the term ‘anaphoric’ for it. I do this because the intended normative interpretation is better labelled the anaphoric conditional reading.

\textsuperscript{7}Further evidence of this occurring, was found in both the two-rule condition – see further on in the chapter – as well as in the split anaphor condition. All subjects chose to turn the 4 card when presented with the rule “If there’s an A on the back of the card, then there’s a 4 on the face of the card”. The following response was typical:

\textbf{Oona, in split anaphor condition:}

[rule: If there’s an A on the back then there’s a 4 on the face of the card]
S: In that case, well this is 4 and it’s the face, I’m assuming this is also a face (pointing to the A card) as in, according to what I am looking at this is a face, so there should be an A on the back of this one (the 4).
E: So you choose just the 4?
S: Yup.

And the subject also judges the 7 card “irrelevant, it doesn’t apply”. In section 5.4.3 we will see in more detail the responses to the split anaphor condition.
reference ‘one side . . . other side’ to the deictic ‘this side . . . that side’, i.e. ‘face . . . back’ and end up with a deictic conditional reading\(^8\):

\[(3) \quad \text{If there is an A on the face then there is a 4 on the back.}\]

Given this interpretation, the correct choice is just the A card. Two of ten subjects chose this in the written questionnaire in the current study, and in other studies the percentage of subjects choosing this option has been only somewhat higher (33\% in Wason and Johnson-Laird, 1970, and 24\% in Stenning and van Lambalgen, 2001). In the dialogue, one of the subjects, having chosen just A initially, changed their choice to A and 7 in the course of discussing the cards, but not before articulating the anaphor-fixing explicitly:

**Stuart, original task:**

E: OK. And the 7.
S: (interrupting) is not relevant at all.
E: OK. What could you find on the other side?
S: You could find an A or a K. But it doesn’t say that if there’s a 7 on one side, then there must be a K on the other side.

E: OK. So . . .
S: (interrupting) or assuming, I am assuming, sorry, that we are starting with these cards, as in this (pointing at the 7) is a 7 card, not a letter card, it’s a 7 card. . . . I know it sounds strange when I am saying it myself, because it says when there’s an A on the other side there must be a 4 on the other, which means this (pointing at the 7) can’t be an A, cause there’s a 7 on one side, but, I am assuming this (running his hand over the top of the cards) is the start point of each card.

E: OK, and if you take away that assumption?
S: Then if there’s an A on this side (pointing to the underside of the 7), it would invalidate the rule.

The subject is thus able to ‘unfix’ the anaphor, once they have made their own assumption explicit. However, this does not translate to card choice. Here we get a soupçon of Oaksford and Chater’s so-called information gain strategy. The exchange continues:

E: OK. So would that mean that you should turn the 7, or not?
S: Well you could turn the 7, but it says don’t turn any cards you don’t have to, and you only have to turn the A.
E: OK. So the 7 could have an A on it, which would invalidate the rule, but . . .

\(^8\)Again here I follow Stenning and Lambalgen’s (2004) terminology although it is not clear what happens to the reference when the card is turned over. The fact that many subjects changed their choices after consideration of turning cards might be related to this point – i.e. considering the action of turning prods them out of a deictic reading of the anaphor.
5.4. RESULTS AND DISCUSSION

S: (interrupting) It could have, but it could also have a K on it, so if you turned that (the 7) and it had a K, it would make no difference to the rule, and you would have turned a card that was unnecessary, which it says not to do.

E: But what if it had an A on it?

S: But what if it had a K on it?

We will come back to this in excerpt the discussion both of ‘interference’ effects, and the varying agency of the cards to prove or disprove the rule, later on.

The conjunctive condition

In this task, subjects were presented with the rule

(4) There are As on one side of the cards and 4s on the other side.

Now the intended reading of the statement was as a universal generalisation, which we could rephrase as:

(5) For all cards, they have As on one side and 4s on the other side.

On this reading, the intended normative answer is to turn no cards, since the K and 7 cards already falsify the statement. Only five of the ten subjects chose to turn no cards in the written condition; and only three of the five stuck to that choice in the interview. (The other two changed their responses to ‘A and 7’ and ‘all cards’.) Clearly, the rule was open to interpretation, probably stemming from the rather awkward original phrasing, and specifically the mismatch between the plural ‘As’/‘4s’ and the singular anaphoric ‘one side – other side’. In the intended interpretation the anaphoric binding should occur per card, but as we will see this is not always the case. Indeed, it seems most natural to read the anaphor as referring to ‘the cards’ as a singular set – which would mean that ‘one side’ is the same side for all the cards – say the face, and ‘other side’ their backs. In this case the rule would only be true when there is a row of cards with an A facing up on all of them, and a 4 on the back of each card, or, vice versa a row of 4s with As on the back.

A more natural way to express the intended interpretation would be simply to say:

(6) Each card has an A on one side and a 4 on the other side.

... but this was judged to be too easy a task for the subject to solve. The fact that this more obvious formulation was not chosen might also bias subjects against taking it.

There is another, ‘existential’ reading of the original rule which also supports the ‘no cards’ choice – namely, that which takes the anaphor to refer to the
background rule (“On each card, there is a letter on one of its sides and a number on the other side”):

(7) There are cards with As on the ‘letter side’ and there are cards with 4s on the ‘number’ side.

Since both an A and a 4 are in plain view, the rule is shown to be true, without turning any cards. So the choice ‘no cards’ may reflect the subject’s belief that the rule is already false, or already true. That this is a live option is supported by evidence from the transcripts, viz. the following subjects’ ‘realisation’ that no cards need to be turned:

William in the conjunctive condition:

S: OK. Um I wasn’t sure exactly what that was all about. ...I think that’s already true, cause there is an A there (pointing at the A) and there is a 4 there (now at the 4), so I guess that’s already proven, just by looking at it.

E: OK. So you don’t need to turn any of the cards?
S: No, but I think I probably ticked that I did. Cause it’s quite confusing.

A good illustration of why ticked boxes do not provide enough information! Furthermore, the subject’s comment, “it’s quite confusing” suggests that the pragmatic expectations afforded by the task clash with the choice of no cards. It is possible that subjects entertain a reading which supports the ‘no cards’ choice, but then dismiss it because of reluctance to give an answer which does not require turning something. In a sense answering ‘no cards’ might suffer from the same kind of bias as the ‘no valid conclusion’ option in multiple choice syllogistic conclusion tasks (described for instance in Newstead et al, 1992). There is evidence for this to be found in the transcript of Ted, who had chosen ‘no cards’ in the written task but when it comes to the interview is very clear about distancing himself from that option: first he chooses A, 7, then settles on ‘all cards’. When the experimenter points out that this is different from his written response, the subject doesn’t want to change his answer, but says his original choice of no cards “doesn’t make sense in the slightest anymore”. The experimenter persists:

Ted in the conjunctive condition:

[at this point subject has chosen to turn all cards]
E: So you read it as every card should have a vowel on one side and an even number on the other, is that what you thought?
S: This is really strange. Yeah. I can’t even work out why I would have done that now. Cause you need to turn some of them to prove or disprove it.

Of the remaining subjects, three answered A and 4 in the written task; one answered K and 7; one answered A. In the interview four of these latter subjects changed their answers and only one stuck to A and 4. What interpretations could lie behind the choices
– A and 4,
– K and 7,
– A and
– A and 7 and
– all cards?

We now discuss each of these card selections in more detail.

The choice of A and 4 was here made by only three subjects in the written task, and this dropped to one in the dialogue. This is a very different pattern of responses to that garnered by Stenning and van Lambalgen (2004). As mentioned above, they conducted written tests on two different conjunctive formulations. The first was

\[(8) \text{There is a vowel on one side, and there is an even number on the other side.}\]

and the second was identical to the formulation used here except with “...vowel ...even number ...” instead of “...A...4...”. In their study, with the first formulation 31 of 69 (45%) subjects chose A and 4, and with the second formulation – the same as that used here – 70% chose A and 4! Stenning and van Lambalgen propose that the dominant reading lying behind this choice is a deontic one: “Every card should have a vowel on one side and an even number on the other” – which means that the relation between card and rules is very different than that intended. Each card is judged individually against the rule, and the truth of the rule itself is not under interrogation, as is also the case in the drinking-age formulation of the rule. Stenning and van Lambalgen propose that subjects reason that K and 7 already flout the rule, so only A and 4 are worth checking (2004, p. 515). I find it implausible that subjects would ignore the fact that K and 7 flout the rule. Rather subjects judge the K and 7 to be irrelevant, provided they do not have a 4 or an A on the other side, which would mean they plump for the choice all cards. This is evidenced in the following transcript:

**Ted, conjunctive rule the first time round:**

[subject has chosen ‘no cards’ in the written]

S: Um ... I’d turn... the A, ... and .... I’d probably turn all of them. (pause) I’m not sure.
E: OK let’s go through all of them.
S: ...(Pointing at K) I would turn that ...because there might be an even number on the back of that, which would mean that the rule was wrong ...because there’s not a vowel on the one side and an even number on the other, it’s a consonant and not a vowel, which is not right. Um ...
E: And if there’s an odd number, then what?
S: If there’s an odd number [on the back of the K], then it’s fine. Um ... (pause, finger on the 4 now) Yeah and the same applies to the 7, so if there’s a vowel on the back of the 7, then the rule’s wrong, but if there’s a consonant on the back, then it’s right.
Note the subject’s description of the certain findings being ‘fine’ or ‘right’, not ‘making the rule true’. Nevertheless his phrasing suggests he is indeed judging the rule against the cards, by a one-by-one strategy, instead of vice versa.

