Looking for logic in all the wrong places: An investigation of language, literacy and logic in reasoning
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“Only irrationality is newsworthy.”

(Krueger & Funder, 2004, p. 318)

A browse through the psychology shelf at your local bookshop makes clear that bad reasoning is big business. Popular titles include

- “Inevitable Illusions: How Mistakes of Reason Rule Our Minds” (Piattelli-Palmarini, 1996, a best-seller in Italian),
- “Don’t Believe Everything You Think: The 6 Basic Mistakes We Make in Thinking” (Kida, 2006, ranked number 38 on Amazon’s list of over 5000 cognitive psychology titles1), and
- “How We Know What Isn’t So: The Fallibility of Human Reason in Everyday Life” (Gilovich, 1991, number 74 in the same ranking).

Such titles are not very encouraging about the state of human reasoning ability. It seems that at every turn we are tricked by ‘cognitive illusions’ into drawing compelling but invalid conclusions. We might wonder: are things really that bad? Or is this just populist hype to sell books?

Actually, if some researchers in the psychology of reasoning are to be believed, things really are that bad. Byrne, Espino and Santamaria (1999) go so far as to blame the disaster at the Chernobyl nuclear faculty on the failure to draw the fairly simple modus tollens inference.2

2 The authors are here referring to the modus tollens inference based on the premises “if the test is to continue, the turbine must be rotating fast enough to generate emergency power” and “the turbine is not rotating fast enough”. Using deontic logic, one could draw the conclusion that “the test must not continue”.

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People have difficulty making some inferences. The power plant workers in Chernobyl did not make the modus tollens inference, and as a result partly of this inferential difficulty, the Chernobyl disaster occurred, with worldwide implications. If we are to avoid repeating the mistakes of the past, we need to examine those mistakes carefully and establish how they came about (Byrne et al, 1999, p. 347).

Indeed, if things are that bad, we need to examine very carefully if, when and how such mistakes come about.

So, what is the scientific research behind the popular titles? What kind of evidence is there for the claim that “mistakes of reason rule our minds”? There are several well-known research programmes feeding such ideas; perhaps the most well-known is the programme initiated by Tversky and Kahneman, investigating heuristics and biases, and associated with probabilistic reasoning. But another major source of empirical support is the research into logical reasoning, often termed the ‘deduction paradigm’ (Evans, 2002).

In the deduction paradigm subjects are asked to assess the validity of arguments. They are presented with a set of premises, and then either asked to decide whether or not a given conclusion follows from them, or to generate their own conclusions on the basis of the premises. This method is intended to evaluate the ability of subjects to reason logically. A central motivation for the research undertaken in this dissertation was to evaluate whether in fact studies using such a method have successfully done so, and if not, what kind of approach provides better access to the logic in reasoning.

Also in the deduction paradigm, the dominant characterisation of reasoning has been in terms of logical deficiencies and nonlogical influences. Indeed, from the first, studies of reasoning have produced negative findings. Wilkins (1928) found subjects to illicitly convert the quantifiers all and some . . . not. Woodward and Sells (1935) reported so-called ‘atmosphere effects’ in syllogistic reasoning tasks: a negative premise increases the chance of a negative conclusion, and a particular (i.e. non-universal) premise increases the chance of a particular conclusion. Around the same time (the 1930s) Luria was conducting studies of reasoning with illiterate peasants in remote areas of Soviet Russia, and found “[t]he most typical responses of the subjects, therefore, were a complete denial of the possibility of drawing conclusions from propositions about things they had no personal experience of, and suspicion about any logical operation of a purely

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3Byrne et al go on to explain that workers at Chernobyl might have not drawn the inference because they considered additional requirements from their background knowledge, and as such, “whether safety procedures had to be followed to the letter in such a case” (p. 347). If additional requirements are considered, then the modus tollens inference is not longer deployable. Human error is thus actually to be located in the judgement of whether or not the turbine’s rotation speed provides sufficient reason to stop the test or not, and thus whether the modus ponens inference is appropriate or not; it has nothing to do with a fault in drawing the inference itself.
theoretical nature” (Luria, 1977, p. 108). In more recent syllogistic reasoning research, the negative findings have continued. Reasoners are subject to belief bias (Oakhill, Johnson-Laird and Garnham, 1989), typicality effects (Sloman, 1998), and other supposedly non-logical content-effects.

