A dialogue model of the resolution of inter-individual conflicts : implications for computer based collaborative learning

Thesis

A dialogue model of the Resolution of Inter-Individual Conflicts: Implications for Computer Based Collaborative Learning

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Thesis submitted for the degree of Doctor of Philosophy in Cognitive Science, IET, Open University, June 1993.

Abstract

As a result of empirical research into the benefits of peer interaction for learning and development, there is growing interest in designing systems to support collaborative learning. How best to do this for classroom learning is still unclear, and the aim of this thesis is to marry theory with empirical study to produce a set of guide-lines for informing the design of computer based collaborative learning.

The resolution of inter-individual conflicts has long been proposed as a mechanism for learning in peer interaction and research indicates that in certain circumstances it does lead to learning. How this finding can be employed in the design of systems is problematic because researchers have typically not unpacked the notion of conflict and not explained how they are resolved.

To overcome this a dialogue model of the resolution of inter-individual conflicts in joint planning is proposed. There are three key components in this model; the Task Representation, the Task Focus and the Dialogue focus. Using this model I begin to differentiate between three different types of conflict. Conflicts are caused by *Task Representation Differences, Intersection Differences or Task Focus Differences* . All three types of inter-individual difference can be resolved with a set of discourse transactions and a set of internal resolution procedures. I propose that the resolution of all three can facilitate joint planning and subsequent individual planning.

Three experiments are reported which investigate these claims. The first experiment shows that pairs performed better than individuals in a planning task and this beneficial effect carries over to subsequent individual planning. The proposed model is used to investigate this facilitative effect. A corpus of inter-individual conflicts is reported. Most of the conflicts identified in this corpus are either intersection differences or task focus differences and evidence is reported which supports the claim that their resolution can lead to learning. The second and third experiments investigate the claims made from the model about task representation differences and evidence was found to support them. The research reported in this thesis is then related to the design of software to support collaborative learning by presenting a set of guide-lines for informing their design. The work also has important implications for developmental psychology and classroom practice.

Acknowledgements

Thank you to my original supervisors Mark Elsom-Cook and Claire O'Malley who encouraged me in the first two years of my thesis. However a bigger thanks go to my current supervisors Peter Whalley and Josie Taylor. Both of whom accepted me as their student when most of the fun bits had been done. I appreciate more than I can say their patience and their understanding in reading through the rough drafts of this thesis.

I would also like to thank the past and present members of CITE, whose help, encouragement and friendship have been invaluable to me. In particular, I would like to thank the following Don Clarke, John Close, Rae Sibbet, Roshni Devi, Magnus Moar and Royston Sellman. Thanks also go to my colleagues in the Leverhulme project, Karen Littleton, David Messer and Paul Light, for their support and friendship.

I would also like to thank the staff and children of Bradwell, Heronsgate and Simpson Schools whose help and assistance made this research possible, in particular Mr Buckle and Mrs Brocklehurst.

A big thanks must also go to my Mum and Dad who have supported me throughout my research and I have just one thing to say to my Gran "the project is finally finished".

Finally, a big thanks goes to Sarah, whose love and support helped me immeasurably.

Contents

Figures

Tables

Chapter 1 : Introduction

1.1 Aim of Thesis

Computer supported collaborative learning has recently become a focus of interest, because empirical research has shown that in certain circumstances peer interaction facilitates learning. The field can be divided up into those systems which support collaboration asynchronously and those systems which support it synchronously. Electronic mail and computer conferencing are used to support asynchronous collaborative learning[1] . Computer companions, computer tutors and collaborative learning environments are used to support synchronous collaborative learning. The aim of this thesis is to propose a dialogue model of the resolution of inter-individual conflicts, which will enable us to analyse the process of collaboration. This analysis can then be used to inform the design of systems to support synchronous collaborative learning.

The resolution of inter-individual conflicts has long been proposed as an explanation of learning in peer interaction. But unfortunately, the processes involved have never been explained. To overcome this limitation a dialogue model of the resolution of conflicts is proposed in Chapter 3. In this model, I propose that inter-individual conflicts are caused by three types of inter-individual difference: *intersection differences, task focus differences* and *task representation difference.* All three types of inter-individual difference can be resolved with a set of discourse transactions and a set of internal resolution procedures. The resolution and support of all three of

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[1] See Newman (1990) for an example of electronic mail in schools and Mason & Kaye(1989) for examples of computer conferencing in education.

these inter-individual differences, it is argued, can facilitate individual planning.

This work will be of interest to software designers who wish to design systems which facilitate and support children's collaborative learning; to developmental psychologists concerned with the role of conflict resolution in collaboration; and to teachers organising collaborative work in the classroom.

1.2 Motivation

Although one of the original aims of computer assisted learning was to provide individualised tuition, there has been growing interest in designing systems to support collaborative learning and several systems have already been developed. Several researchers (Dillenbourg and Self, 1992; Chan and Baskin, 1990) have designed learning companions which "collaborate" with the student to achieve the student's goals. A computer tutor has also been built by Chan and Baskin (ibid) and O'Shea, Evertsz, Hennessy, Floyd, Fox and Elsom-Cook (1988) to tutor students in a collaborative context. A distributed learning environment has been developed by Smith, O'Shea, O'Malley, Scanlon and Taylor (1991).

One reason for this shift in emphasis is that children in schools primarily use computers in groups. Jackson, Fletcher and Messer (1986) in a survey of middle and primary schools in Hertfordshire found that over 80% of all use of computers by children was in the contexts of pairs or small groups. The reason for this finding is partly due to resource limitations and partly due to teachers' commitment to using group based teaching methods

However, arguably the most important reason for this shift away from individualised instruction is that peer interaction may actually facilitate learning. The importance of peer interaction in learning and development has been known for a while in developmental psychology. Piaget (1926, 1932) in his early writings, stressed its importance (see Chapter 2).

Despite this and the fact that several systems have been developed to support collaborative learning, there is very little research which can be used to inform their design. The research that has been carried out has generally been concerned with the organisation of computer based collaborative learning. For instance, Trowbridge(1987) and Light, Colbourn and Smith (1987) have examined the effect of group size. Other researchers have examined the effect on collaborative learning of the gender composition of pairs (Sian and McLeod, 1985; Sian, Durndell, Mcleod and Glissov, 1988; Hughes, Brackenbridge, Bibby and Greenhough, 1988; Underwood, McCafferey and Underwood 1990; Dalton, 1990; Barbieri and Light 1992). Work has also been carried out to examine the effects of the task on computer based collaborative learning. (Crook 1987; Clements and Nastasi, 1988; Nastasi, Clements and Battista 1990; Nastasi and Clements, 1992). Although this research has peripheral implications for the design of systems for supporting synchronous collaborative learning, it is not directly concerned with it.

1.3 Planning

This thesis is concerned with one particular type of collaborative learning and that is learning to solve computer based planning problems. There are several reasons why I choose to investigate collaboration in this context, but before I explain what they are, I first need to define what I mean by a planning problem. A planning problem is one which requires a sequence of actions to be carried out in order to produce a solution. A classic example is the "Tower of Hanoi". Figure 1 illustrates a three ring version of the problem. The goal of this task is to move the three rings from peg A to peg C in the shortest number of moves, but you must not move more than one ring at a time or put a larger ring on a smaller ring. This version of the problem can be solved in a sequence of seven moves.

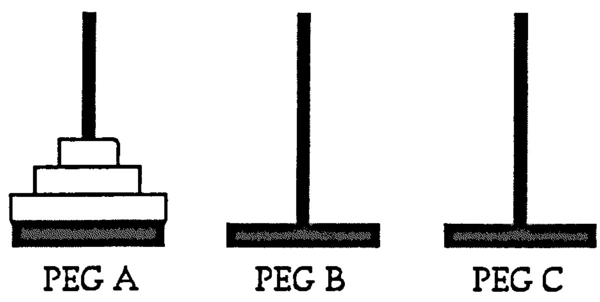


Figure 1.1 : The Tower of Hanoi.

Planning was chosen as an activity to investigate because it is a common task in schools and a component of the national curriculum. Writing and project work involve planning and both are often carried out on the computer and in groups. Also, there are several planning problems implemented on the computer which are used in primary schools. An example is Viking England, where the children have to adopt the role of viking raiders and plan their route; select their equipment and organise a camp.

The resolution of inter-individual conflicts may also be an appropriate explanation for learning in planning tasks (Light and Glachan, 1985). Participants will generally agree about the desired aim of a planning task, but will often disagree about how to achieve it. Planning tasks also provides opportunities for resolving those disagreements and encourages verbalisation more than other activities.

1.4 Conflict

Before moving on to provide an overview of the thesis I need to clarify the term conflict. The term "conflict", which is used throughout this thesis, is an emotive term which people generally think refers to heated discussions or arguments, but this is not the way it will be used here. The term conflict (as later defined in the thesis) will refer to certain types of inter-individual differences. This is a common definition employed by researchers from a Piagetian tradition (see Chapter 2). For instance Doise and Mugny (1984) claim that sociocognitive conflicts can be caused by either "different responses", "different schemata" or "different centrations". Similarly Perret-Clermont (1980) writes that conflicts are caused by children having "different strategies" or "different viewpoints".

1.5 Learning.

Another term which needs clarifying is the use (or not) of the term "learning". As already mentioned, I am interested in learning to solve planning problems. This can entail both quantitative and qualitative changes in performance. A change in planning strategy would be viewed as a qualitative change and is the common measure of learning used in research based on Piaget's work. Being able to solve a problem more effectively (i.e. in fewer moves) would be viewed as a quantitative change and is a common measure of learning used in problem solving research. Whether or not this constitutes learning in a strict sense is a moot point. In order to avoid confusion I will talk about the facilitation of planning performance when referring to learning in my own work.

1.6 Thesis Overview

This section provides a broad overview of the thesis. The aim is to propose a dialogue model of the resolution of conflicts, which can be used to inform the design of software to support synchronous collaborative learning. To do this I need to examine two fields of literature - that of peer interaction and that of discourse processes.

Research into the effects of peer interaction is reported in Chapter 2. This research indicates that under certain circumstances peer interaction facilitates individual planning. The resolution of inter-individual conflicts is a common explanation in several proposed theories of the peer facilitation of learning. However, proposals based on this explanation suffer from the limitation that they do not explain what a conflict is, how it is resolved and how that resolution leads to learning. This limits their usefulness to inform the design of computer based collaborative learning.

Recent research has stressed the role of discourse processes in the resolution of conflicts. Chapter 3 reviews some research into discourse understanding. A central idea in this work is the notion of focus. It is used both in theories of discourse structure and models of plan recognition in dialogue. A focus based dialogue model of the resolution of inter-individual conflicts is proposed in Chapter 3. An important distinction is made in this model between the task focus, the task representation and the dialogue focus. From this distinction three types of inter-individual difference are derived; task focus differences, task representation differences and intersection differences. Each type of inter-individual difference can be resolved by a set of discourse transactions and a set of internal resolution procedures. It is proposed that the resolution of all three of these inter-individual differences can facilitate joint planning and subsequent individual planning.

Chapters 4, 5 and 6 discuss studies which show the facilitative effects of peer interaction and which are analysed in terms of the model. Chapter 4 reports a study which found that peer interaction facilitated planning and subsequent individual planning. A corpus of inter-individual conflicts is collected from this study. Most of the conflicts identified in this corpus were either caused by task focus differences or intersection differences and evidence is reported which supports the claim made in the model that their resolution facilitates both joint planning and subsequent individual planning. No task representation differences emerge because of methodological constraints. However, one conflict was identified which had not been predicted from the model. It had been assumed that participants always shared the same discourse focus but this conflict was the result of the participants having different dialogue foci.

Chapter 4 found evidence that the resolution of task focus differences and intersection differences benefits individual planning. Chapters 5 and 6 investigate the claims made in the model about task representation differences. Chapter 5 reports an experiment in which I was unable to successfully manipulate task representation differences. Because of this another experiment was carried out, which is reported in Chapter 6. Evidence is found in this experiment which does support the claim about the resolution of task representation differences.

The final chapter concludes the thesis by reviewing the contributions and limitations of this thesis. The contributions include a discussion of the achievements and implications for developmental psychology, teaching practice and software design. I also make a number of suggestions for future work, which consists of extensions to the thesis, further experimental work and more general suggestions for future research.

Chapter 2 : A review of the resolution of inter-individual conflicts as an explanation for learning and development in peer interaction.

2.0 Introduction

The previous chapter reported that there was a growing interest in developing systems to support collaborative learning, because of recent research into the benefits of peer interaction for learning and development. This chapter reviews this research and concludes that under certain circumstances peer interaction can facilitate learning. The resolution of inter-individual conflicts is a common explanation for this beneficial effect. The evidence for this explanation is reviewed in this chapter and research is reported which suggests that it can lead to learning. However, existing proposals based on this explanation have a number of problems, which limit their usefulness to inform the design of computer based collaborative learning.