In the above situation it seems the rule is read as ‘pairing’ As and 4s. So as long as As and 4s stick together, and Ks with 7s, the rule is fine. It is thus the same as the normalised conditional reading as described in the original condition. In this case, as mentioned above, any card can falsify, but there is a difference in the verifying agency of the A and 4 on the one hand and K and 7 on the other. Turning A to find a 4 would verify the rule, while turning the K to find a 7 would exclude the rule from applying to it. At most the K/7 combination is consistent with the rule, but it doesn’t provide any evidence for the truth of the in the sense mentioned in the original condition. But is this necessarily a deontic reading of the rule? We could also see it as a restricted-domain reading of the generalisation expressed in the rule. Recall that in Chapter 2 it was argued that unschooled subjects had difficulties reasoning with quantifiers when the context set was unspecified and often attempted to clarify the context set before reasoning with the quantified premise. Could the same behaviour be happening here? That is, the subjects in the current study, when confronted with the rule, which I have labelled conjunctive, for continuity’s sake, but which could just as well have been labelled existential, struggle to figure out the intended context set in which the rule applies. Cards, such as the K and 7, which obviously cannot comply with the rule are disqualified from the domain of ‘application’ of the rule. Within this domain, the truth of the rule is assessed, so it is not a straightforward card-by-card checking task, as a deontic reading suggests.

If the deontic reading is indeed employed we should expect to see subjects importing modal verbs into their reformulations of the conjunctive rule, and justifying their choices as means to check the cards, not the rule. As it happened, only one subject chose A and 4 in the dialogue, so there is scant material in which to seek support for Stenning and van Lambalgen’s claim that a deontic reading lies behind the choice for A and 4. Moreover, there are other readings available which justify a choice for A and 4 without positing a deontic reading of the rule.

For instance, choice of A and 4 can also be understood as resulting from a reading of the rule as applying only to A or 4 cards, as such paraphrasing as

\[(9) \quad \text{For all cards, if they have an A or a 4 on one side, then they have an A and a 4 on them.}\]

Now this reading strictly requires all cards to be turned – as any card potentially falsifies the rule – unless we again assume the subject exercises Fillenbaum’s pragmatic normalisation, which restricts the antecedent reference to known cases, so that the rule becomes

\[(10) \quad \text{For all cards, if they have an A or a 4 on their face, then they have an A and a 4 on them.}\]
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This, in turn, is effectively the same as the previously mentioned normalised conditional reading:

\[(11) \quad \text{For all cards, if there is an A on the face, then there is a 4 on the back, and if there is a 4 on the face, there is an A on the back.}\]

Stenning and van Lambalgen (2004, p. 521) acknowledge the link between a conjunctive suppositional interpretation of a conditional – in which one assumes the truth of the antecedent and answers subsequent questions “from within this suppositional context” – and the conjunctive formulation. In the current study, four of the ten subjects in the immediate inference task indicated that a conjunctive formulation is entailed by a conditional. The link the other way is made explicit by the next subject, who, when presented with the conjunctive rule in the interview, having chosen A and 4 in the previous original condition, proclaims:

**Oona, conjunctive condition:**

S: Exactly the same, I’d turn these two (the A and 4), ’cause there are As on one side and 4s on the other. It’s the same statement, just written in a different way. Isn’t it? Because they’ve missed out the ‘if’, that’s all, that’s all they’ve missed out.

The subject here makes some comments about doing tasks like this before; she mentions medical stats material, aimed at testing sensitivity to presentation and framing effects. This may be relevant because if she conceives of this task as similar, then it is an exercise in interpretation of the rule, and particularly across conditions, and not so much to do with card selection. As such, her choice of A and 4 is a result of interference from the previous condition, and might be different had the conditions been presented in a different order. The subject makes several comments about “reading too much into [the rule]” and “trick questions”; these suggest she indeed sees the task as a means to test framing effects. She also justifies turning the cards “out of curiousity”; this makes clear she doesn’t see card choice as the main focus of the task.

There was one subject who reiterated the choice of A and 4 before changing to ‘all cards’ and her justification certainly supports a suppositional conditional reading of the rule. Although she imports the modal verb ‘should’ into her for-

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9To be more precise: the truth of “If there is a vowel on one side of a card, then there is an even number on the other side” entails “There are vowels on one side of the cards, and even numbers on the other.” Interestingly enough, Stuart offered an additional statement which was entailed by the conditional: “If a consonant is on one side of the card there may be an even or odd number on the other side”. This actually contradicts his selection of the conjunction, unless we assume an existential reading of the conjunction. It also suggests that the immediate inference task might be interpreted by the subjects not as the experimenter intends it – that is, interpretation of the original statement should be treated as fixed while the other statements are examined. However, subjects might be reinterpreting the original statement anew with each given option.
mulation, note that it is here ambiguous between an epistemic and a deontic reading.

Rochelle, conjunctive condition:

S: I think you need to turn the A and the 4 again.
E: OK. Why?
S: Cause if there is an A, if there’s, that’s an A then there should be a 4 on the other side, and the same with that [4]. But with those two, the K and the 7, it doesn’t matter. I don’t think. Well it would prove that it’s untrue, but if we want to prove it’s true, then … (gestures with her hand)

This subject’s use of the phrasing ‘proving true’ and ‘proving untrue’ are discussed in section 5.4.3; below we gone on to discuss the plausibility of a deontic reading.

Further, a choice for A and 4 is also consistent with an existential reading of the rule, i.e.

(12) There are cards with As on one side and 4s on the other side.

In this case, the cards are turned in the search for evidence and the proof that the rule is true takes the form of an existence proof. A subject might want to choose cards conditionally here, i.e. it would only be necessary to turn a second card if the first one did not witness the rule. Since only one subject maintained the choice for A and 4 in their interview (see above) we are left without evidence that such a reading justified any subject’s choice of A and 4 in the written task. Regarding the formulation used here, Stenning and van Lambalgen state, without giving a reason, that “it is implausible that this rule might be interpreted existentially” (2004, p. 522).

Also the choice of just A can be seen as an existential reading but this time coupled with a fixed, or in Stenning and van Lambalgen’s (2001) terminology, “asymmetric” interpretation of the anaphor as ‘face – back’, so that the rule is reformulated:

(13) There are cards with an A on their face and a 4 on their back.

With this reading of the rule, only the A card is relevant as a potential ‘witness’ for the rule. It would be interesting to see what happens if a subject should turn the A to find a 7 – would this mean the rule is false straightaway, or would the subject rather unfix the anaphor and then choose to look at the 4 card to see if it could witness the existential? The only subject to choose just A in the written condition changed immediately to a choice of K and 7 in the interview – see the excerpt from Christopher below for details, without any reference to his earlier choice. As such we have no evidence that this formulation lies behind his initial choice for just A. In fact, given the close connection between the conjunctive and
conditional formulations elsewhere, it might be more prudent to suppose he is
taking a conditional face reading of the rule, that is

\[(14) \quad \text{If there is an A on the face then there is a 4 on the back.}\]

The subject did make an analogous choice for just the ‘up’ arrow in the arrow-
rule condition, but did not choose ‘just A’ in the original formulation of the conditional.

The choice of **K and 7** is at first puzzling. An interpretation of the rule which supports it is

\[(15) \quad \text{There are As or 4s on one or other side of the cards.}\]

The subject (Philippa) who chose this in the written questionnaire had chosen just A for the original condition, which is interesting because, as we saw above, this might result from a simple reduction of the anaphoric ‘one side – other side’ to ‘face – back’. A disjunctive reading of the conjunction rule also indicates insensitive handling of the anaphor, here by basically treating ‘one side – other side’ as ‘one or other side’. In fact, I think this could be the source of the disjunctive element in the posited interpretation, and the conjunction in the original formulation is able to be rephrased as a disjunction because of a ‘free choice’ reading of the set \{A, 4\}, viz:

\[(16) \quad \text{On one or other side of each card, there is an A or a 4.}\]

This might seem far-fetched, but, as we’ll see, the transcripts suggest this is indeed behind the choice for K and 7. In particular, the subject mentioned above changes her answer to ‘no cards’ in the interview, but recalls a disjunctive reading motivating her written answer.

**Philippa, in the conjunctive condition:**

S: So that’s saying every card . . . [rereads rule] but then K and 7, that’s
very blatantly obvious that they don’t have As and 4s.

\[\ldots \text{So I don’t need to turn anything, cause that’s rubbish. Cause there’s a K and there’s a 7.}\]

E: [In your written] you put K and 7.

S: I think I read it as each card either has an A or has a 4, so that
means that this [K] could have had an A or a 4, and this [7] could
have had an A or a 4. These two (the A and 4) definitely follow the
rule. That’s how I read it. But now I read it out loud . . . it says ‘and’,
‘As and 4s’, so I am going against what I wrote down.

