Attitudes to logical independence: traits in quantifier interpretation

Keith Stenning
Human Communication Research Centre
University of Edinburgh
2, Buccleuch Place, Edinburgh, Scotland
keith@cogsci.ed.ac.uk

Richard Cox
Human Communication Research Centre
University of Edinburgh
2, Buccleuch Place, Edinburgh, Scotland
rcox@cogsci.ed.ac.uk

Abstract

Newstead (1989) reports both graphically and sententially elicited data on the interpretation of quantifiers by logically naive undergraduate students. The sentential elicitation method fails to make the critical distinction between entailment relations between sentences, and truth-value-in-a-model relations between sentences and diagrams. The present study modifies the elicitation technique and shows that the resulting sentential data can be insightfully described in terms of broad tendencies of response (to over- or under-infer) interacting with highly specific grammatical structures (subject/predicate relationship). The resulting categorisation of subjects into four groups is then predictive of graphically elicited behaviour. These results are interpreted by contrasting expository and deductive discourse, and proposing that students initially assimilate the latter to the former.

Introduction

Despite their expertise in using natural language, undergraduate students experience considerable difficulties in grasping the interpretation of quantifiers in deductive reasoning when they come to learn elementary logic. Characterising students' initial interpretation of quantifiers before they experience formal logic teaching is therefore a necessary preliminary to characterising what formal logic teaching teaches. We here offer evidence that students exhibit a small number of highly coherent patterns of interpretation. We propose that these patterns can be construed as part of student's assimilation of the novel 'game' of logical interpretation to more familiar expository language uses. We believe that this descriptive study of interpretation offers a foundation of a cognitive characterisation of what happens when students' master deductive reasoning.

In the most systematic existing study of simple quantifier interpretation, Newstead (1989) carried out an experiment investigating initial quantifier interpretations using both sentential and graphical methods of elicitation. His results showed some coherence within modalities but what he interpreted as extensive contrasts between modalities. These contrasts defied coherent description of systematic styles of interpretation.

In this study we show that Newstead's sententially posed questions to his subjects were logically incoherent, and that when they are replaced by logically coherent questions, these are not equivalent to their apparent graphical counterparts. The 'inconsistencies' of response observed cannot be confidently attributed either to the incoherence of the questions, or to students' misinterpretation of the quantifiers. It is not surprising that subjects offer different answers to different questions. On the other hand, we do not suggest that students would necessarily offer mutually consistent answers to different questions even if these were well posed. We present here a study which rectifies the logical problems with Newstead's sentential questions and provides evidence from both sententially and graphically posed tasks about quantifier interpretation. We relate the resulting patterns of response to students' other experiences of language.

The plan of the paper is as follows. In the next section we briefly contrast questions about logical dependence and independence of sentences with questions about the model/non-model relations between sentences and Euler diagrams. We then describe an experiment in which undergraduate subjects answered both sententially and graphically posed questions about quantifier interpretations. The results are analysed for coherent contrasting patterns of individual response. Finally these patterns of response are interpreted as evidence for students' mode of assimilation of deductive reasoning to other more familiar types of natural language discourse.

Questions of interpretation

Newstead used sentential questions about quantifier interpretation of the following kind: "If it is true that ______, is it then true or is it false that ______" where the first blank was filled by one sentence, and the second by a choice of eight sentences. The first *premiss* sentence was of the form *Quantifier AB* with one of the four quantifiers 'All, Some, None, Some ...not' inserted. The second *conclusion* blank's eight sentences are generated by inserting the same four quantifiers in first, the frame AB, and then the frame BA. The critical feature of note is that these are questions about logical relations between sentences, but the only opportunities for response are 'true' or 'false'. In fact, potential conclusion sentences may be related to premisses in three ways: i) as valid conclusions; 2) as sentences whose negations are valid conclusions; 3) as logically independent sentences. Given the premiss *Some A are B* then *Some B are A* is a valid conclusion; *No A are B* is a sentence whose negation is a valid conclusion; and *All A are B* is logically independent.

Newstead posed his questions about sentence relations in terms of truth and falsity. We agree that for logically naive students who have not been taught the distinction between truth and validity, this is probably the right choice, and fortunately it is possible to recast relations of validity in terms of truth and falsity. Valid conclusions from premisses are ones which are true in all circumstances in which the premisses are also true. So questions about validity can be posed by hypothesising that the premisses are true, and then asking whether the conclusions *must also be true*. Similarly, questions about relations of logical inconsistency between sentences can be posed by hypothesising that the premiss sentence is true, and asking whether the conclusions sentence *must also be false*. But crucially, since sentences may be related neither as valid premiss and conclusion, nor as inconsistent, but also as logically independent (with some models of the premiss which make the conclusions true, and some models which make it false), these choices must not be posed as forced exhaustive alternatives. Subjects must also be able to express knowledge of logical independence by saying that they *cannot tell* from the truth of the premiss whether the conclusion is true or false.