The field is usually seen as becoming fully-fledged in the 1960s and 1970s, initiated by the very well-known selection task, as developed by Peter Wason (1968a). Wason’s very first presentation of the selection task (1966, p. 145) is tellingly headed “Errors in deductive reasoning”, and his later conclusions about his subjects’ performance in this conditional reasoning task (described in detail in Chapter 5) are just as pessimistic:

The results, however, are ... disquieting. If Piaget is right ... then subjects in the present investigation should have reached the stage of formal operations. A person who is thinking in these terms will take account of the possible and the hypothetical ... But this is exactly what the subjects in the present experimentsingularly fail to do. ... Could it be that the stage of formal operations is not completely achieved at adolescence, even among intelligent individuals? (Wason, 1968a, p. 281)

Perhaps the most widely accepted conclusion arising from Wason’s selection task is that reasoners suffer from confirmation bias; that is, they seek to verify, to confirm, rather than test and possibly falsify, their beliefs, expectations, or salient hypotheses (Evans, 1989, Nickerson, 1998). Wason himself saw this as the major finding resulting from his series of reasoning experiments (Wason, 1966, 1968b, 1972). Also in conditional reasoning research, the findings have persistently been expressed negatively. Apart from confirmation bias, many other erroneous tendencies have been proposed. Evans long pursued an explanation of conditional reasoning in terms of very superficial matching bias (see Evans, 1998, for an overview); Byrne (1989) presents experimental evidence that subjects “suppress” valid inferences in certain contexts, while in a recent paper, Johnson-Laird and Savary (1999) report on “Illusory inferences: a novel class of erroneous deductions”.

This litany of reasoning errors contrasts with a parallel, though less prominent, realisation in the field, that interpretation of the materials and construal of the task situation play a vital role in determining subject performance, thereby

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4In another experiment in which subjects were asked to generate hypotheses regarding a series of numbers, Wason seems to despair at what he finds:

There would appear to be compelling evidence to indicate that even intelligent individuals adhere to their own hypotheses with remarkable tenacity when they can produce conforming evidence for them. What makes people so narrow minded and so cognitively prejudiced? Why did they find these trivial games so difficult? (Wason, 1968b, p. 172)
undermining claims as to the significance of results from studies which do not take this into account. In fact, early papers by Wason (Wason, 1968b, Wason & Johnson-Laird, 1970) emphasise that the way the subjects ‘structure’ the task determines their card selection. Henle’s (1962) paper is well-known as claiming that all seeming errors of reasoning can be explained by subjects’ interpretation of the premises in combination with their construal of the task situation. Evans (1972) refers to this in arguing that reasoning research is too concerned with classifying behaviour only as correct or ‘erroneous’ (p. 382) and recognises that interpretation of the premises play a role (p. 373):

In order to understand the psychological basis of subjects’ behaviour it is suggested that at least two types of influence must be distinguished:

Those relating to the subjects’ interpretation of the sentences constituting the logical premises of the problems; and those arising from the nature of the mental operations required on a given task.

Interest in subjects’ interpretative behaviour is thus present from early on in the field, but curiously such processes are often considered to be unrelated to reasoning, and hence to logical processes. For example, Evans associates the focus on deviation from the norm with an over-reliance on classical logical as a normative-theoretical model of behaviour. This leads him to formulate a neglect of interpretation as a neglect of ‘non-logical factors’: in arguing for more attention for interpretative processes, he says experimenters “have tended to overlook psychological explanations in terms of factors quite unconnected with logic” (1972, p. 374). Thompson (2000) explains the preference for ‘abstract’ materials, as an attempt to prevent interpretative processes from interfering with reasoning. Abstract materials, “which presumably are not subject to the same type of interpretative analysis as more ‘realistic’ materials”, serve as a measure to “control or eliminate the role of interpretative processes in [theorists’] experiments” (Thompson, 2000, p. 212). It is unclear whether Thompson herself endorses this association of abstract material with absent or unproblematic interpretation; at any rate let me be clear that I do not. If anything, more abstract materials usually contribute to interpretational complexity. And conversely, much can be explained in subject behaviour by means of the normal, everyday use of constructions found in premises. Both Chapter 2 and Chapter 5 provide case studies of this phenomenon.

