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Children's Talk and the Development of Reasoning in the Classroom

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ABSTRACT *Sixty British primary school children aged 9–10 and their teachers took part in an experimental teaching programme, designed to improve the quality of children's reasoning and collaborative activity by developing their awareness of language use and promoting certain 'ground rules' for talking together. Children's subsequent use of language when carrying out collaborative activities in the classroom was observed and analysed, and effects on their performance on Raven's Progressive Matrices test of non-verbal reasoning were also investigated. Comparative data were gathered from children in matched control classes. Qualitative and quantitative analyses of discourse showed a marked shift in target children's use of language in accord with the aims of the teaching programme, and demonstrated that adherence to the ground rules helped groups solve the reasoning test problems. Children's individual scores on the Raven's test also improved. These findings support a sociocultural view of intellectual development and confirm the value of explicitly teaching children how to use language to reason.*

Introduction

Although it is widely accepted that one of the aims of education should be the induction of children into ways of using language for seeking, sharing and constructing knowledge, observational studies of classroom life reveal that this induction is rarely carried out in any systematic way. Teachers very rarely offer their pupils explicit guidance on such matters, and researchers have found that pupils commonly lack any clear, shared understandings of the purposes of many of the activities they are engaged in and the criteria by which they are judged by teachers, and so are often confused, unfocused and unproductive in their use of language (Edwards & Mercer, 1987; Sheeran & Barnes, 1991; Barnes & Todd, 1995). Many researchers therefore conclude that the educational, developmental potential of conversational interaction in the classroom—especially that amongst pupils—is being squandered (Galton & Williamson, 1992; Christie & Martin,

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1997). However, when teachers make such matters explicit and provide direct guidance, pupils have been found to be enthusiastic and effective at grasping 'educated' ways of using language for sharing and constructing knowledge (Brown & Palincsar, 1989; Mercer, 1995; Rojas-Drummond *et al.*, 1997). Given clear guidance from teachers, it seems that children are then able to use group work activities to practise and develop independent strategies for learning and formulating knowledge (Galton, 1989; Bennett & Dunne, 1992; Gipps, 1994).

In recent years, psychological researchers have become increasingly concerned with understanding how children's thinking is shaped by social experience amongst peers and by adult guidance (see, for example, Rogoff, 1990; Bruner, 1990; Rogoff *et al.*, 1991; Wertsch, 1991). Building on the work of Vygotsky (e.g. Vygotsky, 1962, originally 1934), such researchers have elaborated a sociocultural theory of intellectual development in which language has three crucial, integrated functions: as a *cognitive tool* which children come to use to process knowledge; as a *social* or *cultural tool* for sharing knowledge amongst people; and as a *pedagogic tool* which one person can use to provide intellectual guidance to another. Sociocultural theorists link these functions with a strong claim: that social experience of language use shapes individual cognition. Through engagement in dialogues, children gain the psychological benefit of the historical and contemporary experience of their culture. In Vygotsky's (1981) own terms, 'intermental' activity provides a basis for 'intramental' development, in a way and to an extent that is not possible for other species. Sociocultural research has questioned the validity of Piaget's influential theory of cognitive development, which emphasises individual action rather than interaction (e.g. Piaget, 1970); and this has fed criticisms of the progressive approach to primary education which drew on Piaget's work (as discussed by Mercer, 1994a). However, there has been no research which shows precisely how children's social language experience is related to the development of their ability to use language as a tool for reasoning.

Outside the field of sociocultural research, several educational programmes have been created expressly for the improvement of children's 'thinking skills' (e.g. Lipman, 1991; Paul, 1987; De Bono, 1987) and these are used in schools to limited extents in various parts of the world. Although these involve teachers in guiding children into specific types of dialogue, and modelling for children certain kinds of language use, such programmes tend to treat language unproblematically as a vehicle for the representation of thought, and have no basis in any established psychological theory of cognitive development or of teaching-and-learning. Moreover, while evaluations of thinking skills programmes (summarised in Nickerson *et al.*, 1985; Resnick, 1987; Craft, 1991; Wright, 1992) have reported some positive effects on children's creative problem-solving, little convincing evidence has been offered of the transfer of any acquired strategies into curriculum-related peer groups activity or of improvements in individuals' reasoning ability.

The research we describe here draws on all the somewhat disparate lines of enquiry described earlier, in a test of the practical, educational value of encouraging children to use language in particular ways as a 'social mode of thinking' (Mercer, 1995). Working closely with teachers in a series of school-based action research projects, we have developed strategies for teaching children how to use talk as a tool for joint reasoning and have then observed the effects of this experience on their joint and individual activity. One of our main aims has been practical: to help improve classroom education as a process for developing children's communication and reasoning skills. But we have also tested sociocultural theory's claims about the relationship between 'intermental' and 'intramental' activity, and about the role of language as a tool for thinking. This research has required us to develop an eclectic methodology in which qualitative discourse analysis is combined with quantitative measurement and controlled experimentation. As we will show, this enables us to relate children's language use to what they have been taught and to evaluate their use of language as a tool for thinking.