The problem of not allowing responses indicating logical independence does not arise with the graphical questions which Newstead employed. Newstead used Euler's Circle diagrams as representations of completely determined interpretations (in the logical sense) and asked whether premiss sentences were true or false in those interpretations. Because the models are fully determined (contexts are fully specified) no sentence is logically independent and 'true' and 'false' responses are sufficient for all possible relations.

Learning to understand and systematically apply the distinction between validity and truth is the core of the conceptual innovation that is required in learning elementary logic. Understanding validity requires the detachment of language from context, and generalisation over contexts. We do not expect that students will necesarily have facile access to these logical relations between sentences once they are coherently posed—if that were the case, teaching logic would be an easy task. But posing questions about these relations is a prerequisite for obtaining interpretable data about quantifier interpretation and the problems that students experience. Prior to running our experiment we expected that students' behaviour with regard to the 'can't tell' response would be diagnostic of their approach to quantifier interpretation.

Experimental investigation of interpretation

The study reported here followed the design of Newstead (1989) closely with the exception of the redesigned sentential questions. Newstead used abstract, 'realistic' and 'thematic' material and found that the differences had little effect on responses. Since we would not especially expect these materials differences to interact with the change of question instituted here, we used only abstract material.

Method

Undergraduate students who had not been exposed to formal logic teaching were given graphical and sentential questionnaires about their interpretation of the quantifiers *all, no, some, some not*.

Subjects

Subjects were 138 undergraduate psychology students at the University of Edinburgh. They were tested during a lecture on cognitive psychology. These students are drawn from a wide range of departments across the entire University with a predominance of social science faculty students. Few of these students had received any formal logical training at high school although some may have experienced 'set diagrams' like those used in the current study in the mathematics curriculum. None of the students had taken logic courses in the University at the point at which this study was run.

Materials and Procedure

Two questionnaires were used in this study. The order of presentation of the questionnaires was counterbalanced across subjects such that half the subjects received the graphical (EC) condition first and half received the sentential condition (II) first.

The Eulers circle (EC) or 'graphical' condition consisted of the five diagrams depicted in figure 1 of Newstead (1989) and was similar to the EC task described in that paper. Diagram 1 was the identity relation (circle 'A' and circle 'B' superimposed); diagram 2 showed a small circle 'A' inside larger circle 'B'; diagram 3 showed a small circle 'B' inside circle 'A', diagram 4 showed circles 'A' and 'B' intersecting and diagram 5 showed 2 non-overlapping, disjoint circles 'A' and 'B'.

Below the diagrams the 4 premises were listed in the order ALL, NO, SOME, SOME...NOT. Adjacent to each premise were the numbers 1 to 5. Subjects were instructed :

> "Below this paragraph there are five circle diagrams labelled 1 to 5. They represent sets of objects (A's and B's). Below the circle diagrams there are four statements. Please circle the number(s) of the diagram(s) that the sentence is true of. If you think 'All A's are B's' is true of diagram 3, circle 3 alongside that sentence. You may circle more than one number per statement. Please interpret "some" to mean "at least one and possibly all".

The sentential condition was similar to the immediate inference (II) task described by Newstead (1989) with the exception that an additional response option ("Can't tell") was provided. As in Newstead (1989), the questionnaire consisted of four pages. At the top of each page one of the four standard quantified statements was displayed: All A's are B's; No A's are B's; Some A's are B's and Some A's are not B's. These were the premiss statements. Beneath the stimulus statements the four quantified statements were listed (All A's are B's etc) and the converses of these (All B's are A's etc). These were the response statements. Alongside the eight response statements were response options 'T' (true), 'F' (false) and 'Can't tell'. The order of the four stimulus statement pages was randomised across subjects.

Subjects were instructed:

"This is a study of the way people draw conclusions from information. On each of the following pages there is a statement at the top of the page. An example is 'All A's are B's'. Assume that the statements are true and that there are both A's and B's.