The realisation of the importance of interpretation is sometimes even present in articles which report on reasoning errors. For instance, Byrne (1989) summarises the implications of the suppression-effect findings by saying “The results suggest that the interpretation of premises plays an even more central role in reasoning than has previously been admitted” (1989, p. 61). Later on, she says “The moral of these experiments is that in order to explain how people reason, we need to explain how premises of the same apparent logical form can be interpreted in quite different ways” (1989, p. 79, my emphasis). I will later return to the precise status of that ‘apparent’.

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Because many findings were characterised in terms of deviations from the classical norm, many theorists saw that the need for a positive account meant avoiding simply comparing behaviour with this norm. Since the norm was seen to represent the whole of logic, that meant jettisoning logic from an account of reasoning. Such a rationale, I think, lies behind the new wave of theories which aim to characterise reasoning positively, for instance, in terms of adaptive behaviours (Gigerenzer, 1999), and evolutionarily-based accounts (Cosmides & Tooby, 1989), but which explicitly set themselves off against logic-based theories of reasoning. Chapter 4 describes the assumptions which led to the jettisoning of logic from theories of reasoning, and shows how they stem from an overly-simplistic view of the relation between natural language and logic. When we take a more accurate view of the relation between natural language and logic, as the current work describes, it becomes clear that the negative findings in the psychology of reasoning provide no reason to dismiss a role for logic.

An existing seam in the literature of research does make the connection between interpretative processing and logical reasoning. This research aims to explain inferential behaviour in terms of more general semantic and/or pragmatic considerations. For instance, Hilton (1995, p. 248) understands that “failure to recognise the role of conversational assumptions in governing inference processes can lead rational responses to be misclassified as errors and their source misattributed to cognitive shortcomings”; Thompson (2000, p. 212-3) makes the more general claim that “in order to have any explanatory power, a theory of reasoning must contain a theory of interpretation, which specifies how information is derived from the problem environment and applied to a given task domain. In a non-trivial sense, therefore, a theory of reasoning is a theory of interpretation.” Commitment to a comparable view underlies the work of Politzer on the topic of human reasoning (Politzer, 1986, Politzer & Noveck 1991, Politzer & Macchi, 2002, Politzer, 2004), as well as the research programme of Stenning and van Lambalgen (2001, 2005, 2008). The work of both Politzer and Stenning and van Lambalgen are discussed in greater detail later on.

The current dissertation fits squarely into this tradition – that is, it propounds a semantically-grounded approach to reasoning. As such, the main aim is to contribute to our understanding of how semantic considerations shape performance in reasoning tasks. This is achieved by investigating and, when necessary, redescribing the relations between natural language, logic, and reasoning, as these notions are employed in experimental studies of reasoning. New experimental results from diverse subject groups contribute to the analysis and allow us to reinterpret earlier negative findings. By the end of the dissertation I hope to have revealed more of the intrinsic connections between interpretative and inferential processes, and, in doing so, to have undermined the evidence presented in service of negative conclusions about reasoning. In a sense the whole dissertation serves as a counterargument to the belief that “mistakes of reason rule our minds”.

Some key terms

Before we start it is useful to sketch the role of some of the central concepts that are employed in the dissertation. I then briefly motivate and evaluate the empirical approach employed here, and finally give a brief outline of what the reader can expect.

Logic, semantics, interpretation

The terms ‘logic’, ‘semantics’ and ‘interpretation’ will occur frequently in the coming chapters. What do I mean by them and how do they relate to each other? Perhaps most distinct from other psychology of reasoning research is the conception of logic upheld here. In a very general sense, a logic can be defined as a collection of expressions of a language, a collection of structures (usually models), and a satisfaction relation between the two. A structure satisfies an expression if the expression is true of the structure. The final independent definitional parameter is validity, which can be expressed in terms of satisfaction. A conclusion is classically valid in case it is satisfied by all structures which satisfy the premises; there are however many alternative notions of validity, in which a conclusion need be satisfied by some preferred subset of these structures, or even a different set of structures (as in statistical reasoning). A structure consists of a domain and an interpretation function. Intuitively, the domain is what the language is about, and the interpretation function tells us what the expressions of the language mean, in the sense that it assigns suitable denotations to the non-logical parts of the language.