Exploratory Talk and Reasoning

One of the concepts central to our research is that of *exploratory talk*. During the early 1990s, two of the present authors were involved the Spoken Language and New Technology (SLANT) project, which observed children engaged in computer-based joint activities in 12 British primary schools (as described in Mercer, 1994b). One outcome was a typification of a way of using language effectively for joint, explicit, collaborative reasoning. We called this 'exploratory talk', taking the term from the seminal work of Barnes & Todd (1977, 1995). Our most recent definition of it is as follows:

- *Exploratory talk* is that in which partners engage critically but constructively with each other's ideas. Statements and suggestions are sought and offered for joint consideration. These may be challenged and counter-challenged, but challenges are justified and alternative hypotheses are offered. In exploratory talk, *knowledge is made publicly accountable* and *reasoning is visible in the talk.*

The kind of talk we call exploratory is illustrated in Sequence 1, which follows. It comes from our project data and is the talk of three children (aged 10) working together on a computer-based science activity (specially designed for our programme) called *Tracks*. This offers a simulated environment in which weights are pushed along surfaces of material with different frictional qualities (ice, grass, carpet), and in which the sizes of the weights and forces, as well as the surfaces, can be varied systematically. Prompts ask the children to make predictions and carry out experiments to test them. In the extract, they are carrying out one of these experiments.

Sequence 1: Tracks, *School C2: group 1*

Luke: So one of those ... no, one grass, and one ice. And the weight's the same, so two again, and both things on four.
Nicola: Yes, two.
Luke: Both on four. Yes.
Nicola: Why don't you do one—oh, you have already! Now press 'ready'. The top weight will go faster.
Paul: Would it?
Luke: Yes, because it's smooth.
Nicola: Yes, Because it's slippery, it'll go faster. Yes, it does.
Luke: Why?
Paul: Because if there was a rough surface and the bottom one was on ice ...
Nicola: If there was a rough surface, there's more friction, it would slow it down.
Luke, Paul: Yes.

We see Luke, Nicola and Paul all offering opinions and giving reasons to support them. They seek each other's views and check agreement. Relevant information is made explicit. All the children are actively involved, their reasoning is often made explicit in the talk, and they come to agreement before taking joint action. These are all features of exploratory talk.

Our definition of exploratory talk typifies a kind of language use which plays an important function in the cultural activities of many societies (for example, in the pursuit of science, law, government and the negotiation of business). It represents an 'educated' way of using language to construct knowledge which one would expect to be fostered by school experience. However, the SLANT researchers found that the natural incidence in primary classrooms of talk of an 'exploratory' kind was very low. More often children interacted in an uncooperative, competitive way which generated *disputational talk.* When they did cooperate, they tended to share and build information in an uncritical way, which the SLANT researchers called *cumulative talk* (see Mercer, 1995 and 1996 for more explanation and examples). And in accord with the findings of Barnes & Todd (1995) and others (as mentioned earlier), it was found that primary teachers hardly ever drew children's attention to the way they used language together, or explicitly sought to encourage effective ways of using it to share knowledge and solve problems.

Aims

The aim of the research described here was to develop and evaluate a teaching programme for 'scaffolding' children's effective use of language as a tool for reasoning. In carrying it out, we also explored and evaluated three hypotheses about the teaching and use of exploratory talk.

1. That using exploratory talk will help children to reason together more effectively and this can be shown by an improvement in their scores when they jointly tackle the problems of a test of reasoning.
2. That children's use of exploratory talk in joint classroom activities can be increased by using specially-designed teacher-led and peer-group activities.
3. Using exploratory talk for joint reasoning will help children develop better ways of using language as a tool for reasoning individually. This will lead to improvements in the scores children achieve when working alone on a reasoning test.

We also looked at the effect of teaching exploratory talk on curriculum activities in the subject areas of science and citizenship. This aspect of the research is reported elsewhere (Wegerif *et al.*, 1998) and so will not be included here.