2.1 Peer Facilitation of Learning

Evidence in support of the idea that peer interaction facilitates learning is mixed. In support, for example Perret-Clermont (1980) performed a series of experiments concerning the effects of peer interaction on the conservation of the liquids task. This task involves four phases (see Figure 2.1). In the first phase of the experiment, the experimenter pours approximately equal amounts of liquid into glass A and B. She then adjusts the amounts until the child agrees that there are equal amounts of liquid in each glass. In the second phase, the experimenter pours the contents of glass B into glass C and the child is again asked if there are equal amounts of liquid in glass A and C. In the third phase, the experimenter places the contents of glass C back into glass B and asks the child again if the quantities are the same. In phase 4 the experimenter places the contents of glass B into glass D and asks the child once more if the quantities are the same.

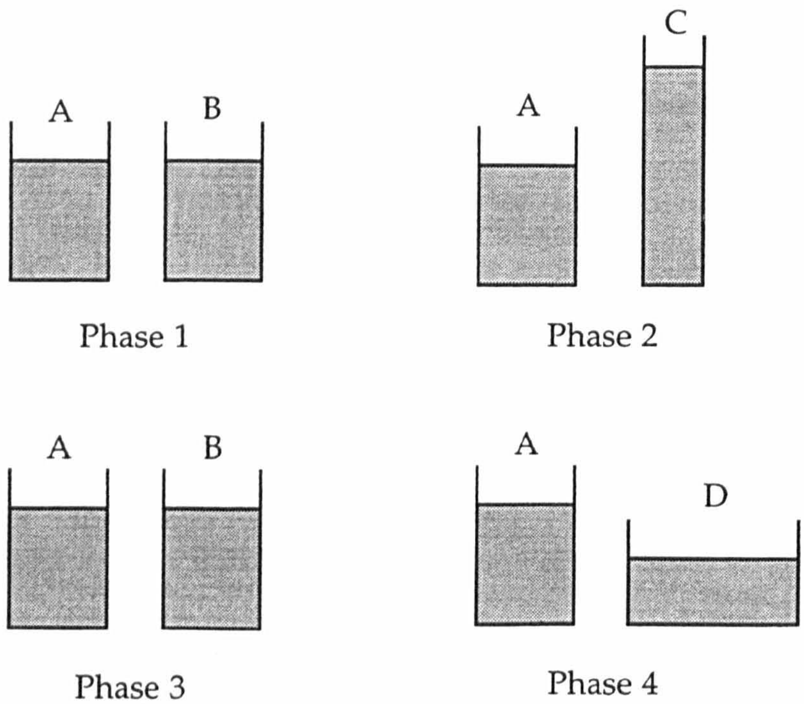


Figure 2.1 Experimental phases in conservation of liquids task.

Using this task a child can be classified as a non-conserver, an intermediate or a conserver. Conservers will always agree that the quantities are the same across all four phases. Non-conservers will have no problems agreeing that the quantities in phase 1 and 3 are the same but will believe the quantities in phase 2 and 4 are different, because they believe the quantity of liquid in a glass is dependent on the shape of the glass. Intermediates waver between conservation and non-conservation.

In Perret-Clermont's experiments there were two conditions, a paired condition and an individual condition. Subjects in the individual condition just had an individual pre- and post-test. The subjects in the paired condition were either non-conservers or intermediates paired with two conservers and they had to share an equal amount of juice between the three of them using four glasses of varying size.

Perret-Clermont reports that subjects who worked in pairs improved significantly more than subjects who worked individually. Furthermore in another study reported by Perret-Clermont (1980) the progress found on the post-test generalised to other conservation tasks. Similar peer facilitation effects have been found by Mugny and Doise (1978) using a spatial coordination task; Weinstein and Bearison (1985) on several conservation tasks; Damon and Killen (1982) on moral reasoning and Dimant and Bearison (1991) on formal reasoning.

However, other studies have failed to demonstrate such effects. Bearison, Magzamen and Filardo (1986) in an experiment regarding the effects of peer interaction on spatial coordination found no facilitative effect of peer interaction. In this task, the experimenter constructs a model village on a cardboard base at a particular orientation, which the child has to reproduce on an identical base but with a different orientation (see Figure 2.2).

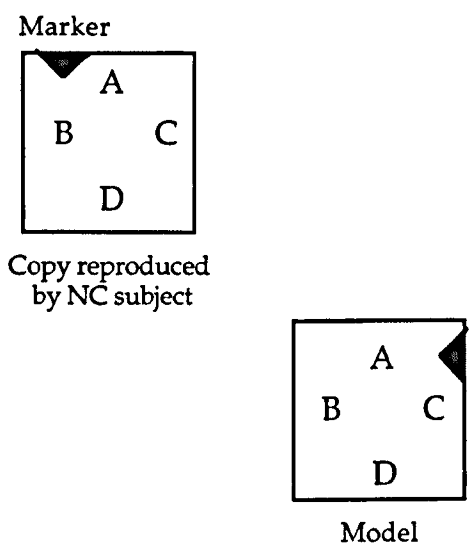


Figure 2.2 Spatial coordination task.

Bearison et al., (1986) used a 3 phase experimental design. The first phase was an individual pre-test. The third phase was an individual post-test. In the second phase the children were randomly allocated to work either with a partner or on their own. Bearison et al., compared the change in pre- to post-test scores of the children who worked individually in the second phase with those who worked in pairs. They found no significant difference between those who worked in pairs with those who worked individually. A similar result was reported by Maverech, Stern and Levita (1988) in an experiment concerning the effects of peer interaction on computer based language learning.

It seems therefore that the facilitative effect of peer interaction is dependent on several factors. One crucial factor is the level of ability of the children. Doise and Mugny (1984) report that peer interaction did not benefit those children who had no understanding of the task in an experiment they carried out on the effects of peer interaction on children's abilities to coordinate their actions. Similar findings have been reported by Perret-Clermont (1980) in an experiment on the conservation of number.

Another critical factor which mediates the effects of peer interaction is whether the participants share the decision making, especially in planning tasks. Forcing the participants to share decision making, by structuring the interaction, has been found to facilitate planning by Glachan and Light (1982) in the *Towers of Hanoi*; Light and Glachan (1985) in the game of *Mastermind*; Light , Foot, Colbourn and McClelland (1987) in a computerised version of the *Tower of Hanoi* and Doise and Hanselman (1990) in the conservation of volume. Similarly, Gauvain and Rogoff (1989) in an experiment on the effects of peer interaction on planning found that those children who had shared responsibility for decision making progressed more on an individual post-test than those children who had only worked on their own.

So it appears that peer interaction facilitates learning but only when both participants have some understanding of the task and when participants share decision making. The next section examines one possible explanation for this beneficial effect.

2.2 Conflict Based Explanations of Learning and Development.

The notion that the resolution of conflicts in peer interaction leads to learning and development is a common proposal in several explanations of cognitive growth in peer interaction. There are two main views on the role of conflicts in learning and development and both originate from Piaget. A brief summary of both is presented in this section.

2.2.1 Early Piaget and Sociocognitive Conflict

The first view stems from Piaget's (1926,1932) early writings where he stressed both the importance of conflicts and peer interaction in cognitive development. In his early writings, Piaget characterised development as the movement from egocentrism to operational thought. Egocentric thought is when the child is centred on their own point of view without taking into account other viewpoints. Operational thought is when the child can take into account multiple features of the situation and attend to different perspectives. A necessary condition in development for Piaget (1926) was the occurrence of repeated conflicts between individual children. These conflicts required the child to attend to another's point of view which is an essential feature of operational thought.

Peer interaction played an important role in this development. Piaget characterised adult-child interaction as intrinsically unequal and based on relations of power, whereas peer interaction is based on relations of cooperation and of equality. It is only through interacting with one's peers that a child can resolve apparent conflicts between different viewpoints. As Piaget so eloquently put it "Criticism is born of discussion and discussion is only possible among equals" (Piaget, 1932 p 409).

Piaget in his later writings virtually abandoned his early views on the importance of conflicts in peer interaction, but they were taken up and extended by Doise and Mugny (1984) in their theory of Sociocognitive conflict. In this theory they emphasise inter-individual conflicts (i.e. conflicts between individuals) and claim that the principle mechanism of learning in peer interaction is sociocognitive conflict (this is discussed in more detail later). They also believe that inter-individual conflicts are a more powerful stimulus to cognitive development than intra-individual conflicts (i.e. conflicts within one child's mind). This is because they claim it is easy for an individual to ignore a intra-individual conflict which is a conflict between successive and alternative centrations, but it is much harder for individuals to ignore sociocognitive conflicts because it is a conflict between two individuals who simultaneously possess two contradictory centrations. Thus their basic thesis is that the integration of two contradictory centrations leads to learning.

> "given appropriate conditions the confrontation of these different approaches may result in them being coordinated into a new approach" Doise (1990) p 50.

But importantly, the beneficial effects of sociocognitive conflict, according to Doise and Mugny, are dependent on <u>how</u> the conflict is resolved. Inter-individual conflicts can be resolved either in purely social terms when one child complies with the other's viewpoint. Alternatively they can be resolved by the participants integrating their conflicting viewpoints. It is only this latter method of resolution which Doise and Mugny claim will lead to learning.

2.2.2 Late Piaget and Cognitive conflict

The second view originates in Piaget's later work, where he further developed his ideas on the role of conflicts in cognitive development. In his theory of equilibration Piaget (1978) characterises development as the movement from one state of equilibrium to another. Equilibration is the process whereby a child moves from a state of disequilibrium to a state of equilibrium. Disequilibrium is caused by challenges or perturbations, which are taken to be conflicts between the different expectations generated by the child's cognitive system compared with actual experience.

In his theory of equilibration Piaget did not place any special importance on conflicts experienced through social interaction. The source of the conflicts did not concern him. Development would occur whether these conflicts were experienced through social interaction or through interaction with the physical world.

Thus we have two views on the role of inter-individual conflicts in learning and development. The first view expressed in Piaget's early writings and later extended in Doise and Mugny's theory of sociocognitive conflict is that conflicts experienced in social interaction are the main stimulants of cognitive growth. The other view, stemming from Piaget's theory of equilibration, is that although conflicts experienced in social interaction will lead to cognitive development, they are no more important to cognitive development than conflicts experienced through interaction with the physical world. What unites them is the notion that conflict plays a central role in cognitive development.

2.3 Evidence for Conflict Based Explanations

We now examine evidence, which comes from a number of different sets of studies, for the conflict based explanations of learning in peer interaction. The first studies investigated whether pairing children together with different perspectives can lead to learning. Both views on the role of conflicts in learning would claim that interaction between children with different perspectives (inter-individual differences) leads to learning. The second set examined whether there is a positive correlation between the number of conflicts observed in the discourse and learning.

2.3.1 Inter-Individual Differences

A considerable amount of research into the role of inter-individual conflicts in learning and development has examined the effects of inter-individual differences in peer interaction. As mentioned earlier the ability of the child relative to his/her partner may be a crucial factor in enabling learning to take place, and we review here apparently contradictory findings in the literature.

2.3.1.1 Improvement through pairing children at different levels of ability. Several researchers have found that pairing children at different levels of ability can benefit both the more able child as well as the less able child. Doise and Mugny (1984) used a spatial coordination task (see Figure 2.3) similar to one used by Bearison et al., (1986) to investigate whether confrontation between children at different cognitive levels will lead to progress.

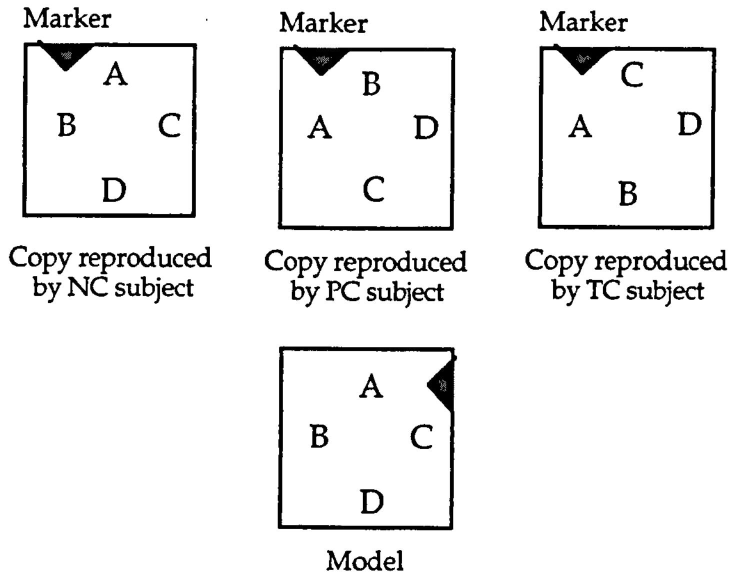


Figure 2.3 Spatial coordination task.

Using this task Doise and Mugny classified children as either a non-compensator (NC), a partial compensator (PC) or a total compensator (TC). Total compensators are children who can successfully complete the task. Partial compensators are children who successfully reproduce one dimension. For instance, the houses may be in the right position on the front-to-back dimension but may not be in the right position with regards to the left-to-right dimension. Non-compensators are children who fail to take into account the orientation of the cardboard base.

Mugny and Doise (1978) paired NCs with other NCs; NCs with PCs; NCs with TCs and PCs with other PCs. The experiment consisted of an individual pre-test, an interaction session and a post-test. Doise and Mugny report that at the post-test the less able children (NCs) paired with more able children (PCs) did significantly better than less able children (NCs) paired with other less able children (NCs). They also found that more able children (PCs) paired with less able children (NCs) did significantly better than more able children (PCs) paired with other more able children (PCs). The only finding that contradicted their thesis was the result that the less able children (NCs) paired with experts (TCs) did no better than less able children

(NCs) paired with other less able children (NCs). In another experiment they further investigated this contradictory finding and concluded that the lack of progress by the less able children (NCs) was due to the dominance of the experts (TCs) in the interaction session (Doise and Mugny 1984).