Each specific logical system studied by logicians reflects different aspects of the structure of the world in its structures. For example, first-order logic considers domains of individuals. It can talk about properties of and relations between these individuals in terms of sets which serve as interpretations of the predicate symbols in the language. It cannot talk about relations between sets. Modal logic is designed to capture notions of necessity and possibility; as such, it has a more complex language, including operators representing possibility and necessity, and more complex modelling structures, often including relations between possible worlds. In a way similar to modal logic, deontic logic seeks to represent the intuitions we have about obligations and permission. It is unimportant for the reader to know the details of these logical systems What I want to emphasise is that logic is essentially about meaning. It is about framing a situation in a certain way; abstracting away from or ignoring certain aspects of its structure and focusing on others.

This is a much broader and less monolithic conception of logic than that employed in many of the existing studies of reasoning. Chapter 4 presents arguments as to why the earlier, narrower conception of logic, more or less equating it with classical logic, is outdated, and does not have the sovereignty often attributed to
it in the realm of human reasoning.

Semantics is most broadly the study of meaning. In the area of linguistics it is usually bracketed off from syntax, which is concerned with grammatical form, on the one hand, and pragmatics, which is concerned with language use, on the other hand. In studies of reasoning, as we will see in Chapter 4, a simplistic reading of the notion that logic is concerned with form as opposed to content, and the attribution of logical form solely on the basis of grammatical form, has often meant that logic is understood to be almost antithetical to semantics, where the latter is understood to deal with content. This might partially explain why many researchers have been reluctant to take subjects’ interpretations of task materials seriously, i.e. because it understood to be quite a separate issue from the logic of the materials – as the earlier comment from Byrne, “we need to explain how premises of the same apparent logical form can be interpreted in quite different ways” (1989, p. 79), demonstrates.

In this dissertation the opposite view is taken. Here I align myself with Stenning and van Lambalgen (2008) in claiming that the ‘logic’ of the task is always relative to an interpretation of the premises, since this establishes what it means to assume the premises are true, the inferences which can be made on the basis of them, and the kind of validity these have. Logic is thus essentially indexed to semantics. In fact, logic, as sketched above, can be understood as what is in linguistics termed ‘formal semantics’.

Finally, it should now be clear that the interpretative processes are intimately related to logic because they are concerned with attribution of logical form to natural language expressions. Consider the example “All bears in the north are white”. Interpreting such an utterance means at least determining extensions for terms such as ‘bears’ and ‘white’, for the present purposes (non-trivial, because, for instance, dirty yellow might count as white when ‘white’ is interpreted in combination with ‘bear’), as well as figuring out what the domain is, over which the ‘all’ ranges, and the effects of changes to the domain on the truth of the generalisation. Does one brown bear falsify it? Or does its truth allow for some exceptions? There are many choices to be made in settling on an interpretation. The experimenter’s interpretation of the task materials is only one among many, as we shall see, and is often highly contrived, in a sense which I make more exact in Chapter 2. Moreover, the experimenter’s assumption that their interpretation is privileged, because it relies only on ‘literal meaning’, representing the truly ‘logical’ interpretation of premise materials, is flawed and thus ultimately untenable, as Chapter 4 shows.

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6 The semantics-pragmatics boundary is addressed in Chapter 4, where it is argued that traditional priority of semantic factors above pragmatic factors, in determining ‘what is said’, has been shown not to hold.

7 This is a slight exaggeration, since of course the meanings of ‘logical’ elements of language, that is, ‘and’, ‘or’, ‘if’ and ‘not’, are understood to contribute to logical form. But such elements are considered as distinct from ‘content’, and it is in this sense that the claim is intended.
Reasoning
What is meant by reasoning? It is hard to find a general but substantial definition in the literature. This is by no means just due to laziness on the part of researchers to define their topic. Everyone will happily concur that reasoning is based on making inferences. But inference is ubiquitous: we infer emotions from facial expressions, infer shapes from outlines and shades, infer body position from middle ear fluid levels, even male toads, “roaming through the swamps at night, use the pitch of a rival’s croak to infer its size when deciding whether to fight” (Gigerenzer & Goldstein, 1996, p. 650). All cognition involves “going beyond the information given”, to use Bruner’s (1957) phrasing. What then, is the proper research area for studies of human reasoning?