The TRAC Programme

Drawing upon our own and other relevant research, we designed a programme for developing children's reflective awareness of their use of talk for joint activity and encouraging their use of exploratory talk. This programme (which we called the TRAC—Talk, Reasoning and Computers—programme) was a specially-designed scheme of work made up of teacher-led and collaborative activities, with some of the latter being computer-based. Embodied in TRAC was our own explicit conception of the 'ground rules' necessary for generating exploratory talk. The findings of our own and other relevant prior research (see Mercer, 1995; Wegerif & Mercer, 1997a) led us to specify the following set of ground rules:

1. all relevant information is shared;
2. the group seeks to reach agreement;

3. the group takes responsibility for decisions;
4. reasons are expected;
5. challenges are accepted;
6. alternatives are discussed before a decision is taken; and
7. all in the group are encouraged to speak by other group members.

The programme (which is described in more detail in Dawes, 1997, 1998) requires teachers to take their class through a series of nine structured lessons which raise children's awareness of how they talk together, and guide them into the use of exploratory talk. Teachers implemented the programme following a day of in-service training led by the research team. Each lesson within the programme was designed to last for about 1 hour and focused on one or more of the ground rules of exploratory talk. The first few also dealt with skills such as listening, sharing information and cooperating, while later lessons encouraged children to make critical arguments for and against different cases. One specified outcome of the early part of the programme is that each teacher and class create their own, user-friendly version of the ground rules for generating exploratory talk established by the researchers. For illustration, here is an example of a teacher reviewing and consolidating a shared understanding of the ground rules with a group of children (aged 10 years), just before they go off to do a TRAC activity together. The activity is one called *Dogs' Home*, in which children have to talk and decide together how best to match each of a motley set of stray dogs with an appropriate family of owners.

Sequence 2: reviewing the ground rules

Teacher: OK. Right, now—the idea of this lesson isn't just to match the dogs with the owners—that's one of the main things. But the other main thing is to think really carefully about how you do it, and how you talk to each other while you are doing it. If you think back to the talking lessons you've had so far, you've got to try and remember what were the good ways of talking to each other, and the useful ways that helped you find out what other people were thinking. Right, now, can you think of any useful ways of finding out what somebody else is thinking?

Thomas: Ask questions?

Teacher: Ask questions. Well, that's what I've just done to you now. I've asked questions, to find out what you think about it. So you could ask each other questions, couldn't you? I'm going to ask you to ask a very definite question—I'm going to give you cards to remind you every single time to ask this question. What do *you* think? Not a difficult question, it's just that you might forget to ask it. And when somebody's answered the question, you say to them: *Why* do you think that? So what have they got to give to you then?

Anna: An answer.

Teacher: An answer. And what will the answer tell you then? Tell you the reason they think it. So—what do you think, and why do you think that? So, say there's three of you in this talking group, right? And one of you will ask the other two people that question, OK? What do you think and why do you think it. And when you've asked it give yourself a tick here, so that you get a tick every time you've asked that question, so we keep a little chart of how many times you've asked the question. There's lots of other questions you can ask as well, aren't there? Now if somebody's telling you what they think, what will you have to do, what will you have to do, to make sure you understand what they are thinking?

Thomas: What do you mean by that?

Teacher: Yes, ask them another question. If you are not sure, get them to talk about it a little, and then they can probably tell you, can't they? You'll have to listen carefully, won't you? Were there any other rules that we thought were useful? I can't remember any? Give reasons, discuss it, make sure everybody in the group gets a go—not just you because you've got the loudest voice and think your opinion is the most important! Everybody gets a go.

Darien: Don't leave anybody out!

Teacher: Don't leave anybody out. Right, so—if you want to, if you find it easier you could cut these up once you've read them. Read it through first, then you can cut it into strips—cut out the dogs and match each one with a family. If you find it easier you could do that. You've got to read it through together first, so that you've all understood what the families are like. OK? Before we start then, why are you doing this lesson, what's the reason for it, what are you trying to end up with doing? Somebody else—Gary? What do you think? You're half asleep as usual—in your dozy morning state.

Gary: To try to find out what other people's opinions are.

Teacher: Exactly! I wish I'd said that! To find out what other people's opinions are. And how will you do it?

Gary: By asking questions?

Teacher: By asking questions, talking to them. So that's all we need to know, isn't it, it's the talk that's important.

It can be seen that the teacher makes explicit the talk-related aims of the lesson, elicits children's understanding of the ground rules and consolidates this understanding as 'common knowledge' (Edwards & Mercer, 1987). Earlier pilot research had persuaded us that the process of generating a class-specific set of ground rules is an important pedagogic feature of the programme. The class's ground rules embody the main characteristics of exploratory talk, and once established the children are expected to follow them when engaged in any joint discussion activities in class. It is therefore important that they feel some 'ownership' and responsibility for adherence to them. Once each target class had agreed a set of 'ground rules for talking', these were written up on a poster and displayed prominently in the classroom. An example of a set of ground rules drawn up by one class is as follows:

Class 5D's Ground Rules for Talk

1. Discuss things together. That means:
   - ask everyone for their opinion,
   - ask for reasons why,
   - listen to people.
2. Be prepared to change your mind.
3. Think before you speak.
4. Respect other people's ideas—don't just use your own.
5. Share all the ideas and information you have.
6. Make sure the group agrees after talking.