The result that a less able child can improve after interaction with a more able child has been replicated by a number of experimenters. It has been found by Perret-Clermont (1980) and Russell (1982) in studies on conservation; Damon and Killen (1982) in a study on moral reasoning; Weinstein and Bearison (1985) in an experiment on several conservation tasks; Azmita (1988) in an experiment on children's problem solving; Roy and Howe (1990) in their study on the effects of peer interaction on children's socio-legal reasoning; Tudge (1985, 1989, 1992) in his experiments on children's understanding of balancing and Howe and her colleagues (Howe, Rodgers and Tolmie, 1990; Howe, Tolmie and Rodgers, 1992a) in their studies on the effects of peer interaction on children's understandings of physics.

A number of researchers also found that a more able child can improve after interaction with a less able child. Glachan and Light (1982) conducted a study concerning the facilitative effects of peer interaction on problem solving. The task they used was the "Tower of Hanoi" (see Figure 2.4).

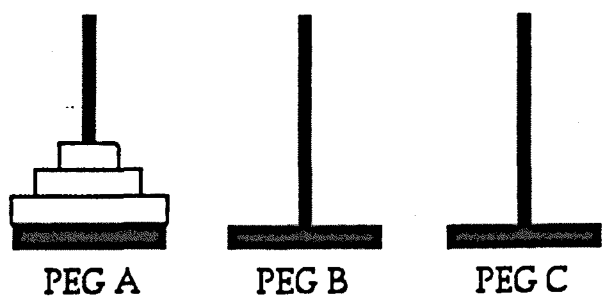


Figure 2.4 Tower of Hanoi.

The aim of this task is to move the three ring tower from position A to position C, with the constraint that only one ring at a time can be moved and a larger ring must not be placed on a smaller ring.

They employed a three phase experimental design. In the first phase the children were individually pre-tested. In the second phase they were randomly allocated to either work with a partner or individually and in the third phase the children were given an individual post-test. Glachan and Light reported that in pairs composed of children at different levels of ability, the more able child was significantly more likely to improve than a child of similar ability who only worked on their own. Several other experimenters have also found this result (Damon and Killen, 1982; Weinstein and Bearison, 1985; Roy and Howe, 1990; Howe, Rodgers and Tolmie, 1990; Howe, Tolmie and Rodgers, 1992a)

However, Tudge (1985; 1989; 1992) reports that in certain circumstances the more able peer can regress after interaction with a less able child. He conducted an experiment on the effects of peer interaction on children's understanding of balancing. His experiment had three conditions, novices paired with novices, novices paired with partial experts and an individual control. He found that the more advanced participants in novice/partial expert pairs often regressed. Regression also occurred in children whose partner initially had been at the same level of ability. As already mentioned the only group of children where there was any improvement, were the novices who had been paired with partial experts.

Tudge claims that there are two reasons for the results he found. The first is the degree of certainty the children have in their own judgements. A child initially may be at a higher level of ability than their partner but may be less certain in their judgement. Children who were not certain in their judgement improved when paired with someone who was at a higher level and confident in their judgement. They regressed when paired with someone who was certain but at a lower level of ability.

The second reason Tudge puts forward to explain his results is the quality of reasoning. Children who were exposed to reasoning of a higher level than their own were likely to improve on the post-test. Children were likely to remain at the same level at the post-test, if exposed to reasoning at the same level as their own. Children were likely to regress or stay at the same level when partnered with a child at a lower level of ability.

2.3.1.2 Improvement through pairing children with different perspectives. Another method of engendering conflict is to pair children at the same level of ability, but with different views.

Mugny and Doise (op cit) reported that interactions between two non-compensators produced neither conflicts nor progress, but in a further experiment on spatial coordination Doise and Mugny (1979) created a situation where conflicts did occur between two non-compensators and it did result in progress. In Mugny and Doise (1978), the children were placed side by side and they thus shared the same viewpoint, but in this experiment they were placed opposite each other and thus had differing perspectives (see Figure 2.5).

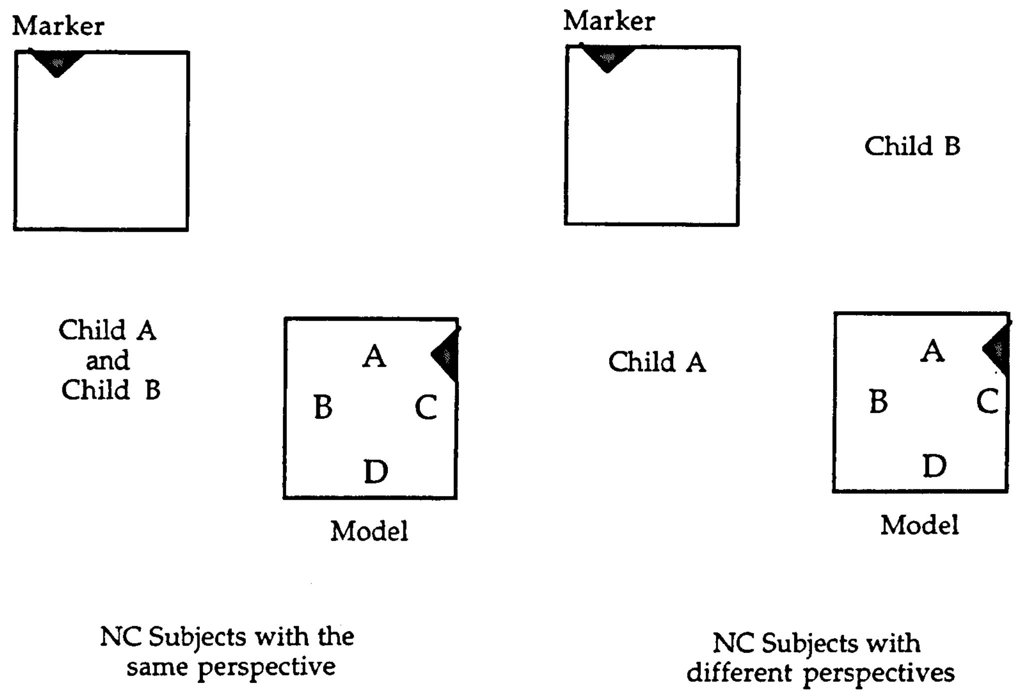


Figure 2.5 Non-compensators with the same and different perspectives.

They then compared pairs of non-compensators, who had differing visual perspectives, with individuals and they found that subjects who had been in pairs improved significantly more at post-test than those subjects who had only worked individually.

A similar result was reported by Ames and Murray (1982) in an experiment on conservation. They compared pairs of non-conservers with differing perspectives on a range of conservation tasks with individual non-conservers and they found that those non-conservers who worked in pairs were more likely to have improved at post-test compared to those non-conservers who worked individually. Also Howe (Howe et al., 1990 and Howe et al., 1992a) in a series of experiments on children's understanding of physics reports children in pairs who were at the same level but with differing views had significantly greater pre- to post-test gains than children who were in pairs with the same view and at the same level.

However, other studies have found that collaboration between children at the same level led to no progress. Emler and Valiant (1982) in an experiment on spatial coordination reported no significant differences between pairs of children at the same level of ability and individuals. Russell (1982) found that non-conservers paired with conservers were significantly more likely to progress on a subsequent individual post-test than pairs of non-conservers. Similarly Azmita (1988) reports that pairs of novices were no more likely to improve than individual novices on a problem solving task. The method of resolution observed in these studies could be one explanation for why they found no benefits. Russell reported that conflicts in his study were resolved by one participant dominating the other, a method which according to Doise and Mugny (op cit) would not lead to progress.

So far we have only considered evidence concerning the effects of pairing children together who have different abilities or different perspectives. The general finding is that pairing children together with different perspectives can lead to development, in certain circumstances. Some of these circumstances are the quality of the reasoning used by the children and the method of resolution used to resolve the conflicts. The next section examines research which investigates the relationship between the number of conflicts overtly expressed in the dialogue and learning.

2.3.2 Conflicts in the Discourse

A second set of studies have examined the conflict based explanations by investigating the relationship between the number of conflicts observed in the discourse and learning outcome. Unfortunately, as seems to be the case with most research in this area, the evidence is mixed. Some studies have reported that certain levels of conflict are associated with progress at post-test. Emler and Valiant (1982) and Bearison et al., (1986) reported experiments on spatial coordination which showed that certain levels of conflict are directly related to learning. Emler and Valiant divided their subjects into two groups; those subjects who had higher than the medium number of disagreements in peer interaction and those subjects who had less than the medium number of disagreements. They found that those in the high group were significantly more likely to improve at post-test than those in the low group. Similarly Bearison et al., (1986) found that those subjects who had 5 to 8 conflicts in a peer interaction session were more likely to improve at post-test compared with subjects who had only worked on the problem on their own, but it has to be noted that Bearison et al., also found a regressive effect when the number of conflicts was very high (i.e. above 20).

A possible explanation for why only certain levels of conflict have been found to be associated with learning is provided by Light and Glachan (1985). They report an experiment using a computer based version of the game called *Mastermind*. In this experiment they compared the pre- to post-test gains of pairs of children who were divided into two groups: a low argumentation group who had less than 10 arguments in the peer interaction session; and a high argumentation group who had more than 10 arguments in the peer interaction session. They found that those children in the high argumentation group were more likely to improve at post-test than those children in the low argumentation group.

The reason they give for this finding is the method of resolution adopted by the children. They analysed how the arguments were resolved in the two groups and found that those subjects in the high argumentation group resolved their arguments by focussing on the task. This was not the case for those subjects in the low argumentation group who resolved their arguments through social-relational means (i.e. through dominance/

compliance). This explanation is consistent with Doise and Mugny (op cit) who claim that resolving conflicts through one participant complying with the other does not lead to learning.

Other researchers have found no relation between the number of overt conflicts resolved and learning. In particular, researchers using planning tasks either report very few conflicts occurring in peer interaction or if they do they are not associated with learning. Glachan and Light (1982; Light and Glachan, 1985; Light 1991) report a peer facilitation effect on learning to plan, but they report there was very little talk between the children and overt conflicts were infrequent. Similarly, Barbieri and Light (in press) in a study using a computer based planning task found no relation between the number of conflicts and subsequent improvement at post-test. This result was also found by Azmita (1988) in her study on children's problem solving. Other researchers using non-planning tasks also report no positive correlation between conflicts and learning. For example, Blaye (1988) in her study of the effects of peer interaction on children's performance on a binary matrix problem and Damon and Killen (1982) in their study on moral reasoning.

However the method used for detecting conflicts in all these studies is not very effective. They only investigate conflicts which are explicit in the discourse, but both Piaget and Doise and Mugny do not define inter-individual conflicts as conflicts which are necessarily, verbally expressed and marked explicitly in the discourse. Both conflict based explanations described earlier allow for conflicts which are implicit in the discourse.

The previous two sections have reported mixed evidence for the conflict based explanations of learning and development, but the general conclusion is that in certain conditions the resolution of conflicts can lead to development. The next section reports research which shows that discourse analysis can help us to determine those conditions.

2.4 Discourse Conditions

Recent research by Howe and her colleagues (Howe, Tolmie, Anderson, and Mackenzie 1992b; Howe, Tolmie and Mackenzie, in press) has shown, that understanding the discourse processes involved in the resolution of conflicts helps us to understand more about when and how it leads learning.

Howe, Tolmie and Mackenzie (in press) report an experiment on the effects of peer interaction on children's understanding of free fall motion. They used a computer based task where the children had to make predictions about the trajectory of falling objects and test those predictions out. The experiment consisted of a pre-test, an interaction session and a post-test. The children were paired in the interaction session on the basis of being similar or different in their predictions and/or their conceptual knowledge. Progress was most likely to occur in those pairs where the children differed in both dimensions and least likely to occur in pairs where the children had different conceptual knowledge but made similar predictions. The probable explanation for this result is that in pairs where the children differed along both dimensions they would disagree over their predictions. One convention in conversation is that when opinions differ they have to be justified (Levinson, 1983). This convention would make the children justify their decisions and thus to consider factors which they may have ignored or overlooked. In pairs, which differed only conceptually, disagreements would not occur because their predictions would not differ and thus there would be no need to justify their decision.

Another important conversational factor is that the participants must share the same task vocabulary for them to be able to benefit from any inter-individual differences. Howe, Tolmie, Anderson, and Mackenzie (1992b) used a computer based kinematics task which involved comparing the speed of moving objects. The experiment consisted of a pre-test, an interaction session and a post-test. Subjects were paired in the interaction session on the basis of being either similar or different on each of three dimensions: judgements (responses made to problems), strategies (conceptual knowledge) and principles (abstract knowledge). Pairs who differed in both or neither judgements and strategies had the greatest pre- to post-test change. However the pairs who exhibited the greatest change were those pairs who were at the same level of knowledge of principles. Howe et al., (1992b) suggest that this is because those pairs who were at the same level of formal knowledge employ the same vocabulary to discuss their decisions. This shared vocabulary, they argue, aids communication, which in turn increases the awareness of conflict and aids in the resolution of the conflict.