In the dialogues, the following subject switched to a choice of K and 7, with
the following justification (the subject ticked A in written task; has just done
original task correctly):
Christopher in the conjunctive task:

S: OK. Well this is basically saying that . . . so this means that there is going to be at least an A or a 4 on each card.
E: What, this rule?
S: This rule says that there is going to be either an A or a 4. So which would mean there’d be a 4 here (pointing to the K) and a A (on the 7) here.
[so K and 7 must be turned]
E: And A and 4, we don’t have to turn?
S: Um, no, I don’t think it would be necessary, because they [A and 4] already conform with the rule as it were.

Finally, two subjects chose A and 7 in the dialogue and their justification reveals a conditional reading. This is plausibly an interference effect from the previous condition, as identified in Oona’s responses – see section 5.4.2, or a result of imputing precedence order on the basis of the order of the conjuncts. Conjunctive phrasings often carry an implicit temporal ordering, as in

(17) They got married and had a baby.

is read as

(18) First they got married, and only after that they had a baby.

Similarly, in the case of the conjunctive rule, subjects might assume the order of the conjuncts confers some kind of precedence order on them, meaning that sentence (4) is interpreted as

(19) First there are As on one side, and only ‘after that’ [when that is the case] there must be 4s on the other side.

This aligns well with the following subjects’ justification for the irrelevance of the 4 card.

Peter in the conjunctive task (formulated with vowels and even numbers):

S: OK, well . . . I think you would have to turn the A over again, cause if it was an odd number that would disprove the rule. So you need to check that. Umm. You’d need to check the 7 as well.
E: Why?
S: Cause if there was a vowel on the other side [of the 7] there’d be a vowel and an odd number. Which again disproves the rule. (pauses) I don’t think the 4 matters because, . . . if it wasn’t a vowel, if it was a consonant, then it wouldn’t disprove the rule, it would just be an even number on the back of that [the K], which doesn’t affect the rule. And (pause) I don’t think the K matters either.

...
5.4. RESULTS AND DISCUSSION

E: So that combination, the K and the 4, doesn’t disprove the rule – is that what you are saying?
S: Yes, because it doesn’t say, that, (pause) erm, any even number on one side has to have a vowel on the other. . . . It just says if there is a vowel there has got to be an even number on the other side.

In the following example the conditional is not explicitly formulated but the emphasised text suggests that subject understands that the rule does say that ‘if there is an A on one side there must be a 4 on the other’:

Stuart in the conjunctive task:

S: You need to turn the A, to check if there is a 4 on the other side, which would validate it. You don’t need to turn the 4, because it doesn’t say if there is a 4 on one side there must be an A on the other.
[subject proceeds to reformulate the consequences of turning the A: a 4 would ‘concur with’, rather than ‘validate’ the rule]
. . . if you turn the 7 (pointing at the 7), initially, there has to be a K. Because if you turn the 7 and there is an A, that invalidates the rule. So you should turn the 7 as well.

S: Yeah, if you turned that (the 7) and that (the A) you could make your mind up whether the rule was right or not.

The amazing variety of readings for the conjunctive formulation of the rule shows that it was by no means a straightforward condition for subjects. The arguments from the previous chapter, namely that grammatical form can belie logical form, and that the ‘literal meaning’ of a given statement is not always apparent, and even when it is, it is certainly not always available to highly literate subjects in reasoning tasks, are here amply supported by the excerpts. As such, the overall finding here concurs strongly with Stenning and van Lambalgen’s declaration that: “[the conjunctive condition illustrates] how unnatural it is for naive subjects to adopt an ‘is-this-sentence-literally-true’ perspective rather than a ‘what-are-the-experimenter’s-intentions’ perspective” (2004, p. 521). This is, moreover, a verdict highly redolent of our findings in chapters 2 and 3 with less schooled subject groups. In fact, one could easily mistake Stenning and van Lambalgen’s (2004, p. 520) general verdict regarding their dialogues with undergraduate students, that “the interpretation of sentence semantics is highly malleable under the forces of task pragmatics”, for a verdict from earlier reported studies from Scribner or even Luria. The earlier proposal that ‘linguistic’ culture supercedes other cultural factors in explaining reasoning behaviour seems to be only further supported by the findings of the current chapter, where we see highly educated subjects’ are concerned with the same parameters as the subjects of Chapter 1: what is my role in the task? how should I interpret these sentences in line with this? what adjustments to semantic parameters would achieve this?
CHAPTER 5. REMINING THE WASON SELECTION TASK

The two-rule task

In my study, all except one subject chose only the 8 card in the written version of the task (see table 5.4). These results are very different from those garnered by Stenning and van Lambalgen (2004, p. 516), where the most popular choice was for just the 3 card, and they found as many subjects choosing a letter card in combination with 8, as choosing just the 8 card. As such, the (limited) current findings are unable to provide support for Stenning and van Lambalgen’s conclusion that (2004, p. 517) this manipulation of the original task is “substantially easier” than the original task.\(^{10}\) Note, though, that in the course of the interviews many subjects changed their minds to either ‘all of U, I and 8’, or ‘any one of U, I and 8’, and other combinations before settling on just the 3 card. No-one stuck to their original choice of only the 8 card. The implications of this are considered below.

The choice of just the 8 card is logically consistent with the modal choice of A and 4 in the original task, as is apparent when one considers the normalised conditional interpretation of the original rule, described above. Positing the same reading of the two rules in this new task explains the choice for just the 8 card in the following way.

Suppose the subject assumes a normalised conditional reading for both rules. Their interpretation can be paraphrased and results in card choices as follows:

\[(20) \]
\begin{align*}
\text{Rule 1:} & \\
\text{If there is an U on the face, there is an 8 on the back and} & \\
\text{if there is an 8 on the face, there is an U on the back} \\
\text{Rule 2:} & \\
\text{If there is an I on the face, there is an 8 on the back and} & \\
\text{if there is an 8 on the face, there is an I on the back}
\end{align*}

Analogously to the original task, the first rule requires U and 8 to be chosen; the second rule requires I and 8. Now the subject may use the given information that one rule is true to deduce that just the 8 card needs to be turned, since turning it will tell you which of the rules has a false second conjunct. This information rules out one of the rules and allows one to conclude the other is true.

This interpretation of the rule also suggests that subjects attribute the property of strong falsity to the conditional – that is, the falsity of “if \(p\), then \(q\)” entails that “if \(p\), then not-\(q\)” holds. In the immediate inference task of the current study, five subjects indicated a strong falsity reading of a negated conditional. Stenning and van Lambalgen (2004, p. 499) also identified strong falsity in many of their subjects; Fillenbaum (1978) observed the attribution of strong falsity in the majority of his paraphrasing subjects. As is evident in the transcripts below, this

\(^{10}\)Stenning and van Lambalgen’s (2004) conclusion is based on a pen-and-paper task with a larger subject group; my results only provide the suggestion that their findings are less equivocal than might have seemed until now.
leads subjects to ‘expect’ certain outcomes once having turned the 8 card. In the
two-rule task strong falsity is equivalent to an assumption that the cards are split
into two \textit{types} – i.e. either Us are always paired exclusively with 8s, or Is are, and
vice versa regarding the 3. The subject’s task is then to figure out which pairing
holds. However, rather puzzlingly, on the type reading \textit{any} card is decisive; it
is perhaps why some subjects switched to ‘any card’ after first choosing just 8.
The 8 card might be seen as more informative because it falsifies one rule and
\textit{simultaneously} witnesses the other. This is something the other cards don’t do,
and as we’ll see later, subjects are reluctant to call a conditional true without
having a witnessing case. Note the similarity here to the interpretations given to
the conjunctive rule. This is evidenced in Philippa’s transcript below.

How can the \textbf{U, I and 8} combination be understood? In my data the switch
to U, I and 8 was often made after the subject was confronted by the experimenter
with the possibility that the cards are \textit{not} sortable into types – such as, that a
letter card could have a 3 on the back, even while the same letter was behind the
8, or by possibility of finding 8s behind both letter cards. It confuses subjects
because it undermines the agency of the 8 card to decide between the two rules,
thus often leading to conclude that the task set-up is flawed. Subjects then cease
to rely on the given information that one rule is true. Even though one of the
rules has been dismissed, by the 8 card, the subject might feel that they need to
verify that the other rule is true, by checking that there is not a 3 card behind
the letter face. If this is indeed the reason for the choice, then this might be
expressed as a dependent card choice, and U, I should be seen as a projection of
\textit{either} U or I, depending on what’s behind 8.