The TRAC programme included some computer-based group activities designed to elicit and support children's use of talk for joint reasoning. Some of these used commercial software while other software was specially designed by one of the authors (Wegerif) with content based on the science and citizenship curricula for Year 5 children in English schools. (The *Tracks* software, which figures in Sequence 1, is an example. See Wegerif *et al.*, 1998 for more information.)

The Implementation of the TRAC Programme and Procedures for the Collection of Data

Sixty Year 5 children, aged 9–10 years, in three state middle schools in the city of Milton Keynes comprised the members of four target classes who (with their usual teachers) took part in the implementation of the TRAC programme. (The classes also contained Year 6 children who followed the programme but were not observed or evaluated by us.) Our research interests required us to gather data on the quality of talk and problem-solving of the children in the target classes, before and after they had followed the programme, and also to compare the performance of the target children with children in a set of 'control' classes.

We therefore matched each target class with a control class of the same age group and similar social background in another local state school (making four control classes: 64 Year 5 children in all). Each target class teacher carried out the TRAC programme with their class, with the children organised into 'talking groups' for the collaborative activities. Each talking group was a mixed-gender and mixed-ability set of three children (plus one or two groups of two if class numbers did not divide by three). The teachers and children of the control classes carried out their normal curriculum activities, the children forming groups of three for the purpose of the comparative tests described later. To minimise any 'Hawthorne effects' on results due to target children's participation in the TRAC programme, children in the control classes were observed, video-recorded and tested in the same ways as the target classes, and groups of children in control classes also carried out the specially-designed computer-based activities. The same period of time (10 weeks, the time needed to carry out the TRAC programme) elapsed between our initial and final data gathering for both target and control classes.

In order to measure any effects of the programme on children's reasoning ability, children in both target and control classes were given a psychological test—*Raven's Progressive Matrices*—immediately before and after the implementation of the programme. We chose this test because it is a well-established test of 'the ability to reason and solve problems involving new information' (Carpenter *et al.*, 1990, p. 404) for children of the appropriate age group, while also correlating highly with measures of academic attainment. It is made up of pattern-based puzzles which hold children's interest. (An example is given as Fig. 1, later in this article.) Moreover, an earlier, smaller-scale study by one of the authors had found that training in discussion skills had significant effects on children's performance of the test (Wegerif, 1996). So that we could investigate and relate effects on joint and individual reasoning, all children took two versions of the Raven's test. The first, the Raven's SPM, was done in groups of three. Then, 3 days later, each child individually attempted the second version of the test, the CPM (which is made up of similar but different puzzles).

We also gathered observational data, suitable for detailed analysis of discourse, which would enable us to perceive any changes in the quality of children's talk. One set of such data was obtained by asking class teachers to identify one 'focal group', from amongst the talking groups in their class, which they considered as fairly representative of the academic ability of the class as a whole. We then video-recorded all of these eight 'focal groups', one in each target and control class, while they tackled the Raven's CPM test together. Recordings of the groups were made in relatively quiet areas within the normal classroom environment, with an auxiliary high-quality microphone (rather than the camera's inbuilt microphone) being used to capture the talk of each group. The total discussions of the focal groups provided approximately 5 hours of video data. An additional 4 hours of observational data was gained by videotaping the focal groups in both target and control classes carrying out the computer-based joint activities which had been specially designed for the TRAC programme. In this article, however, we will only analyse the talk produced by children during the Raven's test.

Methods of Analysis and Findings

For the sake of clarity, we will deal with each of our three hypotheses in turn, describing the methods involved in testing it and the results obtained.

1. Is Exploratory Talk Useful for Reasoning?

The TRAC programme was in fact based on our first hypothesis, that following the ground rules of exploratory talk benefits joint reasoning activity. This hypothesis therefore needed to be tested separately from evaluating the outcomes of the programme. We decided that the best way to test it was by making a comparative analysis of talk, which could be seen to lead to success or failure when groups jointly tackled problems of the Raven's reasoning test. If conversation that approximated the features of exploratory talk was associated with success, then that would provide supportive evidence for our first hypothesis.