In sum, this section has reported research which has shown that by understanding the dialogue processes involved in the resolution of conflicts we can begin to determine the conditions under which it will lead to learning.

2.5 Sociocognitive Conflict and Cognitive Conflict

Having examined the evidence concerning conflict based explanations of learning, we now turn to the issue of the difference between sociocognitive conflict (derived from Piaget's early work and extended by Doise and Mugny) and equilibration (derived from Piaget's later work). Recall that Doise and Mugny argue that inter-individual conflicts or sociocognitive conflicts are a more powerful stimulus to cognitive growth than intra-individual conflicts, whereas in the theory of equilibration they are both equally important in stimulating cognitive development. This section reviews the evidence for these different views.

Doise and Mugny (1979) examined this issue in another experiment on peer interaction using the spatial transformation task. This experiment had two conditions a cognitive conflict condition and a sociocognitive conflict condition. In the sociocognitive conflict condition two children sat opposite each other in positions A and B shown in Figure 2.6.

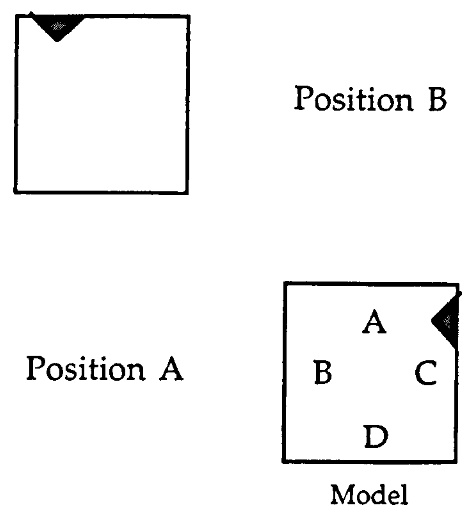


Figure 2.6 Inter and intra-individual conflicts in the spatial coordination task.

The children in the cognitive conflict condition were first asked to solve the problem (i.e. re-produce the model) in position A and then they moved to position B and were asked if they were sure of their first attempt. Doise and Mugny reported that subjects in the paired condition performed better on the individual post-test than subjects in the individual condition.

Mackie (1980) tried to replicate Doise and Mugny's experiment also using a spatial coordination task, but in her study the cognitive conflict was made more salient. She also compared the effects of cognitive conflicts with the effects of sociocognitive conflicts on children from two different cultural backgrounds. One group of children had a Maori background which emphasises cooperativity and the other group had a more European background which emphasises individuality. Mackie found that both groups of children would improve from sociocognitive conflicts but increasing the saliency of the conflict only benefited children from a European background.

Emler and Valiant (1982) also tried to replicate Doise and Mugny's experiment, but they found that non-conservers in the cognitive conflict condition progressed as much as the non-conservers in the sociocognitive conflict condition. Roy and Howe (1990) report a similar result to Emler and Valiant concerning the effects of peer interaction in the domain of socio-legal thinking.

So, again, although the studies reported in this section have found that conflicts experienced in a social context can lead to learning, the evidence is mixed concerning the view expressed by Doise and Mugny that sociocognitive conflicts are a more powerful stimulus to learning than cognitive conflicts. Evidence has also shown that cognitive conflicts are as effective as sociocognitive conflicts in eliciting progress but the effect of cognitive conflicts is mediated by the cultural background of the subjects and the saliency of the cognitive conflict.

2.6 Evidence for Alternative Explanations of Learning

I have reported evidence which suggested that in certain circumstances the resolution of inter-individual conflicts is a mechanism for learning in peer interaction. Obviously there are other explanations for learning in peer interaction which do not place conflict in such a central role. This section will briefly outline several of these explanations. These should not be seen as competitive explanations to the conflict based explanation but as complementary.

2.6.1 Co-construction

The conflict based explanations are derived from Piaget's work. Other explanations are derived from Vygotsky (1986, 1981, 1978). Vygotsky claims that the child develops higher mental functions through the internalisation of social processes. For Vygotsky the crucial aspect in this developmental process is that the child is interacting with a more able partner whether adult or peer.

Although, Vygotsky was more concerned with adult-child interaction, his work has recently been applied to understanding how peer interaction can promote development and learning. Forman and her colleagues have developed the notion of co-construction. This is a collaborative process where the participants adopt complementary roles with one child proposing a solution and the other participant observes, corrects and guides. (Forman and Cazden 1985; Forman and Kraker 1985 and Forman 1987). The observer, Forman claims, provides support which is similar to "scaffolding" (Wood, Bruner and Ross 1976). Over time children will swap back and forth between roles. A similar proposal was made by Miyake (1986) in her work on constructive interaction.

2.6.2 Destabilization

Destabilization is another proposed explanation of learning in peer interaction by Blaye (1988,1989). As already mentioned in the previous section she conducted a series of experiments on problem solving using a matrix classification task. In this task, children have to place coloured shapes into the appropriate matrix cells. Blaye found that working in pairs led to better subsequent individual performance than working alone. However, this facilitative effect was found not to be dependent on the verbal disagreements between the participants during joint problem solving. Blaye suggests it was dependent on destabilization, occurring when the previous placement of one child makes it impossible for the other child to follow their own strategy. Such destabilization, Blaye hypothesizes, results in the child constructing a new strategy which can be more effective than their previous strategy. A similar argument was put forward by Light and Glachan (1985) in their paper on planning.

2.6.2 Social Class

Much of the evidence for Doise and Mugny's theory of sociocognitive conflict is derived from experiments conducted by Perret-Clermont (1980) on conservation. However there is evidence which suggests that sociocognitive conflict does not fully explain the facilitative effects found in these conservation tasks. Perret-Clermont (1980) and Perret-Clermont and Schubauer-Leoni (1981) have found that middle class children performed significantly better than working class children in the pre-test on a conservation of liquids task. However, in the post-test this class difference had disappeared. The sociocognitive explanation would be that 10 or 20 minutes of peer interaction overcomes those differences.

An alternative and more plausible explanation is provided by Light and Perret-Clermont (1988). They base their explanation on several experiments conducted by Donaldson (1978) which have shown that children fail on Piagetian conservation tests not because they are unable to conserve, but because they fail to understand the experimenter's intentions. Light and Perret-Clermont suggest that the class difference found in the experiment on the conservation of liquids task is not the result of a difference in conservation ability, but a difference in understanding the experimenter's intentions. This difference arises because middle class children are better prepared by their parents and their environment to understand this type of task.

They go on to suggest that the reason the class difference disappears at post-test is not because of sociocognitive conflict but rather that the social context of peer interaction provides a framework for understanding the task (because conservation is explicitly or implicitly about equal shares which involves the issue of fairness). In peer interaction this issue is made more salient and Light, Gorsuch, and Newman (1988) have shown that children perform significantly better in conservation tasks when the issue of fairness is made explicit.

Therefore according to Light and Perret-Clermont, peer interaction is effective because it evokes the issue of fairness which supports the child's understanding of the task.

2.7 Discussion

In this chapter, evidence was reviewed which showed that under certain conditions the resolution of conflicts leads to learning. Recent research was reported which showed that understanding the discourse processes involved helps us to determine those conditions. Although it must be acknowledged that there are other explanations of learning in peer interaction, conflict resolution can and does lead to learning and thus in principle it could be used to inform the design of computer supported collaborative learning.

However, this section will point out three specific problems with conflict based explanations, which limit their usefulness to inform the design of systems to support collaborative learning. First, it is not clear what cognitive conflict or sociocognitive conflict are precisely, especially in non-Piagetian tasks (i.e. problem solving tasks). Second, these theories do not explain how conflicts are resolved; and third they do not explain how that resolution leads to learning.

2.7.1 Definition of Conflicts

One problem common to both views on the benefits of conflicts in peer interaction is that it is not clear what a conflict is in non-Piagetian tasks. Both Piaget and Doise and Mugny claim that development will result from the coordination of conflicting centrations. The term centration is a Piagetian notion and it refers to a cognitive scheme which is not yet integrated into a more general structure. For instance in the conservation of liquids task a child will agree that two identical glasses contain the same amount of liquid but when the content of one of the glasses is poured into a tall thin glass and the content of the other is poured into a short wide glass the child may claim that the tall thin glass has more liquid. This decision is based on the child correctly comparing the height of the liquid in the glasses but not taking into consideration the width of the glass. The child has focussed or centred solely on the height of the glasses. If the differences in the width of the glasses is pointed out, she may well reverse her decision and assert that the wide short glass has more liquid, this time basing her judgment on the width of the glass. Thus the child has two centrations one which focuses on the height and another which focuses on the width. Development would result from the child integrating these two centrations into a single organised scheme which can deal with the compensation of opposing equal differences.

The difficulty is that in non-Piagetian tasks, especially planning tasks, it is not clear what a centration is (Blaye 1988). For instance in the "Tower of Hanoi" problem, the notion of a centration is not appropriate because children are not centering on one dimension or another, they are using more or less efficient strategies. A similar picture emerges in an errand running task used by Rogoff (Gauvain and Rogoff, 1988). Again children are using different strategies rather than focussing on one dimension or another.

2.7.2 Resolution of Conflicts

Another problem common to both views on the benefits of conflicts is that they do not explain how conflicts are resolved. Doise and Mugny propose there are different ways of resolving conflicts. They can be resolved either in purely social terms when one child complies with the other child's view point or they can be resolved by the children integrating their conflicting viewpoints. But unfortunately Doise and Mugny do not elaborate any further, although they do claim that resolution through one child's dominance will not produce progress.

2.7.3 Conflicts and Learning

A more fundamental problem with theses theories is that they do not explain how the resolution of conflicts leads to learning. Bryant (1982) made this criticism of Piaget's theory of equilibration but it also applies to Doise and Mugny's theory since it is derived from Piaget's theory.

Understanding how the resolution of conflicts leads to learning is particularly important because there have been several studies which have found that contrary to Doise and Mugny, and Piaget the resolution of conflicts can lead to regression. As was reported in section 2.3, Tudge (1985, 1989, 1992) in his experiments on the effects of peer interaction on children's understanding of balancing reports that at certain levels of ability a more able child who is uncertain can regress when paired with a less able child who is certain. A regression effect was also reported by Bearison et al., (1986). They conducted an experiment on spatial transformation and found a curvilinear relationship between the expression of sociocognitive conflict and learning. This relationship indicated that at very high levels of conflict (over 25 conflicts a session) regression would occur.

Research by Howe and her colleagues has shown that understanding the discourse processes can be useful in explaining when and how the resolution of conflict leads to learning. Howe et al., (in press) report that it is not enough for children to have different perspectives they must also have different predictions. The probable explanation for this result is that conversational convention dictates that you only discuss your reasons for a decision when your decisions differ. Howe et al., (1992b) also reports that if the participants have different task vocabulary, they are unlikely to benefit from any differences between them.

It is the main contention of this thesis that unless we understand more about the nature of conflicts and how they are resolved and how their resolution leads to learning, then we will not be in a position to support learning through the development of appropriate software for use in collaborative problem solving. To this end in Chapter 3, a dialogue model of the resolution of conflicts in joint planning will be developed, based on recent research on discourse understanding. The model will describe various types of inter-individual differences which could cause inter-individual conflicts in joint planning. It then goes onto describe how they can be resolved using a set of discourse transactions and a set of internal resolution procedures. Finally, with reference to the model I will discuss how their resolution can lead to learning.

Chapter 3 : A dialogue model of the resolution of inter-individual conflicts in joint planning.

3.0 Introduction

Under certain circumstances peer interaction has been found to facilitate learning and a number of explanations of this facilitation effect have been proposed (see Chapter 2). The resolution of inter-individual conflicts is a common explanation in several of these proposals. However, Chapter 2 concluded that unless we understand more about the nature of conflicts in joint planning their resolution and how that resolution leads to learning we will not be able to develop software to support collaborative learning.

In order to further our understanding of the process of inter-individual conflict resolution, we need to examine some of the literature on discourse understanding. An important concept in this research is that of focus, which I will discuss with reference to the literature on discourse structure and that on plan recognition in discourse. Both of these are relevant to joint planning, and later in this chapter I will propose a dialogue model of the resolution of inter-individual conflicts (Joiner, 1991; Joiner, 1992a).

3.1 Focus in Discourse

When two people talk they focus their attention on a small portion of what each of them knows or believes (i.e. what they think is relevant to the discussion). As the discourse proceeds, the two participants shift their focus to new entities or perspectives. Grice (1975) was one of the first to identify the problem of focus in his maxim of relevance. In this he points out:

> "Though the maxim is terse, its formulation conceals a great deal of problems that exercise me a great deal: questions about what kinds and focuses of relevance there may be, how these shift in the

course of talk exchange, how to allow for the fact subjects of conversation are legitimately changed and so on" p46 1975.

Focus is a key aspect in both theories of discourse structure and in recent models of plan recognition in discourse.

3.1.1 Focus in Discourse Structure

Theories of discourse structure attempt to explain how people keep track of the topic of conversation when it changes with little or no explicit indication in the discourse. There are two theories of discourse structure which are focus based. These are Grosz and Sidner's (1986) three component model and Reichman's (1978, 1984, 1985) model.