Below each statement is a line. Below the line are some more statements. For each of the statements below the line, decide whether you believe it is true, false or 'can't tell' given the truth of the sentence at the top of the page. Indicate your belief by circling ONE of either 'T' (true) , 'F' (false) or 'Can't tell'.
Examples:

- if you believe that 'No A's are B's' is true given the true statement 'All A's are B's' then circle T
- if you believe that 'Some A's are not B's' is false given the true statement 'No A's are B's' then circle F

Again, please note that you should interpret 'some' to mean 'at least one and possibly all.' Subjects were allowed as much time as they needed to complete the tasks (approximately 20 minutes).

Results

Task order effects

Seventy subjects received the Euler's Circle task first and 68 subjects received the Immediate Inference (II) task first.

The effect of task order upon response patterns in the Euler's circle task was examined. Response patterns were very similar in all cases except for the SOME As ARE Bs condition. Seventeen subjects who received the EC task first responded with the 'B within A' and 'A intersects B' diagrams compared to 7 subjects in the group that received the II task first. Conversely, 24 subjects who received the EC task first responded by nominating 4 diagrams (the identity relation, A within B, B within A and A intersects B) compared to 16 in the II first group. No other task order effects were observed.

Task order effects upon responses in the sentential task were also examined. Frequency tables of stimulus condition (ALL, NO, SOME, SOME..NOT) crossed with the 8 response statements were separately constructed for 'True', 'False' and 'Can't tell' responses. No task order effects were observed.

Euler's Circle (EC) task

Table 1 shows the proportion of correct responses for each quantifier. Correct responses are defined as: ALL - diagrams 1 & 2 only; NO - diagram 5 only; SOME - diagrams 1,2,3 & 4 only; and SOME...NOT - diagrams 3,4 & 5 only. The results closely agree with those of Newstead (1989).

Conversion errors on EC task Conversion errors occur when subjects interpret, for example, 'ALL A's are B's' to imply that 'ALL B's are A's'. Conversion of 'ALL' (i.e. choice of diagram 1 alone) was evident in 28 subjects (20%). Newstead (1989) reports an incidence of 33% in experiment 1 (n=40) and 20% in experiment 2 (n=30). Conversion of

Table 1: Proportion of correct responses for each quantifier (n=138).

Statement	Fraction	Proportion	Newstead
ALL	84/138	.61	.60
NO	112/138	.81	.75
SOME	40/138	.29	.33
SOME..NOT	52/138	.38	.29

Table 2: Number of subjects producing Gricean errors - EC task (n=138).

Response	SOME	SOME..NOT
DIAGRAM 3 ONLY	4	8
DIAGRAM 4 ONLY	27	20
DIAGRAMS 3 & 4	24	24
TOTAL	55	52

'SOME...NOT' (choice of diagrams 4 & 5 alone) was demonstrated by 9 subjects (6.5%). Newstead (1989) reports 4% (experiment 1) and 5% (experiment 2).

Gricean errors on EC task Gricean errors are equivalent to an interpretation of SOME and SOME..NOT according to conversational implicatures rather than logical (formal) interpretation. Note that subjects were *instructed* to adopt a logical interpretation. Gricean errors are indicated by the failure of subjects to choose diagrams corresponding to universal relationships for SOME and SOME...NOT conditions.

In the case of SOME, 24 (17%) subjects chose diagrams 3 & 4 alone. Newstead (1989) reports 14% in his study. For SOME...NOT, 24 subjects (17%) chose diagrams 3 & 4 alone (Newstead reports 21%).

Table 2 shows the number of subjects who chose diagram 3 alone, 4 alone or both 3 & 4.

The percentage of subjects showing Gricean responses (Table 2) are 40% (SOME) and 38% (SOME...NOT). The figures reported by Newstead (1989) are, respectively, 30% and 27% (page 86).

Immediate inference (II) task

Complete data (*i.e.* for both II and EC tasks) was obtained from 125 of the 138 subjects. Table 3 shows the proportion of 'true', 'false' and 'can't tell' reponses to each quantifier in the immediate inference (sentential) condition, along with the correct responses. In table 3, Newstead's (1989) results are shown in brackets if the results of the present study differ by more than .07 from those reported by Newstead (1989 - table 2, page 86).

In table 3, primed conclusion quantifiers (e.g. A') represent the converse conditions (eg ALL B's are A's etc). The introduction of the 'Can't tell' response option in the current study resulted in a marked lowering of conversion and Gricean errors of interpretation compared to the results of Newstead (1989).

Table 4 compares proportion of correct responses for the EC and II tasks. Correct responses for the EC task were defined above in section 4.1. On the II task, correct responses

Table 3: Proportion of subjects responding 'True', 'False', and 'Can't Tell' to syllogism statements in the immediate inference condition, along with correct responses.