We therefore selected the activities of one of the target groups for closer analysis, because that group (Group 1A1) showed the greatest pre-/post-intervention change in score on the Raven's SPM test, from 39 to 47. (The SPM test consists of 60 test items and so is scored out of 60.) For that group we also had the scores of individual members on the other version of the test, the Raven's CPM (which has 36 items and so is scored out of 36). Both sets of scores were then converted to a common 36-point interval scale, following the procedure described in the Raven's test manual (Raven *et al.*, 1995, p. 64). It was then noted that in the pre-intervention tests the group score was *lower* than the highest individual score (31 compared to 32). In the post-intervention tests, however, the group score was slightly *higher* than the highest individual score in the group (34 compared to 33). This suggested that the striking improvement in group score after the intervention could not be accounted for by a change in the quality of reasoning by one individual in Group 1A1, but was a product of a change in the way the group reasoned together.

To investigate this further, we focused our discourse analysis on the talk of Group 1A1 when they dealt with eight problems of the Raven's SPM test. These were problems which had been answered incorrectly in their pre-intervention attempt, but had been correctly solved by the group after the intervention. Here, for illustration, is an example of the group's pre-intervention talk (Sequence 2, which failed to produce the correct answer) and also of their post-intervention talk (Sequence 3, which led to them finding the correct answer). On both occasions, they are dealing with the same problem (D9, shown in Fig. 1).

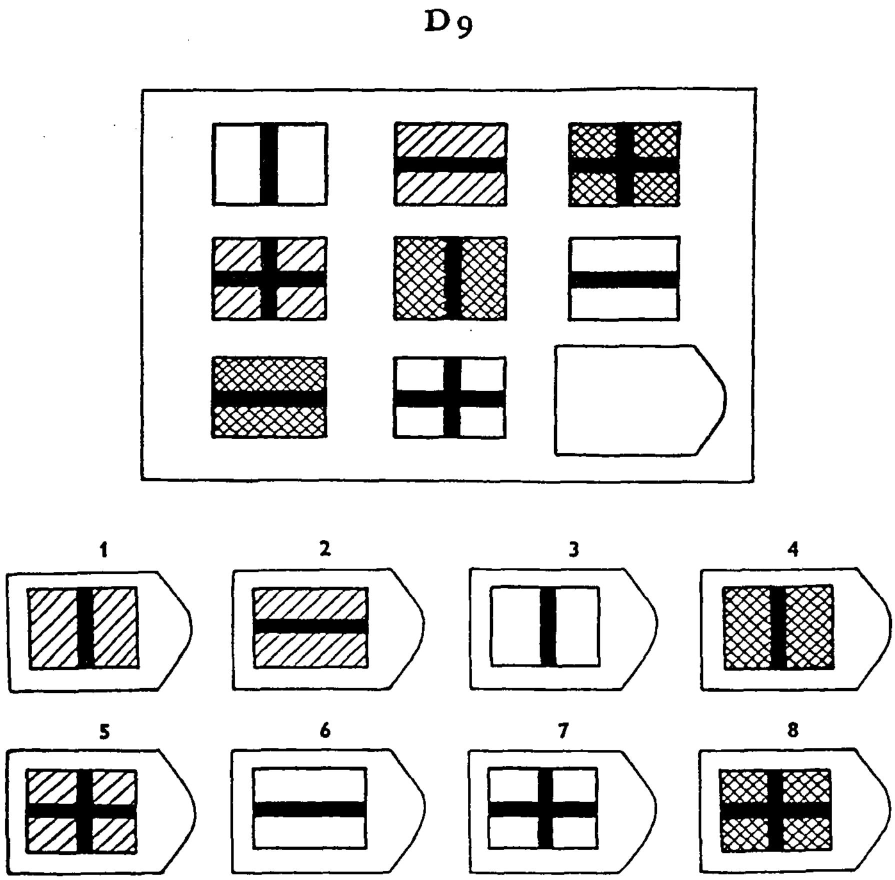

FIG. 1. Raven's Standard Progressive Matrices Test, Problem D9.

Sequence 2: pre-intervention talk of Group 1A1 on problem D9 of Raven's SPM

Tess: It's that.
Graham: It's that, 2.
Tess: 2 is there.
Graham: It's 2.
Tess: 2 is there Graham.
Graham: It's 2.
Tess: 2 is there.
Graham: What number do you want then?
Tess: It's that because there ain't two of them.
Graham: It's number 2, look one, two.
Tess: I can count, are we all in agreement on it?
(*Suzie rings number 2 on the answer sheet*)
Suzie: No.
Graham: Oh, after she's circled it!

Sequence 3: post-intervention talk of Group 1A1 on problem D9 of Raven's SPM

Suzie: D9 now, that's a bit complicated it's got to be ...
Graham: A line like that, a line like that and it ain't got a line with that.
Tess: It's got to be that one.
Graham: It's going to be that don't you think? Because look all the rest have got a line like that and like that, I think it's going to be that because ...
Tess: I think it's number 6.
Suzie: No I think it's number 1.
Graham: Wait no, we've got number 6, wait stop, do you agree that it's number 1? Because look that one there is blank, that one there has got them, that one there has to be number 1, because that is the one like that. Yes. Do you agree?
(*Tess nods in agreement*)
Suzie: D9 number 1.
(*Suzie writes '1', which is the correct answer*).