Until now, reasoning has chiefly been operationalised as assessment of simple arguments viewed as part of syllogistic and propositional logic. This involves drawing or judging a single conclusion from a limited set of premises, in one-off interaction (although the selection task is a notable exception to this format). Such an operationalisation is probably mostly historically-determined. Since one of the goals of this dissertation is to assess the previous research based on such an operationalisation, I likewise investigate reasoning in this format. But it should be clear that the use of this form of evaluating reasoning is the theorists’ choice; actual behaviour does not respect our disciplinary boundaries. As will become clear, for a large part the reasoning in the context of reasoning tasks is found in the process of settling an interpretation. This has led Stenning and van Lambalgen (2008) to distinguish reasoning to an interpretation and reasoning from an interpretation, instead of distinguishing reasoning as such, from interpretation. The point is that reasoning is a concept much more broadly applicable than the above operationalisation suggests. This narrow definition serves a pragmatic purpose and need not be harmful, unless we assume that reasoning is restricted to reasoning from an interpretation, in Stenning and van Lambalgen’s terms, in which case one runs the risk of making the artificial dissociation of interpretation from logic identified above.

Empirical access to reasoning
Given the above discussion of the intimate relation between interpretation and reasoning processes, it should come as no surprise that purely quantitative studies, in which subjects indicate their evaluation of an argument by ticking from a pre-given selection of conclusions, or being asked to say “what follows” from a set of premises, are here considered insufficiently penetrating. Such set-ups basically take interpretation for granted. As an attempt to counterbalance the neglect of interpretation, the empirical approach to reasoning employed in this dissertation is extended tutorial interviews with a relatively small number of subjects. Such an
approach is very unusual in contemporary studies of reasoning and thus deserves an extended introduction.

Quantitative studies are far and away the norm in psychology of reasoning. For example, the experimental set-up which generated Byrne’s (1989) suppression-effect findings was as follows. There were three groups of subjects, and each group was assigned to a different type of premise set (e.g. one or more conditional premises; for more details, see Chapter 1). The subjects were given a booklet with a number of different versions of the premise sets of the same form. Versions differed only according to ‘content’, as in “If she meets her friend then she will go to a play” has the same form but differing content to “If it is raining then she will get wet”. Note here that it is simply taken for granted that sentences with different content, but superficially the same grammatical form, are indeed exemplars of one and the same logical form – a matter taken up more fully in Chapter 4. Each premise set was accompanied by three possible conclusions. Subjects were instructed (on the front page of the booklet only) to assume the premises were true and then to choose one of the conclusions, “whichever you think follows from the sentences” (p. 68). The conclusions chosen by subjects for each item were then counted and statistical tests (ANOVAs, one-tailed planned comparisons) reveal significant effects – such as, in this study, main effects of types of premise sets, and conclusion types, and an interaction between types of premise sets and conclusions chosen.

There are several reasons why such experimental methods are inadequate. Firstly, as mentioned above, the most problematic aspect to a set-up such as Byrne’s is that it takes interpretation of the premises for granted. No attempt is made to find out what it means for the subject “to assume the premises are true”. Under what circumstances is a conditional premise such as “If it rains then she will get wet” true? What counts as a falsifying instance to it? Questions like this remain open and very substantial, as Chapter 1 and Chapter 5 both make abundantly clear. Complexities at the level of interpretation are plausibly responsible for, among other things, the main effect mentioned, of differences in the rate of inference from the various premise sets. Yet Byrne’s method (which is typical for reasoning studies) is unable to access interpretational matters. Related to this, there is no check on broader task construal issues – what does the subject see as their role, in the setting of the task? In less educated subject groups this matter comes forcefully to the fore, as the next chapter demonstrates. The ‘laboratory’ situation is, unfortunately for the quantitative researcher, just as meaningful to the subject as any everyday linguistic interaction. This makes control of the stimulus difficult to achieve, and impossible when interpretative variety and, more broadly, the subjects’ own perception of the task, is not taken into account. Note however, that interpretative processes can be probed with quantitative methods, such as paraphrase judgements. These have been successfully

In chapters 1 and 2 differences between such conditionals are elaborated.
used by researchers (e.g. Stenning and Cox, 2006, Stenning and van Lambalgen, 2004) to couple interpretative tendencies to reasoning behaviour.