TRUE	Premiss			
Conclusion	ALL	NO	SOME	S'M NOT
All	.99	.00	.10	.01
All'	.33(.57)	.04	.06	.06
No	.00	.98	.00	.06
No'	.06	.59(.80)	.00	.03
Some	.85	.02	.98	.59(.83)
Some'	.64(.87)	.04	.70(.87)	.44(.77)
Some..not	04	.75	.51(.93)	.96
Some..not'	.12(.47)	.52(.77)	.33(.83)	.56(.90)
FALSE				
All	.00	.96	.40	.96
All'	.14	.66	.27	.47
No	.98	.00	.97	.60
No'	.66	.06	.68	.41
Some	.09	.96	.00	.01
Some'	.07	.61	.04	.04
Some..not	.92	.16	.01	.01
Some..not'	.33	.10	.04	.04
CAN'T TELL				
All	.00	.00	.49	.00
All'	.52	.26	.64	.45
No	.00	.00	.00	.33
No'	.25	.32	.29	.52
Some	.05	.00	.00	.38
Some'	.27	.32	.24	.48
Some..not	.03	.06	.46	.00
Some..not'	.54	.34	.61	.36
CORRECT				
All	T	F	CT	F
All'	CT	F	CT	CT
No	F	T	F	CT
No'	F	T	F	CT
Some	T	F	T	CT
Some'	T	F	T	CT
Some..not	F	T	CT	T
Some..not'	CT	T	CT	CT

Table 4: Proportion of subjects giving correct responses to II task and EC task items

Task condition	ALL	NO	SOME	SOME...NOT
II	.22	.43	.23	.06
EC	.61	.81	.29	.38

were defined as shown in table 3. For all statements, a much higher proportions of correct conclusions are associated with the Eulers circle task than with the immediate inference task.

Subject Profiles

Although grouped data provides a comparison to earlier work and it is possible to examine piecemeal correlations between answers to different questions, our real interest is in finding patterns of interpretation characterising a subject's interpretative scheme as a configuration. There is a large space of possible patterns of response across both graphical and sentential questions (rather less than 1 million), and therefore a considerable problem in finding useful descriptions. We approached this problem by exploring students' responses to logical independence and their use of the CT response.

An early observation was that a substantial group of students responded CT whenever asked a question in which subject and predicate were transposed. Not only would these students respond CT when given, for example, *All A are B* and asked whether *All B are A*, but they would respond the same way when given *Some A are B* and asked whether *Some B are A*. Further investigation showed that there was also a substantial group of students who *never* responded CT to any question with transposed subject and predicate. Not only would these students respond, for example, T when given *All A are B* and asked whether *Some B are A*, but they would also respond the same way when given *All A are B* and asked whether *All B are A*. Further investigation revealed that this strong bi-modality of response distribution also occured to questions where subject and predicate were not transposed.

Table 5: Frequencies of subjects making numbers of errors on *QAB:QBA?* questions.

CT for T/F	T/F for CT 0	1	2	3	4	5	6	7	8	Tot
0	3	4	10	6	11	7	5	6	13	65
1	1	0	0	2	1	0	0	5	2	11
2	0	1	0	0	3	1	1	0	0	6
3	0	0	1	0	0	1	0	0	1	3
4	1	1	3	0	1	1	0	1	0	8
5	0	0	0	0	0	0	1	0	0	1
6	0	1	3	2	1	0	0	0	0	7
7	0	3	1	1	0	1	0	0	0	6
8	14	2	0	0	2	0	0	0	0	18
Totals	19	12	18	11	19	11	7	12	16	125

For convenience, we label a tendency to respond CT where T or F is correct *hesitancy* and a tendency to respond either T or F where CT is correct, *rashness*. Table 5 exhibits the distribution of subjects across these response tendencies. Rashness and hesitancy can potentially be exhibited both when the conclusion sentence preserves subject/predicate (henceforth *in-place*) and when it changes (henceforth *out-of-place*). Table 5 shows that no subjects have strong tendencies to be rash on in-place questions and hesitant on out-of-place questions.