In Sequence 2, the talk is not 'exploratory' but rather the type of talk which (as mentioned earlier) we call 'disputational', which is associated with competitive activity and individualised decision-making (Mercer, 1995, 1996). Cycles of assertion and counter-assertion, forming sequences of short utterances which rarely include explicit reasoning, are typical of disputational talk. We can see that Tess does offer a reason—a good reason—or her view, but Graham ignores it and she seems to give up in the face of his stubbornness. Suzie has taken the role of writer and she says little. At the end, having ringed the answer Graham wanted, she disagrees with it: but they all move on to the next problem anyway.

Sequence 3 illustrates some ways that the talk of the same children changed after doing the TRAC programme and how these ways helped them to solve the problem. The children's language clearly shows characteristics of exploratory talk. Graham gives an elaborated explanation in response to a challenge from Tess, leading to a clear articulation of the reason why number one is the right answer. Such explanations involve a series of linked clauses and so lead to longer utterances. All three are now more equally involved in the discussion. Language is being used by the group as a social mode of thinking.

Our own prior research (Wegerif & Mercer, 1997a, 1997b) has shown that the implementation of the ground rules of exploratory talk is associated with the frequent use of some specific forms of language: the hypothetical nature of claims is often indicated by a preceding 'I think', reasons are linked to claims by the use of 'because' and agreement is sought through the question 'do you agree?' We can see those features in Sequence 3. Explicit reasoning also requires the linking of clauses, and so utterances tend to be longer in the post-intervention talk of the group. Group 1A1 solved a total of eight new problems in the post-intervention test which they had failed to solve in the pre-intervention test. When we compare talk which led to the group solving these problems correctly with talk which led to wrong answers, we find that there is a clear association with the relative incidence of these key linguistic features. This can be seen from Table I, which compares the number of long utterances (where 'long' is defined through taking an arbitrary cut-off point of being at least 100 characters in length when transcribed), and the incidence of 'because', 'agree' and 'I think'.

This comparative analysis of the successful talk and unsuccessful talk of one group shows that successful talk displays a much higher incidence of the linguistic features

TABLE I. Incidence of key features: comparing talk leading to correct answers with talk leading to incorrect answers for Group 1A1.

Key linguistic feature	Incidence in talk leading to incorrect answers	Incidence in talk leading to correct answers
Long turns at talk	0	11
'Because' and 'cause'	6	26
'I think'	1	24
'Agree'	3	18

associated with exploratory talk. We therefore have evidence that the use of exploratory talk helps the joint solution of problems.

2. *Did the TRAC Programme Increase Exploratory Talk?*

Our second hypothesis was that children's use of exploratory talk could be increased by the use of specially-designed teacher-led and peer-group activities. Relevant evidence for assessing this hypothesis was provided by performing two kinds of analysis—qualitative and quantitative—of the talk of children recorded while they worked together, before and after the TRAC intervention.

We first carried out a detailed qualitative analysis of discourse of the ways children used language in the recorded activities (as illustrated in the aforementioned analysis of the talk of Group 1A1; our method is described in more detail in Mercer, 1995, 1996 and Wegerif & Mercer, 1997a, 1997b). One of the principal aims was to determine the occurrence of any talk of an 'exploratory' kind. Incidences of exploratory talk were indeed identified in the transcribed talk of the focal groups. The qualitative analysis of one group's activities carried out in testing our first hypothesis (as described earlier) suggested that the incidence of exploratory talk was associated with the more frequent use of certain linguistic features. Qualitative analysis of samples of the talk of other groups encouraged this view. Longer utterances seemed a particularly effective indicator of exploratory talk.

The results of the qualitative analysis then enabled us to proceed to a comparative, quantitative analysis of discourse. There now exist software packages known as 'concordancers' which enable any electronic file of written language (known as a 'corpus') to be scanned easily for all instances of particular words. All instances of any word can then be displayed in linguistic context and the frequencies of occurrence of the word in the text calculated. (We have described in detail elsewhere the use of this kind of electronic tool for analysing classroom talk: see Wegerif & Mercer, 1997b.) One such concordancer enabled us to search for key features of exploratory talk in the transcriptions of the video-recordings of the focal groups while engaged in the Raven's test problems. Unfortunately, because of children's absences on the day of recording, the post-intervention talk of one of the four focal groups was not available for analysis and so the analysis was carried out using data from three focal groups and their matched control groups.