Grosz and Sidner (1986) developed their model mainly from Grosz' earlier work in analysing task oriented dialogues (Grosz 1977,1978,1981). It has three components; the *Linguistic structure*; the *Intentional structure* and the *Attentional state*. The *Linguistic structure* decomposes into discourse segments, which are groups of utterances fulfilling particular purposes within the discourse. These purposes are referred to as 'discourse segment purposes'. The *Intentional structure* is a representation of these purposes and the relationships between them. In Grosz' earlier work the intentional structure corresponded to the task structure. The *Attentional state* represents the focus of attention of the participants.

Reichman's model is based on the analysis of various types of discourse involving informal arguments, therapeutic discourse and explanatory dialogues. Discourse structure is defined as a set of context spaces and the relationships between them. Discourse processing involves constructing a representation of the discourse structure. The discourse structure is used to identify the section of dialogue which is governing the generation and interpretation of utterances. This section of dialogue is the current focus of attention and is represented in Reichman's model by the *discourse reference frame.* The *discourse reference frame* can be changed by conversational moves, which represent the various relationships which hold between utterances. Examples of conversational moves are presenting a claim, supporting a claim, challenging a claim and shifting topic.

Both Grosz and Sidner, and Reichman use similar representations of focus. The model proposed in this chapter follows that developed by Grosz and Sidner. In their model the attentional state represents focus. This includes the objects, the properties and relations which are salient at each point in the discourse and is modelled by a set of focus spaces. Each focus space represents items which are either explicitly mentioned in a discourse segment or have become salient during the production or the understanding of the utterances in a discourse segment. They can either be *open*, *closed* or *active*. A focus space is *active* when its discourse segment purpose is the current topic of conversation. It is *open* when its discourse segment purpose has not been achieved and it is *closed* when its discourse segment purpose has been achieved. The discourse focus is the set of open focus spaces plus the active focus space. It is represented as a stack, with the active focus space on top.

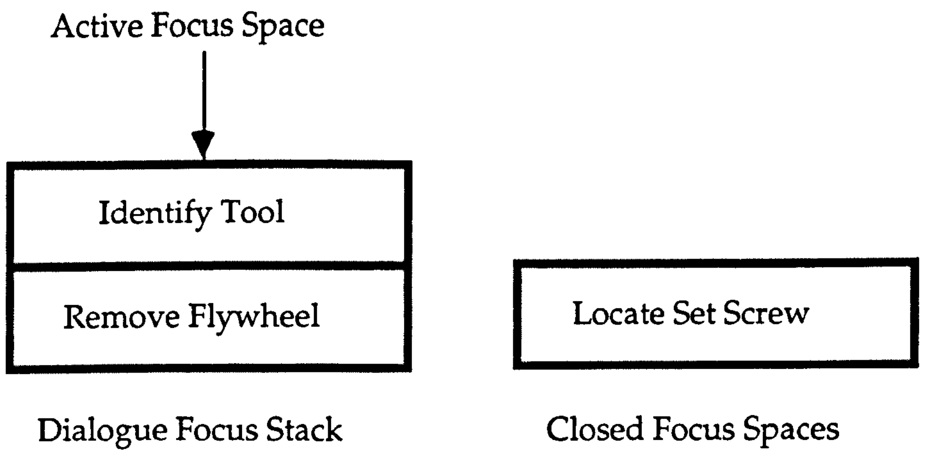
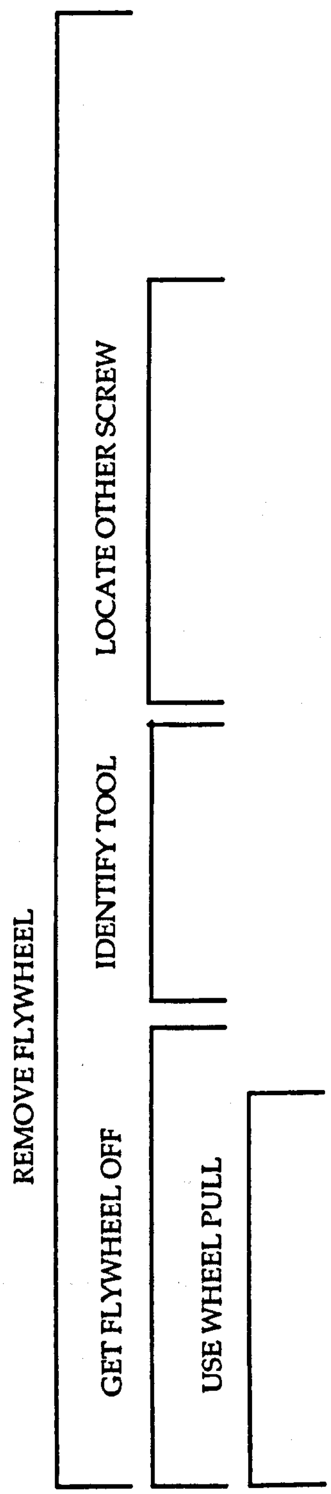


Figure 3.1 : Dialogue focus for utterances 12 to 17.

This model of focus is best illustrated by an example from Grosz and Sidner (1986). In the example below an expert(E) is assisting an apprentice(A) to remove a flywheel. For utterances 12 to 17 the active focus space is "identify tool" and the other open focus space is "remove flywheel". The closed focus space is "Locate set screw".



(1) E : First you have to remove the flywheel.
(2) A: How do I remove the flywheel?
(3) E : First loosen the two allen head setscrews holding it to the shaft, then pull it off.
(4) A: OK.
(5) I can only find one screw. Where's the other one?
(6) E : On the hub of the flywheel.
(7) A: That's the one I found. Where's the other one?
(8) E : About 90 degrees around the hub from the first one.
(9) A: I don't understand. I can only find one. Oh wait, yes I think I was on the wrong wheel.
(10) E : Show me what you are doing
(11) A: I was on the wrong wheel and I can find them both now.
(12) The tool I have is awkward. Is there another tool I could use instead?
(13) E : Show me the tool you are using
(14) A: Ok.
(15) E : Are you sure you are using the right size key?
(16) A: I'll try some others
(17) I've found an angle I can get at it.
(18) The two screws are loose, but I'm having trouble getting the wheel off.
(19) E : Use the wheel pull. Do you know how to use it.
(20) A: No
(21) E : Do you know what it looks like ?
(22) A: Yes
(23) E : Show it to me please.
(24) A: OK
(25) E : Good. Loosen the screw in the centre and place the jaws around the hub of the wheel then tighten the screw onto the centre of the shaft. The wheel should slide off.

Once the tool is identified as indicated in Lines 16 and 17 the focus space "identify tool" is closed and removed from the stack. In line 18 the new focus space "get flywheel off" is opened and this becomes the new active focus space (see Figure 3.2).

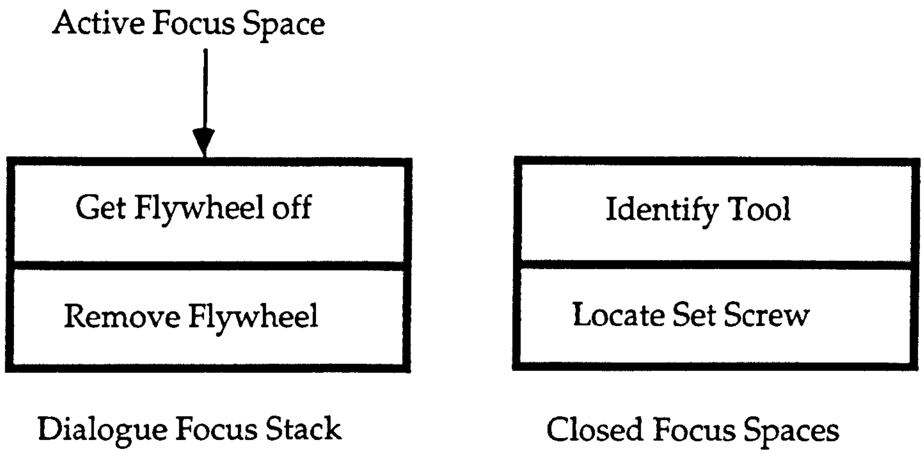


Figure 3.2 : Dialogue focus for utterance 18.

Grosz and Sidner were only concerned with one type of focus, namely dialogue focus, which is the representation of those parts of the discourse which are relevant to the current topic of conversation. But there are other types of focus. This was alluded to in Grice's maxim of relevance and is apparent in Grosz' earlier work (Grosz 1978, 1979) where she distinguished between explicit focus and implicit focus. Explicit focus corresponds to dialogue focus and is a representation of those items in the preceding discourse which are relevant to the current topic of conversation. Implicit focus is a representation of those items in the task representation which are relevant to the current topics of conversation. Thus not only are parts of the discourse in focus but also parts of the task representation. In the dialogue model, I will distinguish between these two types of focus. The former will be referred to as task focus and the latter as dialogue focus.

Reichman's theory is also useful because she has modelled arguments using a set of conversational moves. Participants can challenge claims, challenge challenges, support claims etc. There are also different subtypes of support and challenge. For instance there are direct challenges and indirect challenges. However there are a number of limitations with her model of arguments. One limitation of her approach is that she has not examined why someone makes a challenge or supports an utterance. She only characterises the discourse context necessary for a conversational move (e.g. a challenge to a claim requires a claim to precede it), but she does not specify the relationship between the challenger's beliefs and the claim which made it necessary for the challenger to make a challenge. A further limitation of her model is that she has not examined the effect of a successful or unsuccessful challenge on the participants' task representation. These limitations are addressed in the model of conflict resolution proposed in this chapter.

3.1.2 Focus in Plan Recognition

Following on from our discussion of focus in theories of discourse structure, I now discuss some recent work on focus in plan recognition in discourse. These models represent focus in a similar way to Grosz and Sidner, but they have developed more detailed accounts of focus change.

They are derived from the view expressed by Grice (1957; 1968; 1975), Austin (1962) and Searle (1969;1975) that language is action and in order to understand an utterance it is necessary to recognise the speaker's intention for making it. These models attempt to formalise this view by using Artificial Intelligence techniques for representing actions and reasoning about them. In the field of Artificial Intelligence plans are viewed as a means by which an agent can carry out a non primitive goal. Plans are represented (Fikes and Nilson, 1971; Sacerdoti 1974) as a structure containing preconditions which must be true if the plan can be executed; effects which are the results of executing the plan and a plan body which is a list of subgoals which have to be accomplished.

Recent work has extended the early models of plan recognition in dialogue by developing ones which can recognise plans in extended discourse (Carberry 1987,1988; Litman and Allen 1987,1990). These models use *Focus* as a means for guiding the process. At the start of the discourse these models infer as much as possible using the original plan recognition technique. At this stage it may not be possible to determine the speaker's exact plan and a set of candidate plans may have to be used. As the discourse continues the system attempts to expand as many of the candidate plans as possible, using the original plan recognition technique. Plans which cannot be expanded are eliminated from consideration

Plan recognition models are made more efficient by using a set of heuristics which use the discourse focus as a means of guiding the process. These heuristics are used to expand those parts of the candidate plan, which are in focus as opposed to those parts which are not. This is based on the observation made by Grosz (1977) that at any point in the discourse only one part of the speaker's plan will be in focus and, unless explicitly stated, subsequent utterances will be related to that part.

The work on plan recognition in discourse is interesting because it has led to the development of models of focus change. Carberry's (1987,1988) model accepts a semantic representation of the utterance as input and then uses basic plan recognition techniques (Allen and Perrault, 1980), to try to infer a set of candidate subplans the speaker's attention might be focused on. After recognising the set of candidate plans the next step is to relate the candidate plans to the present discourse context or focus. Focussing heuristics are used to determine the most coherent relationship between one of the candidate plans and the discourse context. The candidate plan which is selected is added to the discourse context as the new focus of attention and the context model is updated.

A limitation with the techniques just described is that they only recognise utterances which are logical steps in a plan. However there are many other ways utterances can relate to plans. Utterances may change a plan, clarify it, correct it, challenge it and support it. Litman and Allen (1987,1990) present a plan based model of focus change which allows for a variety of such utterance-plan relationships.

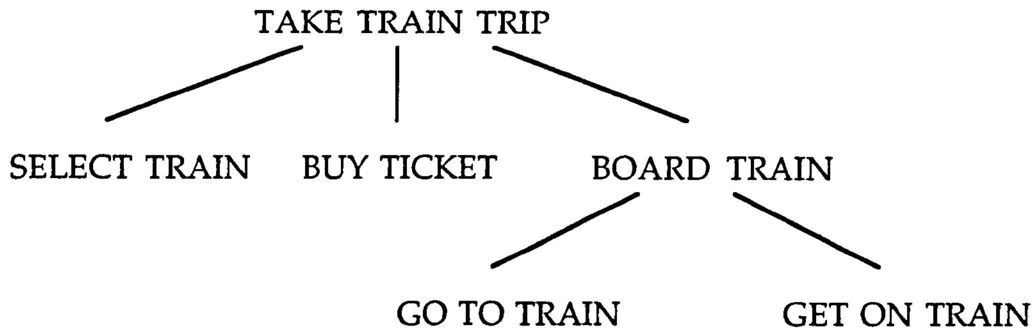
They distinguish between discourse plans and domain plans. Domain plans are used to model tasks. Discourse plans are domain independent plans that refer to other plans. They can introduce a domain plan, clarify a domain plan and so on. Discourse plans can themselves become objects of other discourse plans - for example clarifications can themselves become objects of clarification, thus allowing nesting of discourse plans.