\textbf{Barbara, two-rule task:}

[subject chose 3 in the written questionnaire, has chosen just the 8
card]

\begin{quote}
E: On the other side of the 8 what could there be?
S: A U or an I. And um, \textit{depending on which letter there was it would
tell you which rule applied.}
\textellipsis if there was a U on the other side of the 8, then to prove rule 1,
you’d expect there to be a 3 on the other side of the I, then you could
prove that rule.
E: OK. And what if there wasn’t a 3 on the other side of the I?
S: If there was a 8?
E: Ja, say there was an 8. Or do you think that means there’s something
wrong with the cards?
S: Yeah, well \textit{if only one of the rules is true, it would suggest that there’s
something wrong with the cards, as it would mean that both the U and
the I have an 8 on them.}
E: \textellipsis If you had to decide which ones to turn before you turned any of
them, which ones would you choose?
S: I’d turn over the 8. And I suppose you’d turn those two (the U and
I) over as well.
\end{quote}
William in the two-rule task:

Subject has chosen just 8.
E: OK. So let’s actually turn these.
[turn 8, U to reveal U, 8 respectively]
E: ... OK. Now we turn the I and find an 8. What does that tell you?
S: It tells you that your statement is wrong.
E: Which statement’s wrong?
S: The statement that tells you one of the two rules holds true.
E: Oh right, OK, so in fact you would want to say that two of the rules hold true?
S: Yeah.

The subject below struggles with issues which recurred in many transcripts. Firstly, she is unsure whether the U and I cards need to be turned. As she points out, an 8 on the back of either of them doesn’t prove anything – so finding an 8 behind I “doesn’t disprove rule 1, but fits nicely” with rule 2. However – and here we need to posit a normalised conditional to make sense of her reasoning – finding, say an I on the back of the 8 does provide definitive proof that rule 1 is false. In other words, the I/8 combination has different agency, depending on which is on the face, clearly indicating she is maintaining the normalised conditional reading as described above.

Philippa, two rule condition:

S: Well this one here (the U) I’d obviously have to see if there’s an 8 on it. If there’s an 8 on it ... well that’s nice, doesn’t actually prove the rule, just fits with the rule. If there is not an 8 then that disproves the rule, so that’s crucial. I’d also have to turn this one (the I), because if there wasn’t an 8 on the other side of this then that disproves rule 2. If there was an 8, it ... doesn’t disprove rule 1, but it fits nicely with rule 2. This (8) is also important because if I turn this over and it was an I, then that actively disproves rule 1 because rule 1 says if there’s a U on one of the sides there must be an 8. So maybe just that ... I think actually maybe just this one (the 8) is crucial. ... So I only need to do this one (the 8) because it tells me that one of the rules is definitely correct.
E: OK so say you turned that (8) over and found a U and an 8?
S: Yep. Then I know that rule 1 is correct and rule 2 is wrong.
E: OK. So just the 8 then?
S: Because if they hadn’t told me that one of the rules was definitely true, then I’d have to do all three (U, I, 8). But because I know one of them is true, I only have to do the 8.

This last turn deserves attention. From the subject’s earlier formulation that the 8 card “tells me that one of the rules is definitely correct”, one might think
she is exhibiting confirmation bias. But this last turn shows that she realises the 8 card only has this agency because of the task situation, i.e. one rule is “definitely true”. This can only be understood if we assume she reasons that the 8 card disproves one rule by falsifying the reverse conditional ("if there’s an 8 on the face, then ...") for one of them, and it is this, coupled with the information that one rule is true, which allows her to conclude the other one is true. Indeed, this reasoning is consistent with her previous explanation that an 8 on the back of the I “fits with the rule” but doesn’t “actually prove it”. The continuing irrelevance of the 3 card also strongly supports this normalised reading.

Turning the cards leads to the subject abandon the normalised reading and to reassess the best way to disprove a rule:

S: So if there’s a U then there’s an 8 ... and I just said rule one is correct ... [subject now turns the I to reveal an 8] OH! Oh I didn’t think about the fact that they weren’t mutually exclusive. Oh ... Oh but ... [turns 3 to reveal a U] ... OH! aha ... very clever ... so actually rule two is correct and rule one is wrong. Yup, because I thought they were like mutually exclusive, ok.

E: What do you mean, mutually exclusive? If the 8 was with a U then the 3 would have an I?

S: Yeah, that’s what I thought. So actually I should have turned all four of them, I think. Well because ... or maybe I could have just ... if I turned the 3, I didn’t even think about the 3 ... If I turned the 3 ... if this had been an I that would have proved that rule two was wrong. And if it had been a U, it would have proved that rule one was wrong. This one (3) was the crucial one.

Given Philippa’s previous reasoning, finding an 8 behind both U and I needn’t undermine her choice of the 8 card; she does however seem nonplussed by the finding. This suggests that either the normalised reading of the conditional attributed to her is inaccurate, which seems unlikely given the above analysis, or, more likely, that she generates the conclusion that the rules are made according to ‘type’ during the course of the task, from her previous conclusion about which rule is true. In other words, the falsification of one rule, achieved by turning the 8 card, prompts her to a strong falsity reading of the conditionals. Stenning and van Lambalgen (2004, p. 500) reported that when subjects were confronted with the possibility of an 8 behind both the U and I cards, they became very confused. Stenning and van Lambalgen categorise this as inappropriate transference from ‘truth of the card’ to ‘truth of the rule’, which is certainly an accurate description of William’s testimony above, but in Philippa’s does not seem to be the case. In fact I think this is rather a peculiarity of the two-rule task, where subjects seem to interpret the task as ‘which rule provides an accurate description of the cards?’. The information that only one rule is true, coupled with the conclusion as to which one is true, in the course of the task prompts a ‘type’
reading of the cards; this is what in turn engenders the strong falsity reading of the conditional.

There is more discussion about subjects’ understanding of truth in section 5.4.3.

5.4.2 Tutoring to insight?

In the description of the experiment I mentioned that a subsidiary aim of the interview was to engage with the students until they reached the intended normative answer of the original task, achieved by so pitifully few subjects in pen-and-paper studies. The underlying question was: what would it take to get subjects to do the task as Wason intended, if indeed they can do it at all? The protocol was designed with exactly this in mind; first, by drawing the subjects’ attention to each card in turn. Perhaps this would be enough to get them to see the agency of the 7 card. Next, the variations on the original rule might encourage the student pay attention to exact wording for each task and thus be more inclined to see the ‘literal meaning’ of each rule – without forgetting, as we’ve seen in the previous chapter, that this is a notion which is theoretically and contextually determined. Additionally here, the universally formulated rule “Every card that has an A on one side has a 4 on the other side” serves as a check whether subjects who have already chosen A and 7 will reiterate the choice in the differently-worded version. Third, the original rule was split into the two anaphoric referent versions, as described in the materials section (see section 5.3.2), and this was presented to subjects to provoke them to consider both possibilities in a return to the original task. Finally, if all this failed, the protocol included the drinking-age rule with the hope that cross-task transfer would occur, i.e. that subjects would see the parallels between the violating agency of the 16-year card and the falsifying nature of the 7 card, and choose the 7 card accordingly.

In fact, many of these interventions proved unnecessary, as five of the ten subjects settled on the combination of A and 7 as their choice in the first round of tutorial dialogue. Only one of these subjects had already chosen this in the written test. Three of the others had chosen A and 4; one had chosen just A. Often, the subject changed their mind simply in the act of discussing what could be on the other side of each card. This is evident in the following transcript, where the subject first retracts his choice of 4 card, and then adds the 7 card as soon as he turns his attention to it

**Peter, original task first time around:**

[subject has ticked A, 4 in written]

S: (spontaneously) . . . I need to turn the 4 over to check there is an A there, cause there could be another letter.

E: And what would it mean if there is another letter [on the back of the 4]?

S: Um.
E: If you did turn the 4 and it was a K, it wasn’t an A?
S: If it wasn’t an A then the rule mustn’t be true (frowns), I don’t think, cause, if there’s an A on one side, or there’s not a ... Hmmm ... Actually it wouldn’t disprove the rule, cause, just cause it’s not an A, it doesn’t mean that all As don’t have 4s on the back. So even better in fact, you only have to turn one card, the A.
E: Ok so now let’s go through each of these cards.

... 

E: OK. So that [K] isn’t relevant?
S: No. And I don’t think the 7 either... ah no, actually I do think the 7 is.
E: OK, why’s the 7 relevant?
S: Because, if there’s an A on the other side, then there’s not a 4. It’s not, that like ... it’ll be a 7 and an A, rather than like a 4 and an A, which the rule states is the case. So, third time lucky, I think the A and the 7, you’ve got to turn over the prove or disprove the rule.