One of our first concerns was to ensure that the high incidence of three key linguistic features suggested by our qualitative analysis—the use of 'because', 'agree', and 'I think'—was indeed associated with talk which had other exploratory features. Access throughout the process of computerised concordance analysis to the complete transcriptions helps overcome one of the most serious methodological weaknesses of conven-

TABLE IIa. Total incidence of key linguistic features in the talk of target and control focal groups while engaged in the Raven's test, before and after the implementation of the TRAC programme.

Key feature	Target groups		Control groups	
	Pre	Post	Pre	Post
Because	62	175	92	66
Agree	7	89	13	21
I think	51	146	31	52
Totals	110	411	136	139

TABLE IIb. Incidence of key linguistic features in the talk of each target and control focal group while engaged in the Raven's test, before and after the implementation of the TRAC programme.

	Target 1		Target 2		Target 3		Control 1		Control 2		Control 3	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Because	25	100	12	45	25	30	34	25	28	17	30	24
Agree	7	87	0	0	0	2	12	20	1	0	0	0
I think	7	87	0	12	44	47	27	44	3	5	1	3
Totals	39	174	12	57	69	79	73	89	32	22	31	27

tional 'coding' approaches to the analysis of classroom interaction, which is the forced assumption that particular words or linguistic features always carry the same meaning, regardless of context. As Edwards & Westgate (1994) and others have pointed out, this is simply not consistent with what is known about language use. Because our method enables us to examine each incidence of all key words in context, it avoids this problem. We were therefore able to check that any passage of talk showing a high relative incidence of key features was indeed 'exploratory', according to our more general definition (as set out earlier). The same kind of computerised text analysis was then used to compare the relative incidence of those three key features in the pre- and post-intervention talk of the focal groups while engaged in solving the Raven's test. As our initial qualitative analysis had also suggested that effective reasoning was associated with children making longer contributions to the decision-making discussion, we next compared the relative incidence of 'long utterances' in the talk of the groups. The findings of these quantitative analyses are given in Tables IIa, IIb, IIIa and IIIb.

It can be seen from Table IIa that in the talk of the target focal groups there was a fourfold increase in the incidence of key linguistic features after the intervention, while in the talk of the control groups the incidence of these features remained approximately the same. Table IIb shows that the scale of this increase varied somewhat between the groups. Nevertheless, an analysis of variance revealed that the difference between the target and control conditions was statistically significant ($F = 5.547$: one-tailed $p = 0.039$). Tables IIIa and IIIb provide similar information for the incidence of long utterances in the talk of the groups. The analysis of these data also revealed a significant difference between target and control conditions ($F = 7.033$: one-tailed $p = 0.028$).

3. *Evaluating Changes in Performance on the Raven's Test*

We have shown how following the ground rules of exploratory talk helps children solve

TABLE IIIa. Total incidence of long utterances in the talk of all target and control focal groups while engaged in the Raven's test, before and after TRAC.

Target groups		Control groups	
Pre	Post	Pre	Post
14	66	55	47

TABLE IIIb. Incidence of long utterances in the talk of each target and control focal group while engaged in the Raven's test, before and after TRAC implementation.

	Target 1		Target 2		Target 3		Control 1		Control 2		Control 3	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Long utterance	1	35	0	6	13	24	25	16	20	18	19	13

reasoning test problems together. We have also shown that the intervention programme increased the amount of exploratory talk used by the target focal groups. To strengthen our claims for the pragmatic value of exploratory talk, we looked to see if children in the target classes made *significantly* greater gains in their scores on the Raven's test, over the period of the implementation of the TRAC programme, than those in the control classes. We first examined the scores achieved when the test was attempted by the children in groups. The relevant findings are presented in Table IV.

It can be seen that there is relatively greater improvement in the scores for the target classes, which is in accord with our hypothesis. However, an analysis of covariance (with post-test scores as the dependent variable and pre-test scores as the covariate) indicated that the difference between the gains of the target and control groups was not statistically significant (F = 2.43; one-tail $p = 0.06$).

We next examined the scores achieved by children when they tackled the Raven's test individually. Table V shows the changes in individual test scores for both target and control classes. An analysis of covariation (again with post-test scores as the dependent variable and pre-test scores as covariate) revealed that the gains made by the individual target class children were significantly greater than those made by children in control classes (F = 3.141; one-tail $p = 0.04$).

TABLE IV. Mean group scores (out of 60) on the Raven's SPM test.

Target classes (25 groups)			Control classes (23 groups)		
Pre	Post	Difference	Pre	Post	Difference
41.43	45.58	4.05	42.72	44.08	1.36

TABLE V. Individual scores on the Raven's CPM test.