In Litman and Allen's Plan Recogniser, the system first recognises the utterance purpose. For instance in the example below it recognises the purpose of the utterance as a REQUEST FOR INFORMATION.

passenger	6: 10 to Croydon?
guard	platform 6

It then tries to associate this purpose to a domain plan either directly or indirectly, by associating it with a discourse plan which is itself related to a domain plan. For instance, it recognises that REQUEST FOR INFORMATION is part of the clarification discourse plan IDENTIFY

PARAMETER IN PLAN. It then goes onto recognise that this discourse plan is in turn part of the domain plan GO TO LOCATION OF TRAIN and furthermore that this domain plan is part of the much larger domain plan shown below.



This domain plan is then used by the system to generate an appropriate response.

But, unfortunately for the purposes of the model proposed in this chapter Litman and Allen do not model inter-individual conflicts (i.e. arguments or disagreements) in discourse.

3.2 Components of the Dialogue Model.

As mentioned in the introduction, the dialogue model proposed in this chapter attempts to incorporate the research on discourse understanding described so far into a model of the resolution of inter-individual conflicts. Focus was a important feature in these models of discourse understanding. However, most of them assumed that participants share the same task representation. This assumption is obviously incompatible with a model of the resolution of inter-individual conflicts. Thus in order to incorporate focus into the model an important distinction is made between the *dialogue focus*, the *task focus* and the *task representation*. In the model participants have a shared dialogue focus but have different task foci and task representations. The representation of the dialogue focus, the task focus and the task representation is presented in this section.

3.2.1 Dialogue Focus.

Dialogue focus is defined as a representation of the objects and events which have been mentioned in the discourse and are relevant to the current topic or topics of conversation. It is assumed to be the same for both participants. It is represented by a set of focus spaces, where a focus space represents a particular discourse segment. Each focus space represents the objects explicitly referred to in the discourse segment it is related to and the purpose of that discourse segment. The discourse segment purpose corresponds to a domain or discourse plan.

Focus spaces can be either open, closed, or active. Open focus spaces are those focus spaces whose discourse segment purpose has been introduced into the dialogue but has not been achieved yet. Closed focus spaces are those focus spaces whose discourse segment purposes have been introduced into the discourse and have been achieved or rejected. The active focus space is the focus space whose discourse segment purpose is the current topic of conversation.

The set of focus spaces which are represented in the dialogue focus are all the open focus spaces and the active focus space. The active focus space is removed from the dialogue focus if its discourse segment purpose has been achieved or rejected. Previous models only allowed focus spaces to be removed from the dialogue focus if the discourse segment purpose had been achieved. In this model a focus space can also be removed if its discourse segment purpose is successfully challenged or rejected.

The following extract about two apprentices trying to disassemble an air compressor will illustrate the notion of dialogue focus and show how it changes.

DISASSEMBLE COMPRESSOR

REMOVE DRIVEWHEEL

REMOVE FLYWHEEL

(1) E : Right you two have got to take apart
this air compressor

(1) A : Right we've got to take this thing apart

(3) B : Where shall we start ?

(4) A : Lets remove the drive wheel first

(5) B : No the flywheel first

(6) A : Oh yeah

At utterance 4 the dialogue focus has two focus spaces; "disassemble compressor" and the active focus space "remove drivewheel" (see Figure 3.3)

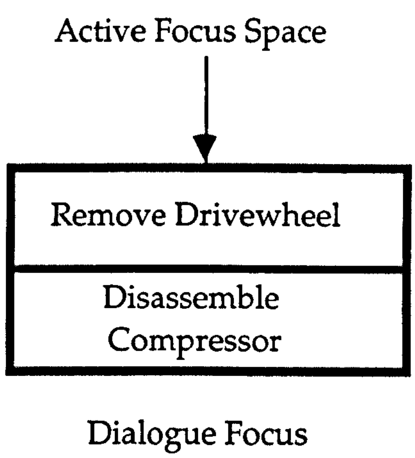


Figure 3.3 The dialogue focus at utterance 4.

In utterance 5 the focus space "remove drivewheel" has been rejected and removed from the dialogue focus because it was successfully challenged by utterance 5. The new active focus space is "remove flywheel" and the new representation of dialogue focus is shown in Figure 3.4.

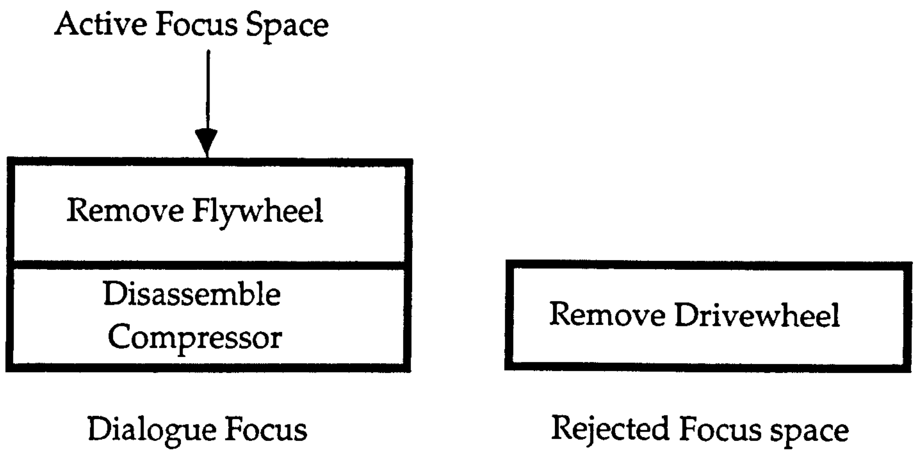


Figure 3.4 The dialogue focus at utterance 5.

As can be seen in this extract the dialogue focus is changing (i.e. from remove the drivewheel to remove the flywheel) but even though it's changing the participants still maintain a shared focus by updating their models accordingly.

3.2.2 Task Focus

The *Task focus* is defined as the subset of knowledge relevant to the purpose of the dialogue focus. It is similar to Grosz'(1977) notion of implicit focus. The difference between Grosz' implicit focus and task focus is that implicit focus, unlike task focus, is assumed to be the same for both participants, whereas the participants' task focus can be different. (i.e. what one person thinks is relevant may not be what another person thinks is relevant). For instance, in the extract above in line, 5 when the dialogue focus shifts to "remove Flywheel" A and B's task foci may be entirely different. A's may contain knowledge about where the set screws are and B's may contain knowledge about which tools are used to remove the flywheel.

3.2.3 Task Representation

In this model, the task is represented by goals, beliefs and plans. Goals are what people wish to achieve (e.g. disassemble an air compressor). Beliefs are the participants' knowledge of the world. (e.g. the set screws are located on the hub of the wheel). Plans are the actions people carry out to achieve their goals. Plans have preconditions, subgoals and effects. Preconditions are a set of beliefs about when you can carry out a plan. Subgoals are the goals you have to achieve before you can carry out the plan and effects are a set of beliefs about what an operation will achieve if the plan is successfully carried out.

Participants can have different task representations and each item represented in the task representation is associated with other items. For example the goal "making a cup of tea" is associated with its subgoals "put tea bag into cup", "pour hot water into cup", "take tea bag out", "pour milk into cup".

Items represented in the task representation also have a measure of confidence associated with them. This measure attempts to represent how confident a particular individual feels about an item. A person's confidence in an item is in part determined by the origins of that item. A person is liable to be very confident about an item derived from direct perception but may not feel very confident about items which are derived from other sources.

Another property of the task representation is that it is distributed. A distributed representation can allow for the fact that participants may have several different task models. They may have different models representing different aspects of the task and they may also have several different models of the same aspect of the task. This part of the model is based on di Sessa's (1986; 1988) work on users' understanding of complex devices. A further property essential for representing intra-individual conflicts is that the task representation allows for inconsistencies. It is capable of representing inconsistent beliefs by representing the conflicting beliefs in different task models.

So to sum up, as shown in Figure 3.5, the model is a subset model. The dialogue focus is a subset of the task focus. It represents what is relevant to the current topic of conversation and has been mentioned explicitly in the discourse. The task focus represents a subset of the task representation, which is relevant to the current dialogue focus.

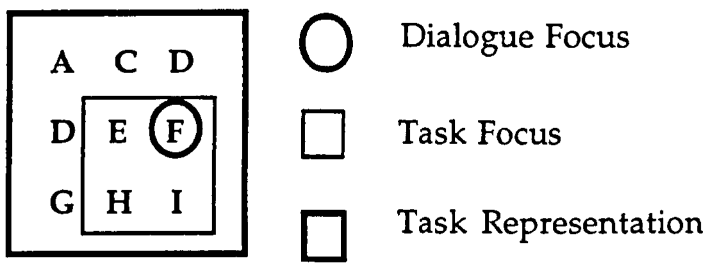


Figure 3.5 The Model.

3.3 Perception of Inter-individual Conflicts

An inter-individual conflict is perceived when one participant perceives either an inconsistency or a contradiction between the dialogue focus and his or her own task focus. Contradictions occur when the speaker proposes a belief, which conflicts with a belief in the hearer's task foci. Inconsistencies occur when one participant proposes a plan and this conflicts with the hearer's task foci. It may conflict with the hearer's task foci in a number of ways. First it may interact with another plan or goal. Second, it may conflict with the hearer's task focus because the hearer believes a precondition has not been met or a subgoal has not been achieved. Finally it may conflict because the hearer believes the plan will not achieve the desired goal.

It is important to note that inter-individual differences will only lead to an inter-individual conflict when they appear in the task focus. Figure 3.6

shows two participants with several inter-individual differences but at this present moment in time they are not in conflict because their task foci are the same.

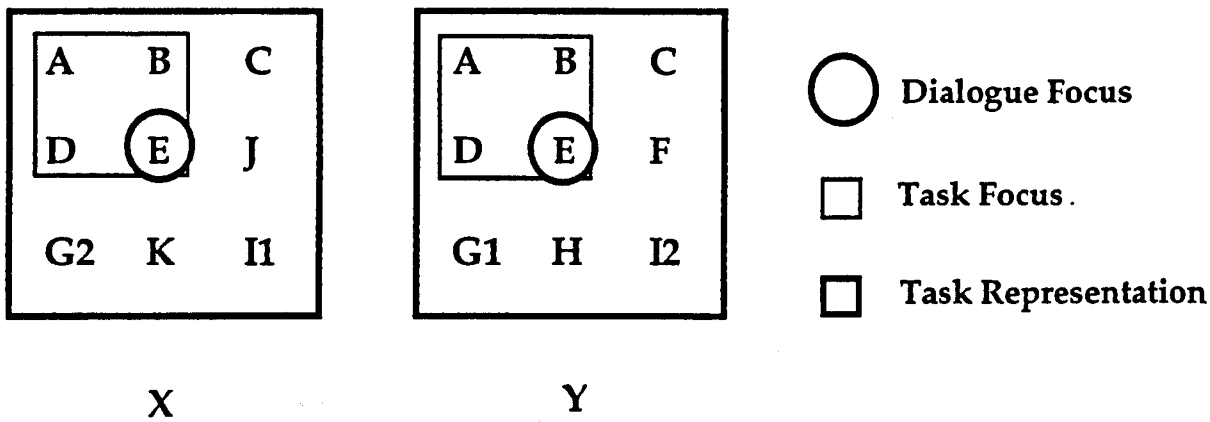


Figure 3.6 Inter-individual differences but no conflict.

3.4 Types of Inter-Individual Differences.

In Chapter 2, I argued that we need to elaborate what an inter-individual conflict is in joint planning. I begin to do that in this section by proposing that conflicts are caused by three different types of inter-individual differences; *task representation differences, task focus differences* and *intersection differences.* These three inter-individual differences are derived from the proposal made in section 3.2.

3.4.1 Task representation differences

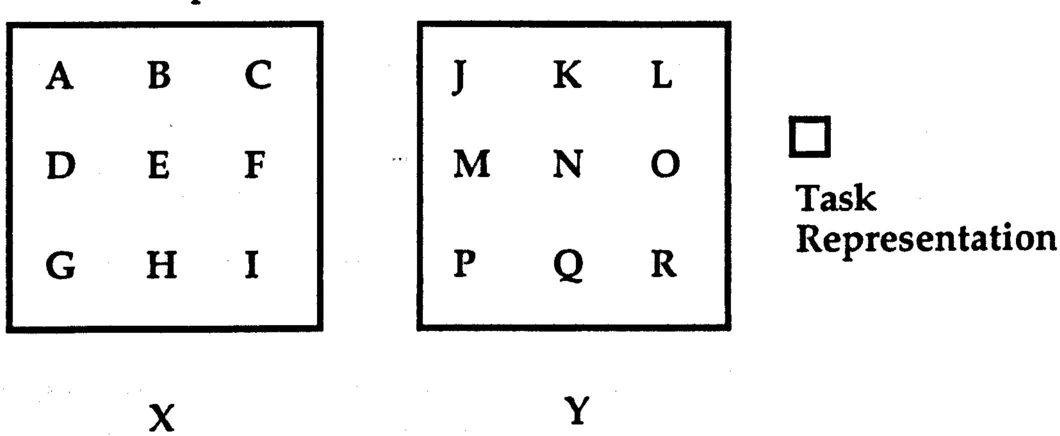


Figure 3.7 : A No Overlap Task Representation Difference.