What is interesting in this transcript is that the subject comes to ‘insight’ himself, both with regards to the 4 card and the 7 card. All the experimenter does is prompt the subject to consider each possible combination of front and back explicitly. This seems to suggest that Wason’s intended interpretation is particularly unequivocal and stable; and that once subjects have ‘seen’ it, they will choose it above others and let it guide their card selection. Perhaps surprisingly, however, this is by no means always the case. Rather, the insight seems extremely local. Firstly, the subject above goes on to choose A and 7 in the conjunctive rule condition which is presented directly following this exchange, suggesting that he is still applying this same conditional reading to the now conjunctive rule. The subject then goes on to choose the 8 card in the two-rule task (the equivalent to the 4 card in the original task). This shows that we should not be too quick in attributing to the subject some general insight which then drives interpretational strategies, as might be formulated in terms of ‘paying attention to literal meaning’ or whatever. In some cases it seems like the subject has to reassert this seemingly rather unnatural choice against a default, i.e. the normalised conditional which supports the choice for A and 4. At any rate, the data suggest that the subject’s interpretation of the conditional varies per task.\footnote{Thompson (2000) reports an analogous finding reported in a more general context – subjects’ responses to the same material varies according to the task setting, i.e. suppression-effect task requirements compared to selection task requirements.}

In fact, these tutorial interventions proved to be instructive because of how much they reveal about what van Lambalgen (2003) labelled “the unbearable lightness of interpretations”. Subjects who had chosen A and 7 went on to choose the equivalent of A and 4 in the arrow-rule, described above, and in the quantified ‘every card’ version of the rule, and the 8 card (the equivalent choice to the 4 card in the original task), in the two-rule task. Even the solitary subject who had
chosen A, 7 in the original task right from the written task and reiterated it in the tutorial, chose the 8 card in the two-rule task. Also, in the split-anaphor version of the original task, specifically with the rule “If there is an A on the back of the card, there is a 4 on the front”, many subjects chose the 4 card, again, going against earlier ‘insight’ that this card was not able to give definitive evidence that the rule was either true or false (see more discussion in section 5.4.3 below, on confirming versus falsifying). This is not to say that subjects are just being fickle in their choices; also below we’ll see why the 4 choice in the ‘A on back’ rule makes sense even when you’ve settled on A and 7 in the original task.

On the other hand, as we have seen above in section 5.4.1, there were several subjects who grasped the agency of the 7 card – namely, it potentially falsifies the rule – but do not think that this means it should be turned. In the given case, the subject’s reasoning aligns well with a phenomenon identified in Stenning and van Lambalgen (2004) regarding dependencies between card choices (p. 503):

**Stuart, original task:**

S: Then if there is an A on this side (pointing to the underside of the 7), it would invalidate the rule.

E: OK. So would that mean that you should turn the 7, or not?
S: Well you could turn the 7, but it says don’t turn any cards you don’t have to, and you only have to turn the A.

Stenning and van Lambalgen suggest that this phenomenon might be a way to limit the cognitive demands of the task. This suggestion is supported by the current study, for if we look at the above exchange in context – see below, we see that the subject is first fixing the anaphors, then perfects the conditional to a biconditional when this assumption is dropped. In other words, turning the cards over, turning ‘face’ into ‘back’ and vice versa, also changes the direction of the conditionality. It seems the subject needs to set these parameters to reduce the cognitive demands of the task, in its intended form, which require the conditional is read asymmetrically while the anaphor is simultaneously read symmetrically i.e. ‘one side’ refers to both ‘face’ and ‘back’ of the card. Rather, some subject seem to cycle between the choice for ‘just A’ and ‘A and 4’. Exactly the same behaviour is identified in Stenning and van Lambalgen (2001, p. 288 and also 2004, p. 510), labelled ‘interference effects’.

**Stuart, original condition continued:**

[in the course of considering cards he has chosen just A]

E: OK. And the 7 . . .
S: (interrupting) is not relevant at all.
E: OK. What could you find on the other side?
S: You could find an A or a K. But it doesn’t say that if there is a 7 on one side, then there must be a K on the other side.
E: OK. So...
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S: (interrupting) or assuming, I am assuming, sorry, that we are starting with these cards, as in this (pointing at the 7) is a 7 card, not a letter card, it’s a 7 card. And this rule is only saying if there is an A on one side there must be a 4 on the other. So if you turned this [the 7] and found an A, then the rule isn’t saying that if there is a 7 on one side, then there cannot be an A on the other...

In the last turn we see the subject ably making explicit his assumption that the anaphoric ‘one side – other side’ is read asymmetrically, that is, it reduces to ‘face – back’, and when he is asked to reason without it, he accordingly changes his verdict on the agency of the 7 card, but then immediately switches to the assumption that the condition must be read symmetrically, i.e. as the normalised conditional interpretation as described above:

E: OK, and if you take away that assumption?
S: Then if there is an A on this side (pointing to the underside of the 7), it would invalidate the rule.
E: OK. So would that mean that you should turn the 7, or not?
S: Well you could turn the 7, but it says don’t turn any cards you don’t have to, and you only have to turn the A.
S: With the assumption, that this [the top of the cards] is the start point, that’s (the A) all you need to turn.
... But, if we are not using that assumption, then you would have to turn this, 4, as well, and if this had anything other than an A on it, then it would invalidate the rule.

This last excerpt encapsulates the ‘interference’ phenomenon: giving up the asymmetry of the anaphor means giving up the asymmetric (unnormalised) reading of the conditional; conversely, giving up the normalisation means giving up the symmetry of the anaphor and reducing it to a face-back reading. Both subjects who never reached the normative A, 7 choice exhibited this behaviour; that is, they seemed unable to uncouple an asymmetric reading of the conditional – from an asymmetric, ‘face-back’ reading of the anaphor. So for instance, the subject below has reached the insight that her earlier ‘perfecting’ of the conditional – note her use of the word “so” – is unwarranted:

**Oona, original task, after several attempts:**

S: ...it depends how you read it. I’m saying if you read into it, way too much, then you’d say, ah, if there’s an A on the one side then there’s a 4 on the other side, so if there’s a 4 on one side there should be an A on the other side. But not necessarily, because where does it say that there has to be a 4? If 4 is facing up why should A be on the back side of it?

Nevertheless, when the experimenter asks the subject to rechoose without making the assumption that ‘if 4 is facing up there should be an A on the back side’, the subject switches to a fixed anaphor reading:
E: So take that insight, well what you just said, 4 doesn’t have to have
A on the other side of it, then what about the 7?
S: Yeah,...cause it could have an A on the back, couldn’t it? But we
are not talking about cards which have 7 side up.

She then goes on to reiterate her choice for A, and 4, and not 7.

There is another possible source of subjects’ ‘defaulting’ behaviour to the
modal A, 4 choice, and the posited normalised conditional reading which moti-
vates it. Above the possibility was raised that constraints on cognitive load might
be operating to cause subjects to couple a symmetric (i.e. biconditional) reading
of the conditional with a symmetric reading of the anaphor. A complementary
suggestion is that this coupling might reflect more typical use of conditional sen-
tences. In the Wason selection task, the directionality of the conditional is at
variance with the symmetry of the anaphoric element ‘one side ...other side’;
when ‘one side’ refers to the back, the variance is even stronger, because the
conditional runs from an unknown antecedent to a known consequent (we can
see what is on the visible face of the card, and not what’s on the back). It was
mentioned that conditionals with known consequents are often marked, or even
unacceptable. In seeking to make sense of the materials, subjects may reduce
their interpretational range to those in which the antecedent is known, and the
consequent unknown, so that the ‘face’ card is the only one to ever appear in the
antecedent of the conditional rule.

Again we are provided with an occasion where the similarities between sub-
jects across the educational range are apparent. Recall the argument of Chapter
2, which was that especially unschooled subjects’ difficulties with all sentences
was to a large extent due to the mismatch between their use in reasoning tasks
and the way they occur in everyday language. Here we have seen that when
highly literate subjects are presented with a conditional with an anomalous in-
formational structure, they struggle to interpret it ‘literally’ and seek rather a
reading which more closely resembles everyday language usage. The challenge
for these subjects, as it was for the subjects of Chapter 1, is to figure out for
which key parameters the problematic premise differs from its everyday cousin,
and then adjust these to solve the task. As we also saw in the earlier subject
group, the achievement of the normative interpretation seems to be very much an
individual affair. The following section illustrates this in reverse.

Does the drinking age rule help?

As already explained, all but two subjects had already settled on the choice for A
and 7 before they were presented with the drinking rule. So there was negligible
opportunity for investigating whether the parallels between the tasks could be
used to induce the normative choice in the original task. However, where there
was the opportunity, it appeared that no amount of parallel-drawing helped the
subject, even when compliance instructions (asking ‘whether the cards comply
with the rule" instead of whether it is true) were used. The difficulty very clearly lies in the need to decouple the anaphor from the conditional, not in the non-compliance of the 7 card.

Oona, in the thematic then abstract tasks:

E: OK. So you think whiskey and 16 years.
S: Those are the most relevant ones, yeah. Because once you are over 18, no-one’s going to tell you that you have to drink alcohol and you can’t drink lemonade anymore. What happens if you really like lemonade?