These results suggest a scheme for insightful abstraction over the sentential response data. Setting thresholds on the number of CT responses required to qualify as hesitant, and and on the number of T or F responses to qualify as rash can be done both within Q AB questions and Q BA questions. This reduces the space to four binary dimensions. Hierarchical loglinear modelling (*e.g.* Stevens, 1992) revealed that 3 second-order terms (rashness on in-place questions by rashness out-of-place; rashness out-of-place by hesitancy out-of-place; rashness in-place by hesitancy out-of-place) made statistically significant contributions to a model of the data. The technique also permitted the cut-off points on each dimension used to categorize subjects to be iteratively adjusted until residuals were minimized. The selected cut-off points were $0, >= 1$ responses for rashness on in-place items; $< 5, >= 5$ for rashness on out-of-place items; and $< 6, >= 6$ for hesitancy on out-of-place items. As it turns out, there are no subjects who are hesitant on in-place questions and so only three of these dimensions are useful in presenting the data. Figure 1 shows the number of subjects at the vertices of the cube defined by these three dimensions.

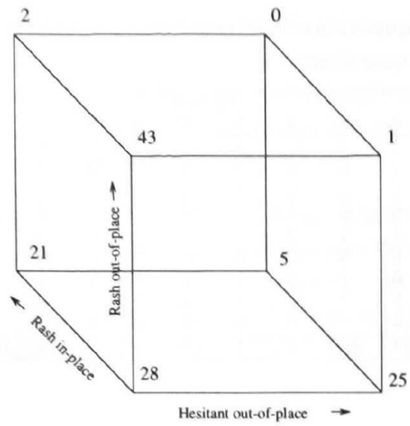

Figure 1: Frequencies of subjects classified as rash or hesitant on out-of-place questions and rash on in-place questions.

Only four of the possible eight categories have more than five subjects in them. A substantial number of subjects (28) are neither rash nor hesitant on either in-place or out-of-place questions. The other three substantial categories all consist of exhibiting a single type of error tendency either rashness on in-place questions (21), rashness on out-of-place questions (43), or hesitancy on out-of-place-items (25), but few subjects show two or more of these tendencies.

Relations between sentential and graphical behaviour

A full analysis of the graphical responses is beyond the scope of this paper. Our initial concern is to show that the graphical behaviour exhibited is strongly related to the sentential behaviour as elicited in the present study and categorised here. Most sententially based theories of syllogistic reasoning performance (e.g. Chapman & Chapman 1959) have claimed that the 'illicit conversion' of *All A are B* into *All B are A* is centrally implicated in reasoners' errors. This lead Newstead (1989) to take 'graphical conversion' (as exhibited in the choice of only the identity diagram to represent *All A are B*) as a graphical equivalent of sentential conversion, and to point out the lack of correlation between sentential and graphical behaviour in his data. We therefore take graphical conversion defined in the same way as a convenient feature of graphical behaviour to correlate with our analysis of sentential behaviour.

Twenty-five of our subjects exhibited this graphical pattern of choice. Table 6 shows the relations between this graphical conversion response, rashness on out-of-place questions, and hesitancy on out-of-place questions. Finally, table 7 shows the number of subjects making various graphical response combinations to SOME and SOME NOT premisses, as a function of rashness and hesitancy on out-of-place items.

Discussion

Typically, the data used in the literature to examine interpretation and to explain reasoning patterns has consisted of

Table 6: Numbers of subjects classified by rashness and hesitancy on out-of-place questions, and by EC-conversion.

		Hesitancy				
		No		Yes		
		Rash out-of-place				Totals
		no	yes	no	yes	
EC-conv	no	46	33	20	1	100
	yes	3	12	10	0	25
	Totals	49	45	30	1	125

Table 7: No.'s of subjects making various graphical response combinations to Some and Some–not premisses, classified by rashness and hesitancy on out-of-place questions.

SOME							
			Not Hesitant				
Choices	1234	124	134	14	234	34	4
Not Rash	24	1	2	2	5	8	6
Rash	6	2	1	3	2	14	10
			Hesitant				
Not Rash	8	4	2	2	1	2	10
Rash	1	1	0	0	0	0	1
SOME-NOT							
			Not Hesitant				
Choices	345	34	3	45	4	5	0
Not Rash	30	12	4	0	5	1	2
Rash	7	9	2	3	9	2	4
			Hesitant				
Not Rash	12	3	2	6	5	0	0
Rash	0	0	0	1	1	0	0

responses to particular inferences. The field has concentrated on specific errors — especially on errors of commission (*e.g.* illicit conversion) rather than on errors of omission (*e.g.* failing to conclude from *Some A are B* that *Some B are A*). Our analysis of the sentential data shows that there are strong response tendencies which generalise across particular logical inferences. Hesitancy and rashness are traits. These traits are especially strong across quantifiers within preserved subject/predicate structures, and within changed subject/predicate structures. Furthermore, errors of omission are as common as errors of commission. These observations show at very least the incompleteness of existing frameworks of explanation such as Grice's, which by their nature can only explain errors of commission, and only with specific quantifiers.