Task representation differences occur when one participant has a goal, belief or plan, which the other participant does not have in their task representation. There are three different types of task representation difference. However, not all of them can lead to an inter-individual conflict.

The first type of task representation difference is called a "no overlap" difference. An example is shown in Figure 3.7. This is when both participants' task representation are totally different. According to the model, this type of difference will never lead to an inter-individual conflict. Perception of a conflict involves the participants sharing a common dialogue focus. In a "no overlap" task representation difference this is not possible because they have not got anything in common. In fact participants with this difference would find it hard to communicate at all.

Another type of task representation difference is a partial overlap difference. This is when part of X and Y's task representation is the same and part of it is different (i.e. their task representations partly overlap).

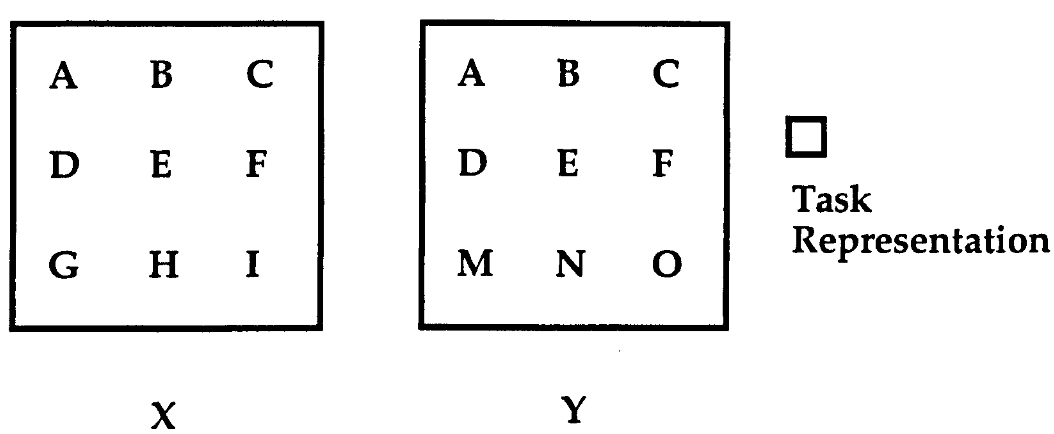


Figure 3.8 : A Partial Overlap Task Representation Difference.

In this example conflicts would arise if one participant needs to refer to G H I or M N O. No conflicts would result if both participants were focused on items A B C D E F.

The final type of task representation difference is a subset difference. (see Figure 3.9). It arises when one participant's task representation is a subset of their partner's.

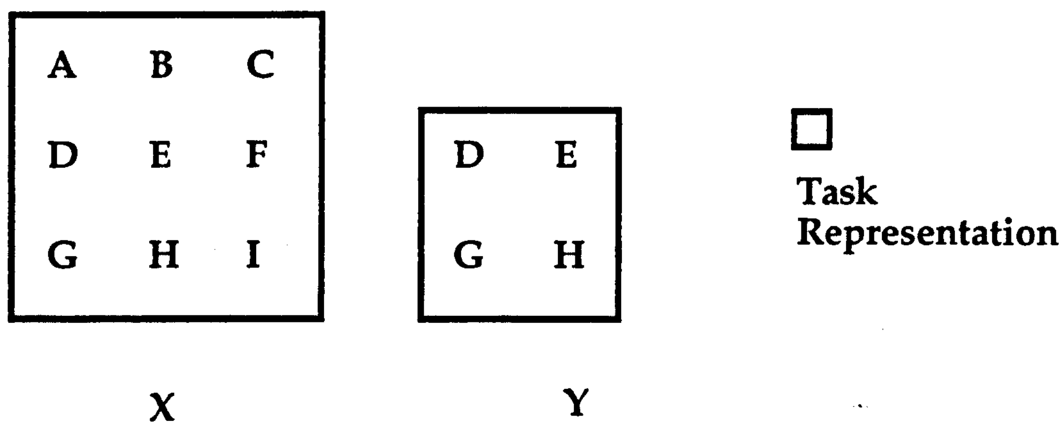


Figure 3.9 : A Subset Task Representation Difference.

Subset differences are often used to describe the difference between teachers and students, with the student knowing a subset of the teacher's knowledge. However, this is often an inaccurate description of student's knowledge, because frequently they have qualitatively different task representations to their teachers. A more accurate description could be a partial overlap or no overlap task representation difference.

3.4.2 Intersection Differences

The term intersection comes from set theory and refers to the overlap between two sets (see Figure 3.10). Intersection differences occur when participants have conflicting or contradictory beliefs about an object in their task focus. In other words, participants disagree in areas of mutual knowledge (i.e. in the area where their knowledge intersects).

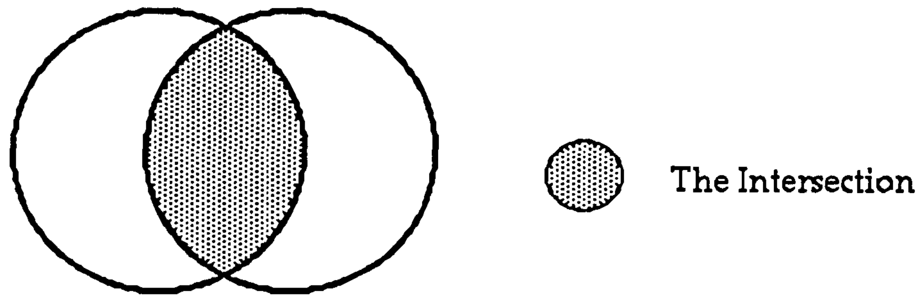


Figure 3.10 An intersection.

There are several different types of intersection difference. Figure 3.11 shows a single intersection difference. This is when participants have contradictory beliefs about an object. For instance in Figure 3.11 the participants have conflicting beliefs about F.

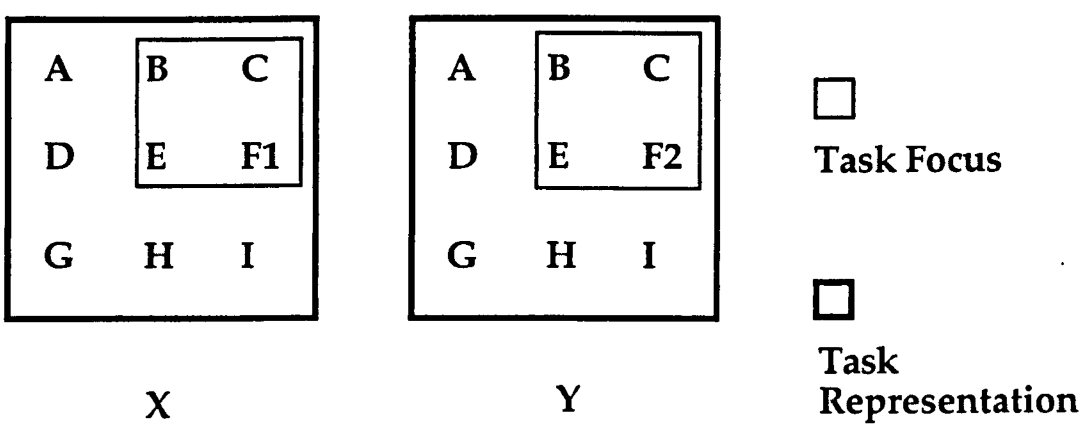


Figure 3.11 A Single Intersection Difference.

A second type of intersection difference is a double intersection difference. This is when both participants have contradictory beliefs in their task representations. Conflicts would arise with this type of difference when both participants had a different (i.e contradictory) belief in their task focus. For example in Figure 3.12, participant X has F1 in their task focus and participant Y has F2 in their task focus. Obviously no conflict would arise if both participants had the same belief in their task focus.

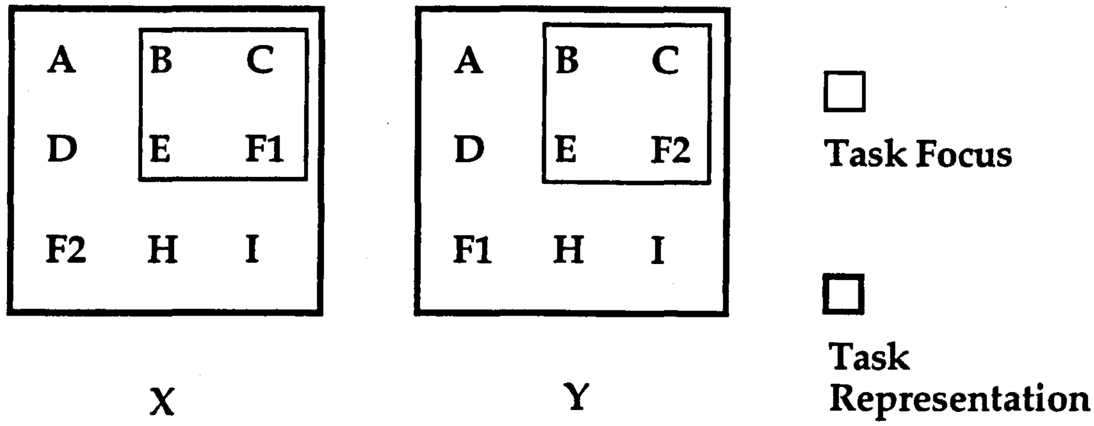


Figure 3.12 An Double Intersection difference.

The third type of intersection difference is a mixed intersection difference. This occurs when one participant has one belief about an object in their task representation and the other participant has contradictory beliefs about that object. For example in Figure 3.13 participant X has two contradictory beliefs about F and Y has only one belief about F.

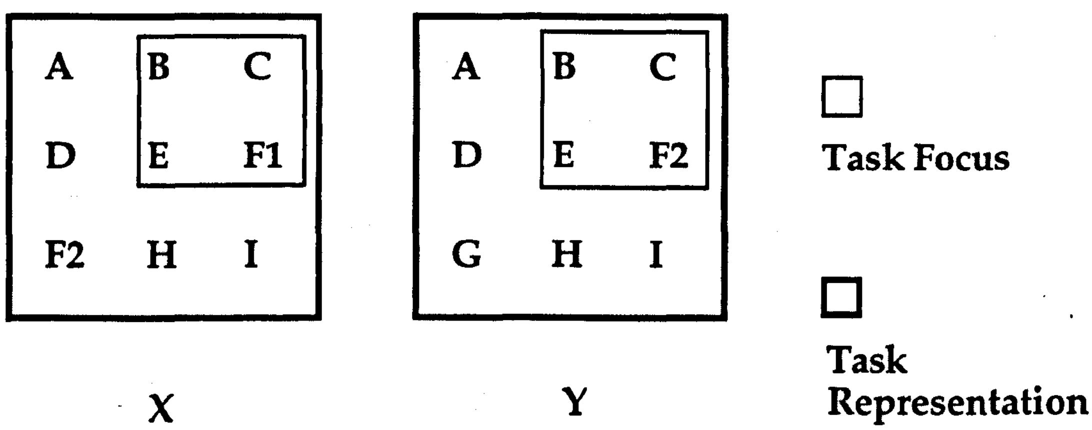


Figure 3.13 A Mixed Intersection Difference.

3.4.3 Task Focus Differences

Task focus differences occur when one participant has a goal, plan or belief in their task focus, which the other participant has in their task representation, but not in their task focus. There are three types of task focus difference. They mirror the three types of task representation difference - i.e. no overlap, subset and partial overlap. The key difference between task focus differences and task representation differences is that task representation differences involve missing knowledge, whereas in task focus differences both participants have the requisite knowledge, but only one of them has it in their task focus.

Figure 3.14 shows a partial overlap task focus difference. In this example participant X has A, B, D and E in their task focus and Y has B C E and F. The common elements in their task focus are B and E.

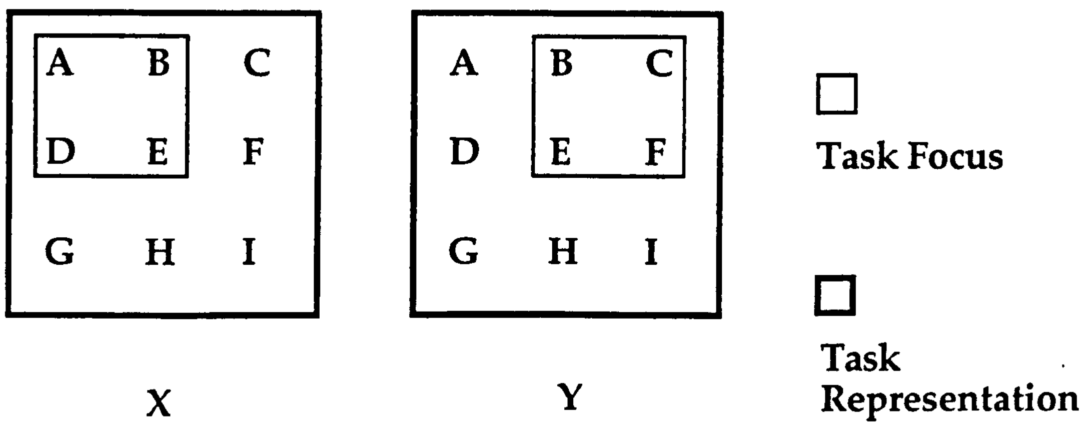


Figure 3.14 A Partial Overlap Task Focus Difference.