Target classes (60 children)			Control classes (64 children)		
Pre	Post	Difference	Pre	Post	Difference
30.56	32.68	2.11	31.87	32.89	1.01

Discussion and Conclusions

We have reported on the development and evaluation of a teacher-led programme for developing primary children's use of language for reasoning and collaborative activity. Our three main findings are:

(a) using the kind of language we call 'exploratory talk' helps children to work more effectively together on problem-solving tasks;
(b) using a specially-designed programme of teacher-led and group-based activities, teachers can increase the amount of exploratory talk used by children working together in the classroom; and
(c) children who have been taught to use more exploratory talk make greater gains in their individual scores on the Raven's test of reasoning than do children who have not had such teaching.

As well as evaluating the implementation of the TRAC programme, our study also tested psychological and pedagogic principles upon which the programme is based. In this respect our findings are unequivocal. The ground rules of exploratory talk can be taught and their use improves the quality of children's joint work. Sheeran & Barnes (1991); Brown & Palinscar (1989); Galton (1989); Bennett & Dunne, 1992; Gipps (1994) and Christie & Martin (1997) and many other educational researchers have argued that if the 'ground rules' of educational language practices were more carefully explicated, justified and 'scaffolded' by teachers, this would improve the educational quality of whole-class, group-based and individualised activities in primary classrooms. They have also argued that the best primary education will be achieved through a balanced integration of teacher-led, whole-class activities with structured peer group activities and individualised work. In this way, children benefit from the intellectual guidance of a teacher while also becoming active, skilled participants in intellectual communities of discourse and practice. Our findings provide strong additional support for these views. The implementation of programmes like TRAC might not only enable children to become more effective in using language as tool for reasoning and sharing knowledge, but also lead to raised levels of individual achievement. A crucial area for attention in future research is then the extent to which children are able to apply the communicative reasoning skills they develop to the study of the curriculum. We have some qualitative evidence that this is in fact the case in relation to science (Mercer, 1996); and our own forthcoming comparative qualitative and quantitative analyses of TRAC children's use of talk in curriculum-related computer-based activities may provide further relevant evidence.

We also have shown that being taught to use exploratory talk helps develop children's individual reasoning skills. It appears that even non-verbal reasoning, like that involved in solving the Raven's problems, may be mediated by language and developed by adult guidance and social interaction amongst peers *without* the provision of any specific training in solving such problems (cf. Raven *et al.*, 1995, p. 16). This finding therefore supports the claims of sociocultural theorists (e.g. Vygotsky, 1981; Bruner, 1990; Rogoff, 1990; Wertsch, 1991) that the development of human mental abilities depends on a link between the 'intramental' and the 'intermental', mediated by language. More specifically, our results support the view that the induction of children into cultural language practices influences their use of language as a cognitive tool. It is worth noting that standardised non-verbal reasoning tests like Raven's have commonly been taken to be paradigmatic measures of individual reasoning ability, independent of the influence of social or cultural factors. These findings challenge that position and instead support a psychological perspective which recognises the part played by engagement in cultural practices, and the interactive role of adults and peers, in the development of children's reasoning. By providing evidence that teacher-directed activity can have a significant influence on the development of pupils' reasoning, and by illustrating ways that language is used as a cognitive, cultural and pedagogic tool, our research supports the argument that a sociocultural perspective provides the best available theoretical basis for the critical analysis and improvement of educational practice (Mercer, 1995).

But while observed changes in children's language use were quite striking, the gains made by some of the target children in their performance on the Raven's test were modest. Significant changes in group performance on the test, which we also predicted, did not materialise. To some extent at least, our findings suffer from the relatively small numbers of groups of children involved, and the effects of situational factors (commonly encountered in educational research) such as the absence of children at key points of data collection. A larger-scale implementation could have provided better data for statistical analysis. Our data analysis also shows that the impact of the TRAC programme varied across the classes in which it was implemented. We know that the teachers involved differed in the extent of their enthusiastic commitment to TRAC, and informally we can make connections which help explain the varied results; but unfortunately, we lack observational data about teachers' implementation of the TRAC lessons which would enable us to provide a more rigorous explanation. There was also some notable variation amongst children in classes, with some children in target classes clearly changing their use of language for reasoning much more than others. So while our results are very encouraging, they also suggest that we need to know more about the reasons for the varied responses of both teachers and pupils to the programme. At the end of the implementation, we obtained very useful feedback from teachers on elements of the TRAC programme and suggestions about ways in which specific activities could be improved. These various outcomes of our evaluation have informed our current research, in which 11 teachers in five middle schools are implementing a revised version of the TRAC programme, and from which we will gain more detailed information about teaching strategies and the quality of teacher–pupil interactions.

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