When it is understood that questions about the validity of inferences are quite distinct from questions about truth value in a particular model, behaviour can be shown to be far more coherent than previously appreciated. Patterns of answers to sentential questions about validity are predictive of patterns of answers to graphical questions about truth values in models.

If behaviour is systematic but does not conform to a logical model, this raises the question how it should be modelled. The most prevalent theoretical model in discussions of quantifier interpretation is that of Grice's (1975) conversational principles. Grice's maxims allow hearers to make reasonable inferences about the speaker's intentions. *Some A are B* is taken to imply that *Not all A are B* because it is supposed that the speaker would have been maximally informative, and therefore would have said *All A are B* if that was what they meant. The prevalence of this inference (and others like it) in the present data is all the more suprising in the light of the explicit instruction not to draw it. Suprising or not this is a result replicated from Newstead's and other studies.

Grice's maxims are embedded in a theory of a certain kind of discourse. It assumes that the participants are cooperating and that their goal is to transfer information from one to the other. In deductive discourse, the use of language that logic is most directly designed to model, there is no automatic assumption of cooperation, neither is transfer of information the goal. Drawing a valid inference from a premiss is, by definition *uninformative* at the object level of information at which Grice couches his theory. Grice's approach suggests a class of explanation for why there is anything to learn in logic classes and why it can prove so arduous. If our natural language skills are primarily honed on the comprehension and production of expository discourse aimed at the cooperative interchange of information about which the participants' knowledge is initially unequal, then we might suppose that learning deductive discourse requires unlearning many of these skills. We have to learn to turn off deeply embedded habits of drawing conversational implicatures.

Insofar as it goes, this appears to us to be a promising theoretical direction, but it is important to realise how incomplete the program is. Grice offers no theory of how deductions are informative, even though it is clear that deduction is goal driven discourse which is sometimes cooperative and which does inform. Similarly many of the implicatures Grice describes assume the speaker is *omniscient* with regard to the domain at issue and it is not clear why such assumptions are so readily made. Specifically, Grice does not provide any explanation of where assumptions of omniscience originate. It is true that some interpretation errors accord with Grice's maxims but it is equally clear that many do not. More importantly, his kind of theory, as it stands, offers no explanation of the extremely prevalent errors of omission in our data. Why should students fail to appreciate that *Some A are B* entails that *Some B are A*? And why should there be any correlation between errors of omission and of commission? And between errors across quantifiers? And with subject/predicate structure?

The most striking feature of our sentential data is the degree to which traits of error behaviour are defined by differences between inferences in which subjects and predicates maintain their status in sentences (in-place questions), and ones in which their status changes (out-of-place questions). It appears that learning when subject/predicate status has logical implications, and when it does not is also a major part of the task of learning logic. This can be expressed in terms of learning to adopt an 'extensionalist stance' in which both subject and predicate terms denote sets, and that attribution is understood as asserting relations between sets. This is definitely *not* our initial understanding of the semantics of our natural language. In natural language, one of the important functions of subject/predicate structuring is to indicate the information asymmetries between participants in cooperative expository discourse. Subjects paradigmatically denote shared knowledge; and predicates convey the information which is being transferred. Thus our results show the need for deepening the Gricean approach into a fuller theory of how the different kinds of discourse work, so that we can specify both beginning and end-points of students' learning trajectories.

The relation between traits of rashness and hesitancy as narrowly defined in this study, and other known traits from the student modelling literature (*e.g.* Jonassen & Grabowski, 1993) is an important topic for future research. Are these general, almost temperamental traits, which are here exhibited interacting with the learning of new discourse functions for specific grammatical structures, or do they have no broader significance beyond this particular setting? Do the patterns of response constitute profiles characteristic of individuals, or are they stages on a common trajectory from naive to sophisticated understanding? How responsive are they to educational intervention?

Our belief is that answers to these questions will provide a much needed theory of how logic is embedded in social practices. Learning the discourse of deduction and understanding how it relates to the discourse of exposition is all about understanding different possible social relations in communication. Exposition is discourse with knowledge and 'authority for information' asymmetrical between participants. Deduction is discourse with symmetrical knowledge and authority for knowledge. It would be suprising if learning such a profound communicative shift is not affected by broad behavioural traits.

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