Secondly, each response is treated as if it came from a separate subject, thereby losing potential information about individual tendencies and any resultant ‘trait’ differences between individuals. Presumably this is justified by the aim of Byrne’s study, which is cast in terms of determining whether reasoning depends on “formal rules of inference” or “mental models” (as described by Johnson-Laird, 1983) and as such is concerned with finding a universal mechanism by which reasoning occurs. But, as Stenning and van Lambalgen (2008) have cogently argued, reasoning is not a ‘mechanism’ which operates in a contextual vacuum. Such conceptions are in any case severely challenged by findings from subject groups other than the undergraduate population in which quantitative studies are invariably conducted. In less schooled groups, the fact that simple reasoning tasks prove very difficult to subjects argues against the idea that such tasks provide neutral access to some universal reasoning mechanism. Additionally, there are many studies which have found significant differences between individual reasoners. Research within literate subject groups shows that performance on the selection task correlates with SAT scores (Stanovich, 1999). Other reasoning studies which look for individual differences found that reasoners can be classified according broad groupings in their interpretative and reasoning strategies (Stenning and Cox, 2006, Ford 1995).9 Politzer (1981, reported in Politzer 2004, p. 99) even found a difference in interpretational strategies between arts and science students at a university! In sum, simply collating data across subjects, when subjects drawn from a narrow band of the population, and finding significant differences across experimental conditions, does not indicate empirical access to universal reasoning behaviour has been achieved.

Finally, reliance on quantitative studies has meant that most explanations concentrate only on the modal answer10; for example, in Wason’s selection task, this means explaining the choice of the A and the 4 card (for more details, see Chapter 5). In fact, there is a much bigger range of responses present, albeit often in smaller numbers. These rarer occurrences tend to be sidelined. There can even be divergent rationales behind a single choice – as the conjunctive condition of the selection task, reported in Chapter 5, illustrates: some subjects choose a certain card because it potentially falsifies the rule; others because they think the rule is already false. In many forced-choice studies, a full range of plausible responses is not even offered, as is the case in Byrne’s original study of the suppression effect.

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9 Ford’s 1995 study of syllogism-solving strategies indicates that reasoning subjects can be divided into two groups, namely ‘verbal’ and ‘spatial’, and inasmuch as this difference can be cast as that between subjects who focus on sentential form and those who don’t, Byrne’s treatment of all subjects as equal is potentially undermining her own argument for one or other type of ‘mechanism’.

10 The modal answer is that which is chosen by the highest percentage of subjects. It represents just one point on the distribution over the space of possible answers.
task described above. As Dieussaert, Schaeken, Schroyens and d’Ydewalle (2000) showed, subjects will spontaneously generate a much broader range of responses than the three simple propositions offered in Byrne’s original study; this being so, a forced-choice study runs the risk of seriously underestimating the categories of response which need to be explained.

With the above arguments I hope to have given the reader a sense of why a purely quantitative approach is an inadequate instrument with which to access the complexities of reasoning behaviour. Before phenomena can be counted, classified and explained, the categories for classification must be established. In short, there is still exploratory work to be done.

One might well wonder why there has been such a reliance on quantitative studies in the psychology of reasoning. A partial reason might be the bad name that ‘think-aloud’ protocols received around the time the field was burgeoning. Nisbett and Wilson’s (1977) famous article suggested that we are often not conscious of, and thus not in control of, the influence that certain stimuli have on our behaviour. As such, verbal reports of reasoning might just be ex post facto rationalization, unrelated to the original automatic reasoning processes driving our behaviour.\footnote{Incidentally, such a distinction between conscious, verbal processing and unconscious, automatic processing has provided important impetus for dual-process theories of reasoning (Evans, 2003).} But even before this, there was a preference for the laboratory stimulus-response method. The abstract which opens Wason’s first publication about the selection task is telling (Wason, 1966, p. 135):

One of the curious things about the earlier, introspective studies of thinking was that they demonstrated more than anything the inadequacies of their own methods. The course of thinking is affected by factors which are not available to introspection. Modern experimental work has avoided some of the issues by restricting itself to studying what people do when they solve problems.