... E: Now the instructions are slightly different. You have to determine for each card whether or not these cards obey this rule (the original rule).
[subject says A needs to be turned, K doesn’t]
S: This one (the 4) you do need turn over to make sure the card obeys the rule. It’s that if thing again. Actually no, it’s not the if thing. If there’s an A on the one side then there’s a 4 on the other side. It doesn’t say if there’s a 4 on the one side there’ll be an A on the other side.
E: Mhm. So the 4 could K or A.
S: I would expect it to have an A though.
E: But if it doesn’t, does it matter?
S: If it doesn’t, it doesn’t matter, because the rule is saying, if there’s an A on the one side then there’s a 4 on the other side, so A is the most relevant card here, but 4 still comes into it.
E: And 7?
S: Nope. 7 and K don’t matter. Unless... you turned over 7 and found an A!
E: So say you turned over 7 and found an A.
S: It still doesn’t matter, because the thing doesn’t say, if there’s a 7 on one side, then there’ll be an A on the other side.
E: OK. But say, say, [bewildered] um ... S: If I turned 7 over and found an A, what would I do?
E: Ja. Let’s turn it over [turns the 7 to reveal an A]
S: Oh no! There’s an A.
E: What does that mean.
S: [long pause] That ... it’s not complying to the rule. Because say you reverse the statement, there’s a 4 on one side, there should be an A on the other side, but there’s not. There’s an A on one side and 7 on the other side. What’s that 7 doing there? How did it get there?
E: So knowing now, what you know about that 7, would you want to turn it over?
S: Yeah. I would now, cause I know there’s an A on the other side.
Only when she sees her own perfection of the conditional does she conclude that the 4 card is unimportant, and she has to reestablish this insight in the very next step, when considering the 7 card. The subject goes on to retract her choice of the 7 card, because she can’t be certain that it has an A on the other side. When the experimenter tries to provoke her to think otherwise by comparing the drinking age rule to the original task, she is quite explicit that the two are not the same:

S: ... this (pointing to the drinking age cards) is different, because if you are 19 it doesn’t matter what you are drinking. Just like if you are drinking lemonade it doesn’t matter what age you are. If you are drinking whiskey it does matter. If you are 16 it does matter. But in this case (pointing to the AK47 row), if there’s an A on one side, and there is a 4 on the other side, then there should be an A on the other side of this one (the 4).

This excerpt provides irrefutable evidence that the abstract original rule condition is of a different order of complexity to the thematic variations, here in the form of the drinking-age rule, and that, crucially, this complexity stems from the combination of the anaphoric ‘one side–other side’ with a conditional formulation.

Understanding falsification vs verification

Several subjects did exhibit increasing grasp of central concepts needed to perform in the task, specifically the asymmetry between confirming or validating a rule and falsifying or invalidating a rule. The subject below initially has acute difficulty in fixing his concepts. Confusion stems from the lack of distinction between confirmation and proof: 4 and 7 have equal status to ‘validate’ and ‘invalidate’ the rule respectively. This has been problematic earlier on in his transcript, evidenced by his inconsistent use of the word ‘validate’. In the conjunctive condition, he first of all says a 4 on the other side of the A ‘validates’ the rule, then corrects this to ‘concurs with’ when the interviewer repeats it back to him. The last turn in the second excerpt below provides clear illustration of his struggle to draw adequate conceptual distinctions; he finally manages it.

Stuart in various conditions:

[conjunctive condition]
E: So now let’s say we turned it (the A) and found a 4. You said that validated the rule.
S: It concurs with the rule, yeah.
...
[original task again: subject has just said all cards need to be turned]
E: OK so you turn the letter A because if the A has a 4 what does that mean?
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S: It means the rule is right.
E: Is that enough then?
S: No
E: OK and if the A has a 7?
S: It means the rule is wrong, or it implies the rule is wrong, it doesn’t mean it. Actually yes it does. If it (the A) has a 4, it implies the rule is right but it doesn’t mean the rule is right. But if it has a 7, it means the rule is wrong.

This excerpt is interesting also from a linguistic point of view, for the sheer variety of terminology the subject tries out. First he uses the word ‘validate’ to describe the A/4 combination in relation to the rule. When this is repeated back to him, he switches to ‘concur’. Later on, he says the same combination A/4 “means the rule is right”. In a subsequent turn he spontaneously adjusts this terminology, after considering the A/7 combination, saying that A/4 “implies the rule is right, it doesn’t mean it”. Making the distinction between “meaning” and “implying” enables him to distinguish different agency for the A/4 and A/7 combinations. (Here we should understand “implying” not in the language-theoretical sense, i.e. generating an implicature, but in the colloquial sense of “suggesting”.)

The subject goes on to choose to turn the 7 card. Later on, his insight into the asymmetry of validating and falsifying, and especially the functioning of this asymmetry in the tasks, is again evident in his very self-assured answer in the two-rule task:

Stuart, two rule condition:

E: Which cards?
S: (thinks for a good 30 seconds) You need to turn the 3 (decisively).

... Because rule 1 says if there’s a U on the far side, one side, there’s an 8 on the other. Bear in mind that a card must have a letter and a number. Rule 2 says if there’s an I, it must have an 8. Which means if I turn this 8 (pointing to the 8 card), it could have a U or an I, and that wouldn’t tell me either or. If I turn a U (pointing to the U card) and it has an 8 that would validate it, not an 8 it would invalidate it, I (pointing at the I), same as the 8 (pointing at the U card), but if I turn the 3, then it’s definitely got either a U or an I on the other side of the 3, so if I turn this (the 3) and find out what that is on the other side of this card, then it’ll tell me which one of these rules is false. Like if it’s got a U, then rule one is false, which means rule 1 must be right. [...] You wouldn’t actually be checking which rule is right, you would be eliminating which rule is wrong.
5.4.3 Task-level semantic parameters

The simplicity of the selection task is deceptive. What Wason perhaps envisioned as an exercise in very basic scientific thinking actually involves a whole package of settings or assumptions which the subject must make in the context of the task, and which mostly have little to do the power of falsification, as has hopefully become clear in the course of examining the transcripts. These settings have to do with, apart from the interpretation of the rule itself, the relations between the cards and the rule, the status of the rule in the context of the task, the notion of truth which is called for in the task. All these factors feed into how a subject treats a falsifying card, but are quite separate from understanding what the notion of falsification is, as the following section demonstrates.

‘False’ vs ‘wrong’

In the original condition, as we saw in section 5.4.2, subjects were quick to offer correct analysis of the role of the 7 card in disproving the conditional rule, yet commonly failed to connect this with their choice of turnings – either they still didn’t think it necessary to turn it, or they included cards which were overridden by it, such as the 4 card. We have seen in subject 3’s testimony that potential falsifiers needn’t be chosen, and here such a verdict is repeated:

Oona in original condition:

E: And if there was an A on the other side of the 7?
S: Then the rule is false.

...E: OK and the 7, you wouldn’t want to turn?
S: Um, no, because ...if there is a 4 behind here (the A) then the rule is definitely true, if there is an A behind here (the 4) then, you know, that’s further confirmation of the rule being true. If there is an A behind here (the 7) then the rule’s messed up. (laughs).
E: But you don’t think you need to turn it?
S: No.

...or they may not be considered enough to evaluate the rule:

Rochelle in two rule task:

S: Oh no if I’d turned the 3 and found an I then the second rule, then that would be untrue. So I’d presume that that (indicating the first rule) was true. If one had to be true. And [I’d] probably not turn anything else.
E: So, in conclusion, what do you want to turn? [goes through subject’s sequence of choices]
S: Well it would be easier most definitely if you just turned all of them over. But I’m sure there is a way of doing it without actually having to turn them all over.
E: *Which one do you think are necessary to turn over?*

S: *I think the U and the I are, still, ... but then also the 3, because it disproved, but I don’t know if I am just thinking that because it did in this case ... I think I might just turn all of them.*

The last turn is especially puzzling; what could the subject mean when he says that he is unsure about the necessity of turning the 3 card because it disproved the rule only “in this case”. Such a rationale suggests the subject sees his role as that of giving a strategy for assessing the truth of the relation between cards and rule more generally; as such the task itself is a sample? As we saw above, this At any rate, the above behaviour indicates confusion about what is needed to establish the truth of a rule, including questions regarding what the exact relation is between the rule and the presented cards. Does it apply to all of them as a set? Or should each card be evaluated individually against the rule? And only these cards? What counts as evidence that the rule is true or false? And what is my job in all this?

This study yielded plentiful evidence that subjects were labouring under similar difficulties to those identified by Stenning and van Lambalgen’s in their qualitative study (2001). Stenning and van Lambalgen identified, among others things, the following aspects of the task to be sources of difficulty for subjects: confusion between truth of rule and compliance of cards to rule; ‘cards as sample’ reading; ‘degrees’ of truth/lack of brittleness of truth; dependencies between cards leading to contingency in card selection; choice on the basis of possible information gain.

Before we explore subjects’ understanding of these various factors, it is instructive to sketch what the required settings are, which the ‘scientific’ thinker employs in correct performance. Firstly, the scientist must have the correct assumption regarding the relations between the cards and the rule. This involves understanding that:

- The cards are not a ‘sample’ from a larger domain, as Stenning and van Lambalgen (2004, p. 502) have pointed out. The use of conditionals in everyday language to express generalisations operating normally on an open-ended domain (see also Chapter 2), probably makes this a counterintuitive assumption. But, unlike conditional generalisations in everyday language, the subject must here consider the rule to refer to the cards as a complete set in themselves. If, however, the subject does see the cards as sample, it makes the task impossible to solve in its intended form. Enterprising subjects find several means to resolve the quandary: they take a type reading of the cards; or they might be inclined to probabilistic reasoning, giving answers in terms of whether the rule is likely to true in general or not (Stenning and van Lambalgen, 2004, p. 502-3). Another possibility, mentioned above, is that the subject sees the cards as a random selection from a larger sample, but their task as development of a strategy which applies more generally, to any coupling of cards and rule.
The cards are not made according to type – so that a combination of, say, 4 on the back of an A card does not mean that A will be on the back of the 4 card. However, cards are made according to the type specified by the background rule, so that only 4s or 7s, and no other numbers, will occur on the back of a letter card. Especially in the two-rule condition many subjects seemed to assume the cards had been made according to one or other type – more discussion of this follows below. The ‘scientific’ subject sees that each card must be treated individually.