Why “studying what people do when they solve problems” should be limited to asking subjects to tick boxes, as if thereby accessing “factors which are not available to introspection” is unclear to me.

Another reason that the stimulus-response method might have been viewed as sufficient, would be that experimenters have operated from the assumption that interpretation is a straightforward process. After all, one might argue, we are communicating successfully all the time, so interpretation can’t be going that badly. What’s more, spoken interaction often consists of incomplete or seemingly vague utterances, which are augmented by context and pragmatic conventions, yet in general this proceeds in a smooth and uniform manner. Why wouldn’t it do so in the context of a reasoning task, one might ask, where the premises are written in full sentences, thus presumably exceptionally clear and unproblematic?
Well, as will become clear, as soon as we examine the specific linguistic material used in these tasks, the meaning of the premises is by no means clear or unproblematic. The language used is far less unequivocal as it might seem – especially, as registered above, in the case of ‘abstract’ materials. Moreover, in the typical laboratory set-up, the context needed for interpretation and assessment of the linguistic material that is used, is often found lacking. It will become clear that successful performance in most reasoning tasks requires a delicate combination of contrived and everyday interpretation of linguistic materials, which it takes quite some effort to maintain.

Perhaps Wason’s comments should be understood as part of a broader zeitgeist, in which cognitive science was trying to establish itself a science. Bruner diagnoses this as resulting in an over-reliance on a computational metaphor for understanding the mind (Bruner, 1990, p. 4):

> Very early on [in the cognitive revolution], ... emphasis began shifting from “meaning” to “information”, from the construction of meaning to the processing of information. The key factor in the shift was the introduction of computation as the ruling metaphor and of computability as a necessary criterion of a good theoretical model. Information is indifferent with respect to meaning.

It should be obvious that this criticism is especially pertinent in cases where meaning is central to the cognitive task being investigated. In studies of perception, by contrast, the “construction of meaning” may not play such a central role. But as we will see, constructing meaning is integral to reasoning.

It may be impossible to pinpoint why the emphasis has been so firmly on quantitative studies, but it is important to see the shortcomings of such a one-sided empirical programme and to be open to multi-method studies, which also allow space for in-depth qualitative studies.

**Tutorial interviews: profits and perils**

In this dissertation, empirical investigation took the form of extended interviews with subjects covering several reasoning tasks. With both schooled and unschooled subjects, structured interview protocols are invaluable for several reasons. Firstly, the considerations a subject takes into account in reaching an interpretation can be very revealing of the sometimes antagonistic considerations and resulting tensions that subjects deal with in understanding the task, both their role in it and the intended interpretation of the materials. These varying considerations are only identifiable in an extended interaction with the subject. Secondly, as mentioned above, studies which allow subjects to generate their own conclusions have revealed the great variety of responses that reasoning subjects make. If we are to take our subjects seriously, we need to understand what is behind this variety, and this can be aided greatly by a conversational interaction
with the subject. Once the varying rationale behind the full range of responses has been identified, we are better able to understand the range of choices generated in the quantitative studies of tasks, and not only the modal choice. Thirdly, tendencies in individual subjects can be better identified; this can then be used to design quantitative studies aimed at testing the validity of individual profiles. Finally, a spin-off value of the experiments with unschooled subjects, described in Chapter 1, is their ability to ‘make the familiar strange’, allowing us to explore assumptions about language functioning which in most cases are shared between the experimenter and the subjects of the experiment, but are nevertheless assumptions, only occasionally warranted in the experimental situation.

There are two obvious perils of an interview method: firstly, the inherent subjectivity of the interviewer/experimenter in the interviewing situation. The experimenter is bound to focus on responses they find interesting or relevant, and ignore others. The experimenter might inadvertently influence the interviewee in this, encouraging them to follow one or other train of thought, and dismiss some others. However, using a structured or semi-structured protocol somewhat counteracts this problem as it brings a measure of objectivity into the topics covered. Furthermore, the topic of the interview is a set of cognitive tasks, with clear goals, which further curbs the range of relevant responses, and as such, I think that subjectivity is a relatively minor problem here.