However, this is not to say that each card has equal agency. In fact, they all play a different role. The K card is simply irrelevant. The 7 card can falsify, the 4 card can provide verification for the rule, and the A has the potential for both. The task is exactly to specify which cards can affect the truth of the rule, but only in the context of the whole set. So for instance, the A card, if considered on its own, would ‘prove’ the rule if it had a 4 behind it. However, given that there are other cards, the force of this evidence weakens, and creates a dependency within the cards: a 7 behind the A card will falsify the rule immediately, but finding a 4 behind the A requires further turning of the 7 card before conclusions can be drawn.

Next, let’s consider what is required regarding the semantic status of the rule in the context of the task and the concepts of truth and evidence which are needed for the task.

Understanding of asymmetric agency of confirmation or verification and falsification. In the intended construal of the task, finding one counterexample to the rule proves that it is false, while finding one instantiation of the conditional isn’t enough to conclude that it is true. Most subjects do grasp this asymmetry; if not immediately, then in the course of the task, as illustrated in section 5.4.2.

In fact, a subject should conclude the rule is true even if there is no witnessing case for it. This is application of the ‘classical’ notion of truth in the sense that propositions can only take on one of two truth values, so that if there’s no evidence to the contrary the subject should conclude that the rule is true. How classical is this though? When does a proposition come to take on these values? As we’ll see in the section on positive evidence below, in the split anaphor condition this requirement on truth becomes very counterintuitive for subjects. Additionally, as Stenning and van Lambalgen (2004, p. 498–9) have suggested, if subjects interpret the conditional as a causal relation, then even when there is positive evidence, as in a witnessing case, it might not suffice for concluding the truth of the rule.

Finally, and this is related to the above discussion regarding the relation between the rule and the cards, the subject should be clear on the status of
the rule. The truth of the rule is determined by the cards and not vice versa – which is not the case in the deontic version of these rules. In the deontic task, the status of the rule remains intact regardless of what is on the cards. The rule is stipulated, and each card complies with it, or not. Each card can thus be judged according to the rule, independently of the other cards. It is also clear that each card represents an individual and is thus unrelated to all others – a 16-year old drinking whiskey carries no information about who’s drinking lemonade. In the descriptive task, however, as we’ve seen above, there is a much more nuanced relationship between rule and cards. The truth of the rule depends on the relation of the cards to the rule, but it does not depend on all cards equally: indeed the task, as intended, is to specify which cards of the set can affect the truth of the rule. Many subjects avoid using the terms ‘true’ and ‘false’ and rather use terms such as right and wrong, correct and incorrect, even calling the rule “a lie” at some point. What this indicates about their theory of truth is discussed in more detail below.

In the following sections I show how the setting of these high-level task parameters causes difficulty for subjects and suggest how the settings relate to each other.

**New finding: the need for positive evidence**

The discussion in section 5.4.2 should have made readily apparent that even when subjects have reached the normative A,7 answer in Wason’s original rule condition, they often go on to choose cards in other conditions which do not seem to reflect this ‘insight’. In other words, just going on the choice of cards, it appears that the adoption of the intended reading for the conditional in that condition does not provoke subjects to take that same reading of a conditional later on – even when it is an almost identical formulation. However, as the discussion below makes clear, there are important distinctions between conditions which change the significance of card selections.

In the current study this phenomenon came to the fore in the split anaphor condition, when a subject was presented with the rule “If there is an A on the back of the card, then there is a 4 on the face of the card”. Every single subject in the study wanted to turn over the 4 card in this condition, often when they had already dismissed the significance of the 4 card in the original task. The solitary subject who had adopted the normative interpretation of the conditional in the original rule from the very first, in this condition initially chose only the 7 card but added the 4 card when faced with the clearly uncomfortable conclusion of a true rule in the case of a K behind the 7.
Peter in ‘A on back’ condition:

S: In this case I think you would need to turn the 7. And... that would be the only one you need to turn. ...if there is an A on the back [of the 4] then it fits the rule (pointing to the 4) and if there is a K on the back then it doesn’t apply to the rule, so it doesn’t matter, which leaves this one (pointing to the 7) cause if there is an A on the back of here, and it’s a 7, then you’ve disproved the rule.

E: OK and if there is not an A on the back of that (the 7)?

S: If there is not an A on the back ...(thinks) then ...maybe you do need to turn that one (pointing to the 4). If there is not an A on the back [of the 7], then it doesn’t disprove the rule and it doesn’t prove it. So you’d have to turn the 4 I think.

The 4 card was of concern to subjects because it was the only potential source of evidence for the rule; as we see in the next turn the subject goes so far as to say that a K behind both 4 and 7 disproves the rule.

E: And what if the 4 also didn’t have an A on the back – what would that mean for the rule?

S: Well then... for this set of cards, the rule... it would disprove the rule I suppose. Cause if there is not an A on the back of this card (pointing to the 4), (pause) then...there isn’t a 4 on the face of it.

OK, if there is not an A on the back, then none of these cards have an A on the back, and a 4 on the face, which is what the rule states. So for this set of cards it’s disproven, it’s not true.

Extremely common in this condition was the specification of the turning order ‘first 7, and if there’s no A, then 4’:

Christopher in ‘A on back’ condition

S: If there is a A on the back of this card (the 7) then it’s finished, you basically don’t care anymore. Whereas if there is a K [behind the 7], all it seems to prove really is that this (the rule) could be true. [...] I suppose we do... need to turn this card (the 4), just to affirm the rule.

Stuart, ‘A on back’ condition:

[subject has chosen 4 and 7]

S: ...you would turn this [7] one first. Because if you turned this [7] and it had a K, you would still have to turn this (the 4), to make sure that it had an A, but if you turned (the 7) and it had an A, you would know that the rule is wrong, because it would have an A on the back and a 7 on the front. So you turn this [7] first, and that [4] second. You would only bother to turn this (the 4) if you found a K.
The excerpts show that subjects are fully aware of the asymmetric agency of falsification and verification: an A behind both 4 and 7 unanimously meant that the rule was disproved, showing that the subjects understood that the A/7 combination overrules the verifying contribution of an A/4 combination. However, the excerpts also illustrate that subjects are not only concerned with falsification in this condition.

Is this a different interpretation of the conditional than the normative one in the original case? It is impossible to say. The key factor here is the lack of the A card, and specifically the dual role that the A card plays in the original task, as potential falsifier and as potential witness to the rule. Here only the 4 card is a potential witness; only the 7 card can falsify. In a sense this condition provides a more stringent test of falsification than Wason’s original task; but it also shows that there is implicit existential import in the conditional. Look again at what our scientific thinker (Peter) concludes, on considering the possibility that neither the 7 nor the 4 have an A on them:

S: ... OK, if there is not an A on the back [of the 4], then none of these cards have an A on the back, and a 4 on the face, which is what the rule states. So for this set of cards it’s disproven, it’s not true.

In other words, the truth of the conditional depends on the existence of a witnessing case. In the original condition, the A card disguises this requirement – because if it doesn’t have a 7 then it not only doesn’t falsify the rule, but it also witnesses the rule. As such, there is no possibility to fail both to falsify and to witness the rule. If the subject has considered the consequences of turning the A they will have realised that it failing to falsify – i.e. not finding a 7 – here coincides with providing evidence for truth. However, in this split anaphor condition, a K behind both the 4 and 7 card leaves the subject in the uncomfortable position of having no evidence either way. Now according to the material implication reading of the conditional, one should conclude that the rule is true. But subjects do not do this. Does this mean they are thinking unscientifically? No. Rather the original task at this point comes apart from the Popperian paradigm, in which one concludes from a failure to falsify that the unfalsified hypothesis is corroborated, but certainly not that it is true.

Card-checking vs rule-checking

How may the complexity of relations between card and rules affect subjects’ understanding and performance in the descriptive case? What construal of the task might result? A few options are:

- **card-checking**: choosing A and 4 because they may satisfy the rule; K and 7 patently already do not. Plausibly this is related to a generic reading of the cards, which in turn brings on a conjunctive reading. In this case the task would be understood as: what cards should you turn to see if they
satisfy the rule? Under this reading the status of the rule would not be under question; the task would be more one of evaluating the ‘truth’ of the cards given the rule.

- **rule-forming**: on the basis of what findings would you say this is a true rule about these cards? Choice of A, 4 is reasonable here too; if you substitute ‘hypothesis’ for ‘true rule’. Cards here are chosen on the basis of the potential evidence they supply for the rule; thus increasing the likelihood/probability that it is true. Hence the task here is about evaluating the rule, but more at the stage of ‘discovery’ than ‘justification’.

- **rule-checking**: this is the intended interpretation; the rule is considered true if it is not disproved by the given set of cards.

Subject Oona’s testimony from the original condition illustrates the first of these possibilities: A and 4, she says, because there should be an A on the other side of the 4, ‘just like if I turn over A there should be a 4’. The subject also specifies that 4 should be turned over first. I conjecture that these choices arise because she interprets the task as card-checking, as opposed to rule-checking: which cards can be checked against this rule? Her utterances suggest she takes the rule to be true, and her job is to specify which cards are worth checking to see if they satisfy it.

**‘True’ vs ‘correctly applied’**

Confusion regarding the notions of truth and falsity manifest themselves in subjects’ language use. The different agencies of specific letter/number combinations to falsify, validate, or prove a certain rule and the extent to which this is grasped might be supposed to be evidenced in the subject’s use of the terms. That is, coarse linguistic distinctions suggest that the subject has coarse conceptual distinctions, which hamper performance in the task. However, this is not always the case. Notice for instance the emphasised sections of the following excerpt:

**Ted in ‘every card’ condition:**

S: Uh maybe,...yeah no yeah the A and the 7,...because the A, well naturally you’d need to see what’s on the back of it, um... if it’s a 4 then the rule’s correct, if it’s a 7, the rule’s incorrect. K...doesn’t matter...because...we’re not concerned with Ks in this case, as I said, doesn’t matter whether it’s a 4 or a 7.

...S: Um...and with the 7, you need to turn that to check whether or not the rule’s correct, cause if it’s...an A, then the rule’s wrong, if there is a K, then the rule’s right.

This subject correctly chooses A and 7 at the first pass at the task, yet keeps using a symmetric ‘correct’/’incorrect’ distinction until much later on in the interview.
Note that the symmetric ‘right’/‘wrong’ distinction used to justify turning the 7 card (see last turn) captures exactly the reasoning about falsification that Wason sought from his subjects. The emphasised excerpts suggest the subject is using ‘correct’ as in ‘correct description of this card’. The subject is taking a ‘case-by-case’ reading (see next section) of the rule to work his way through the cards. In a case-by-case reading of the cards, each card is judged according to the rule, and only if all four fit the rule can it be judged true. So we can understand the subject’s language as referring to the criteria of ‘fit’ of card to rule, for each card. The symmetric linguistic distinctions he draws are thus expressing adequate discernment for each card’s relation to the rule. The subject correctly choses A, 7 because he realises that the rule is true if precisely these cards ‘fit’ the rule; the K and the 4 are not significant in this sense: they do not affect the ‘fit’ of the set of cards to the rule so the rule doesn’t apply to them.

Regarding the fit of rules to cards, there is interesting testimony to be found in the conjunctive condition:

**Rochelle, conjunctive condition:**

S: I think you need to turn the A and the 4 again.
E: OK. Why?
S: Cause if there is an A, if there’s, that’s an A then there should be a 4 on the other side, and the same with that [4]. But with those two, the K and the 7, it doesn’t matter. I don’t think. Well it would prove that it’s untrue, but if we want to prove it’s true, then . . . (gestures with her hand) [continued below]

How can this curious distinction of ‘proving untrue’ and ‘proving true’ be understood? The subject continues to use it as the dialogue continues, and eventually settles on ‘all cards’, chosen to fulfil both these criteria. I couldn’t help thinking she had some sensible distinction to make, but just wasn’t labelling it well. ‘Proving untrue’ is in the above turn doing double duty as a description of applicability criterion and falsification, as in, the rule doesn’t apply to the K and the 7 because they make it untrue. This testifies to a card-checking approach as outline above; as in, which set of cards can satisfy the rule? Being prompted to consider what she has just said seems to make the subject reconsider her choices.

[continued from above]

E: What would prove it’s untrue?
S: If you turned the K and it had a 4 on it, then that would make the rule untrue.
E: So but you don’t think you need to turn the K and the 7, is that right, or do you?
S: Well you need to turn the A and 4 to prove it, but then . . . well I suppose you actually have to turn the K and the 7 as well to . . . to make sure that it, that it’s not untrue.
E: To make sure you’re not disproving it?
S: Yeah. So actually probably you have to turn them all.
E: But for different reasons though?
S: Yeah. To turn those two [A, 4] to prove it and to turn those [K, 7] to make sure you’re not disproving it.

Presumably the K and 7 should not have As or 4s on them; then we would be in the restricted-domain biconditional reading of the conjunction.

Another example of confusion about the status of ‘truth’ in the task:

**Oona in the original task:**

[she has answered A and 4, but ‘4 first’]
E: So let’s think about what could be on the back of the A. On the back of the A there could be a 4 or a 7.
S: There should be a 4.
E: There should be a 4?
S: Yes, because it says if there is an A on one side then there is a 4 on the other side.
E: Ja, but you have to check whether that’s true or not.
S: Ah! OK fine. If it is true that’s what it should be. But yeah you’re right, it could be a 4 or a 7.
E: So say you turned it over and there is a 7. What would that mean?
S: The rule is wrong. Well it’s, it’s a lie!

For the rule to be a lie, it must be purporting to tell the truth – as a characterisation of the cards. Elsewhere she says that a 7-A combination would mean the rule ‘is messed up’, yet insists this is no reason to turn the 7. Again, this makes sense if one supposes that she doesn’t take the status of the rule to be under scrutiny, and rather takes her task to be one of investigating its applicability to the cards, and, as such, the task is one of card-checking. Her use of the phrase ‘messed up’ aligns well with this; rather than simply stating that the rule is falsified, the rule doesn’t ‘apply’ properly to the cards. This is not a straight deontic reading; rather, truth is read as ‘applicability’.

### 5.5 Summary, conclusions and outlook

“Psychology is in some ways harder once one acknowledges interpretational variety, but given the overwhelming evidence for that variety, responding by eliminating it from psychological theory is truly the response of the drunk beneath the lamp post” (Stenning and van Lambalgen, 2004, p. 491).
In this small qualitative study we found much new and corroborating evidence of interpretational variety, in a range of manipulations of Wason’s selection task. In particular, the current findings strongly supported earlier explanations of the modal choice of A and 4 in the original task arising from ‘interference effects’, i.e. the influence of the anaphor element on the conditional direction, and could now relate this to another popular choice, just A. For the first time subjects were interviewed about their understanding of a conjunctive phrasing. This condition provoked a surprisingly range of responses and an attempt was made to explain the interpretations lying behind these and to relate them to other rule formulations. Different findings in the two-rule manipulation entailed a necessary extension of the analysis provided by Stenning and van Lambalgen (2004) on this task.

The posited range of interpretations for the various conditions was then placed into the context of the broader semantic settings of the task. The tutorial dialogue setting clearly helped subjects to reach the intended interpretation of the task, with almost all reaching the normative selection by the end of the interview. However, there was also great variability in subjects’ interpretations of the different conditions, suggesting that the normative interpretation of the original task serves as a highly scaffolded interpretation for the subjects. Slight variations in the conditions led subjects to adopt different interpretations of the conditional. In the split anaphor condition we saw that a seemingly different selection could represent the same reading of the conditional, and the task demands interact with this to produce a different selection.

Briefly the various possible relations of cards to rule and the ways these affected the subject’s construal of their task and the conditions for truth and falsehood in the task were discussed. Novel findings here are the existential import assumed by subjects which surfaces only in the split anaphor version of the task; the assumption of strong falsity in the two-rule task and the card-per-card reading interacting with a descriptive understanding of the rule to produce a notion of truth which resembles ‘applicability’.

I hope to have convinced readers that the Wason selection task is by no means just a simple test of falsification, but that the basic set-up can be fruitfully used to investigate a wealth of semantic issues that subjects are concerned with in reasoning about the truth of a descriptive rule. Most earlier research has been purely quantitative and has thus failed to reveal these factors, but, as Stenning and van Lambalgen suggest, it was time to start looking further than in the pool of light around the lamppost.

5.5.1 Experimental suggestions

The natural next step would be a quantitative study on the basis of the findings here. However, the suggestion would be to collate data from subjects across conditions, to investigate the extent to which there is stability of interpretation. In
section 5.4.2 it became clear that individual subjects adjust their interpretation of a rule and according truth conditions surprisingly easily. However, the small size of this data set might be magnifying the seemingly endless interpretational caprice. With a bigger data-set one would be more able to identify tendencies towards one or other readings, across conditions but within subjects. Furthermore, the tutorial data have shown how certain choices are highly connected for some subjects, such as the choice for ‘just A’ and ‘A and 4’ in the original task, and this kind of information can now be used to identify patterns of related but non-equivalent responses in a big data set.

An issue arising from this study which deserves further attention is the connection between conditional and conjunctive phrasings such as in the original and conjunctive tasks. This connection is implicit in Athanasiadou & Dirven’s (1995, 1997) analysis of course-of-event conditionals – in particular the commitment to both the antecedent and consequent in such conditionals – as Chapter 2 described. There remain many open questions about the circumstances under which conditional phrasings have conjunctive force, as well as those in which conjunctive formulations are interpreted conditionally, one being the seeming conversion of the conjunct order into a kind of suppositional precedence ordering, perhaps similarly to or by means of an imposition of temporal order.