A second, related, problem is the richness and open-endedness of the data, which arises even in structured, goal-oriented interviews such as used here. In the stage of analysing transcripts, the experimenter constantly makes choices about which phenomena to discuss and which to ignore. As such, it depends on the discretionary ability and interest of the experimenter which semantic phenomena are identified and analysed, and how they are classified. This remains a hazard. Given the fact that the research is intended to be exploratory, however, and as long as no claim is made to exhaustivity, this aspect does not fatally detract from the value of the approach.

Perhaps the most basic problem associated with structured interview studies in general is the difficulty in creating the same meaning in situ across participants (Hill & Anderson, 1993), and this was something I was especially aware of in the study reported in Chapter 1, where the specific demands of the interview situation were foreign to the subjects. University undergraduates, by contrast, have probably quite rich ideas about what is expected from them in such an experiment (which is not to say this helps). But this problem becomes a strength for our current purposes: a unique aspect of the current research is that the process of interpreting the experimenter’s words is part of the interview itself; it is not something which must be neutralised or ‘controlled for’.

The empirical data of this dissertation are generated by very simple argument forms, but they reveal a wealth of complexity and depth in human semantic interactions. With this dissertation I aim to show that such interactions belong at the heart of a theory of reasoning, not outside it.
Outline

The dissertation is structured as follows. In the next chapter, the findings of an interview study with subjects with varying but low education levels, similar to those conducted by Luria (1976) and Scribner (1997), are presented. The aim of the chapter is to engage with and challenge the interpretation of illiterate reasoning behaviour as typified in Luria’s negative conclusions. This is achieved by reanalysing the typical responses garnered in interaction with less educated subjects, but with heightened attention to semantic and pragmatic factors which are shaping their responses. The increased understanding of discourse contexts and their impact on the attribution of logical form as reflected in modern semantic and pragmatic study enables us to do this.

Chapter 2 takes as its starting point the finding that conditional premises of a certain format proved easier to the less schooled subjects than certain universally quantified premises. An explanation of this is sought in everyday usage of these constructions. To this end, a preliminary analysis is made of occurrences of all in a corpus of spoken English, and its equivalent in a small corpus of spoken Xhosa, the language spoken by the subjects of the experiment reported in chapters 1 and 2. Findings here support a semantic analysis of all generalisations as primarily contingent as opposed to law-governed, which in turn explains the difficulty especially unschooled subjects have in using such sentences as premises in the context of a reasoning task. A parallel analysis of the kinds of conditionals used in reasoning tasks explains why conditional premises, by contrast, are less problematic for subjects.

In Chapter 3 these findings are placed in the context of the broader debate on the cognitive consequences of literacy. A critical survey of empirical findings and general theories in this area indicates that much work has not been self-critical or precise enough. The work of David Olson is described and assessed in more detail, and an adapted version of his literal meaning hypothesis is proposed to explain the difference between schooled and unschooled subjects’ performance in reasoning tasks.

Consideration of the notion of ‘literal meaning’ feeds directly into Chapter 4, the chapter which forms the analytic backbone for the whole dissertation, as it explains how much previous work in the psychology of reasoning has relied on an oversimplified picture of the relations between natural language, logic, and reasoning, giving rise to confusions about logical form, its relation to meaning in general and to literal meaning in particular. Here the main thesis is that a notion of ‘literal meaning’ of premises is uncritically and mistakenly used as a basis for normative judgements about logical reasoning. This notion of ‘literal meaning’ has served as a proxy for active investigation of interpretative processes, but it is imported from an outdated theory of linguistic meaning. I use recent arguments of philosopher of language François Recanati to show this.

Finally, Chapter 5 reports on an interview study on Wason’s original selection
task and several variations of it. The analysis builds on the work of Stenning and van Lambalgen regarding the selection task paradigm, in identifying and describing the plausible interpretations of the presented rule which explain the large range of responses recorded (also in previous quantitative studies) and the task-level semantic parameters which interact with these to explain subject behaviour. This chapter is intended to show that standard reasoning experiments, although they have previously been aligned primarily with explanations of reasoning in terms of deviation from a norm, provide rich data for a positive theory of human reasoning.