Figure 3.15 shows a subset difference, i.e when one participant's task foci is a subset of the other's.

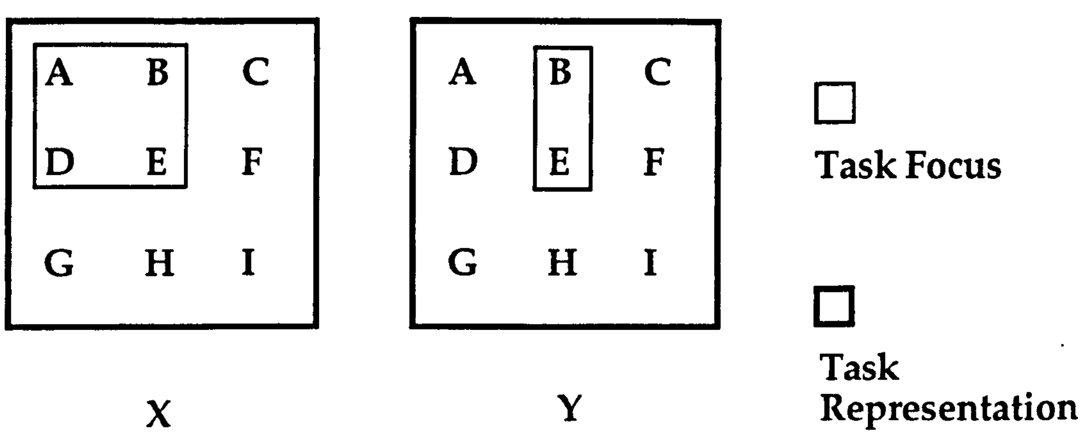


Figure 3.15 A subset task focus difference.

The third type, a no overlap difference, occurs when the participants' task foci do not overlap (see Figure 3.16).

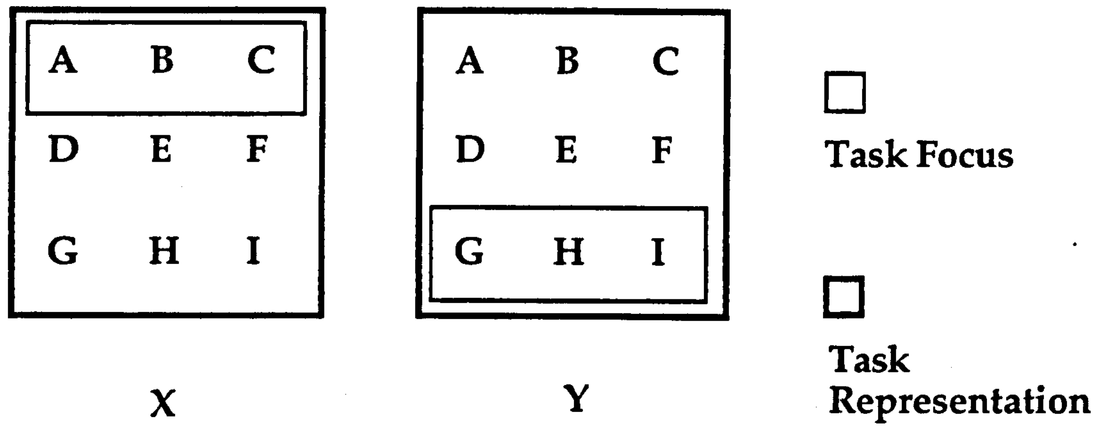


Figure 3.16 No Overlap Task Focus Difference.

This inter-individual difference should not lead to an inter-individual conflict. The model assumes that for participants to perceive a conflict they must share the same dialogue focus and since the dialogue focus is a subset of the task focus, a subset of the task focus must be shared by both participants. In "no overlap" task focus differences this is not the case.

In sum, conflicts are caused by three types of inter-individual differences. Task representation differences involve missing knowledge. They are the result of one person knowing something the other does not. In the case of task focus differences both participants have the requisite knowledge, but one participant does not have it in their task focus. Intersection differences, on the other hand, are the result of participants having conflicting beliefs.

Of course in reality, participants have many inter-individual differences, which can be any combination of the three types proposed.

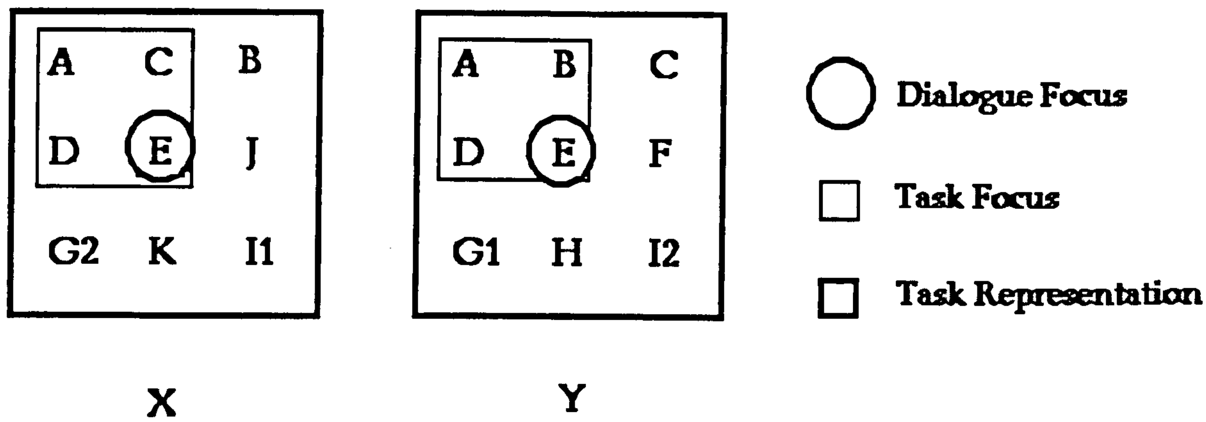


Figure 3.17 A multiple inter-individual difference.

Figure 3.17 shows two participants with all three. They have a partial overlap task focus difference; a partial overlap task representation difference and two intersection differences. These inter-individual differences may turn into conflicts depending on where the dialogue focus shifts next. This is why analysis of the dialogue and the resolution strategies is so important.

3.5 Resolution of Conflicts

In Chapter two, I argued that it is important for the development of computer supported collaborative learning that we begin to understand how conflicts are resolved. In this section, I propose that inter-individual conflicts are resolved by a set of internal resolution procedures and a set of discourse transactions. I will then show how these methods can be used to describe the resolution of the three types of inter-individual differences and how complex disagreements can be modelled as combinations of these three types. Furthermore, I argue that their resolution can facilitate joint planning and subsequent individual planning.

3.5.1 Intra-individual conflicts

Internal resolution procedures are used to resolve intra-individual conflicts which may occur as a result of social interaction. They can be divided into two sets depending on whether the intra-individual conflict is an inconsistency or a contradiction. Inconsistencies are are taken to be instances when there is a belief or goal in a person's task focus which invalidates a proposed plan of action. They may be the result of missing knowledge or because, the person did not have the requisite knowledge in their task focus when the proposal was made. If the person is confident that the belief or goal which is invalidating a proposed plan is true then inconsistencies are resolved by either repairing the plan or rejecting it.

Contradictions are when there are two mutually contradictory beliefs in a person's task focus. Contradictions are resolved internally in several different ways. One method is for the person concerned to accept the belief in which she feels the most confident. Another method, which can be used if the person is equally confident that both beliefs are true, is to search for beliefs which support or contradict one or other of the beliefs. A further method is to ask someone or find information or to try out one or other belief. A fourth method is to coordinate the two beliefs into a framework where the apparent contradiction is resolved. Draper (1987) has proposed that abduction is a process people could use to resolve contradictions (or as he calls them paradoxes).

3.5.2 Inter-individual conflicts

Discourse transactions are used to describe the resolution of inter-individual conflicts. In this model there are five classes of transactions: proposals, challenges, supports, resolves and acceptances. The functions of these transactions are taken from Reichman's work on conversational analysis. The transactions are similar to Litman and Allen's (1987; 1990) discourse plans (see section 3.3). Like discourse plans transactions have a purpose and they affect the discourse focus. However, unlike Litman and Allen, the manner in which these transactions affect the participants' task foci and their task representation is explained.

The first type of transaction is a proposal. In this model a person can make a proposal by proposing a course of action or a belief. The effect of a proposal is to change the dialogue focus and the hearer's task focus to correspond to that proposal. A proposal is accepted if it is consistent with the hearer's new task focus. When a person makes a challenge or support they will also be making a proposal.

The second class of transactions are challenges. These are transactions which if accepted would invalidate a previous proposal. A challenge can be made when one participant has perceived an inter-individual conflict. There are three types of challenges in this model;

i) *Challenge without Explanation* is when someone challenges a proposal by just saying "No" or "don't" without any explanation as to why they think the proposal is invalid. The effect of this challenge is to remove the proposal or active focus space from the discourse focus.

ii) *Challenge with explanation* is when someone challenges a proposal by making another proposal which ,if true, invalidates the previous proposal. The effect of this challenge is to shift the dialogue focus and the challenged person's task focus to the proposed explanation. The challenged person will accept the challenge if her new task focus is consistent with the new dialogue focus. Acceptance of the challenge removes the proposal and the challenge from the discourse focus.

iii) *Challenge with an Alternative* is when someone challenges a proposal with by making another alternative proposal. This is different to challenge with an explanation because its effect is not to invalidate the previous proposal but to propose an alternative to it. The effect of this challenge is to shift the dialogue focus and the challenged person's task focus to the alternative proposal. If the challenged person's new task focus is consistent with the new dialogue focus the challenged person will accept the alternative proposal. Acceptance removes the old proposal from the discourse focus and replaces it with the new proposal.

The third class of transactions are supports. Supports are transactions where one person makes a proposal to justify a previous proposal. They can be made directly after a proposal or directly after a challenge to a proposal. The effect of a support is to change the dialogue focus and the hearer's task focus to correspond to statements made in the support transaction. If the hearer's task focus is consistent with the new dialogue focus then the hearer accepts the support to the proposal.

The fourth class of transactions are resolves. These are transactions which lead to either the challenge being accepted or rejected. They can be made when it is apparent in the discourse to both participants that they hold mutually contradictory views. There are two major types: resolve by coordination and resolve by hypothesis testing.

i) *Resolve by coordination* is when one participant makes a new proposal which coordinates the mutually opposing views into a framework where both are valid. The effect of this transaction is to change the dialogue focus and the hearer's task focus to correspond to the new proposal. If the hearer's task focus is consistent with the new dialogue focus then the hearer accepts the new proposal.

ii) *Resolve by hypothesis testing* is when someone makes a proposal to test the validity of the alternative proposal. This checking can be done by either asking someone; finding some relevant information or by trying out one of the views. The effect of this transaction is to change the dialogue focus to testing the views. The effect of this testing process is the rejection of one or even both views.

The fifth and final class of transactions are acceptances. There are two types of acceptances; agreement and compliance

i) *Agreements* occur when one person accepts another participant's proposal because their task focus is consistent with the dialogue focus (i.e. proposal).

ii) *Compliance* occurs when one person accepts another participant's proposal even when their task focus is not consistent with it. It can occur for several reasons. Firstly, there may not be a way to resolve their disagreement; secondly, there may not be time to resolve it and thirdly the relationship between the participants may inhibit resolution. Doise and Mugny (1984) write that asymmetrical relationships, synonymous with adult-child interaction, lead to compliance on the part of the child because the child thinks the adult knows best. Compliance does not indicate progress.

An important aspect of this model is that these transactions can be nested, allowing for nested challenges and supports. An nested challenge is a challenge which is challenging another challenge. A nested support is a support which is supporting another support. The model also allows for challenges to challenge supports or supports to support challenges. In principle the model allows for an unlimited depth of nesting.

Nesting can occur because, as already reported, often, when someone is making a challenge or a support they can also be making a proposal. Thus just as a proposal can be challenged or supported, a challenge which is also making a proposal (e.g. challenge with explanation and challenge with alternative) can also be challenged or supported. Similarly supports which are also making proposals can also be challenged or in turn supported.

3.5.3 The Resolution of Inter-Individual Differences

In the previous section, I proposed that intra-individual conflicts are resolved by a set of internal resolution procedures and that inter-individual conflicts are resolved by a set of discourse transactions. Next, I will show how these two sets can be used to model the resolution of the three types of inter-individual differences and I will argue that the resolution of each can lead to the facilitation of joint planning and subsequent individual planning. Finally, I will show how complex disagreements can be modelled as combinations of these three types of inter-individual difference.

Before I show how each inter-individual difference is resolved, I have to say that it is not always possible to tell solely from the discourse which of them caused a particular conflict. All three inter-individual differences can be resolved by one participant making a proposal; the other challenging it and this challenge being accepted. In these cases, the only way one can be certain which inter-individual difference caused a particular conflict is to have some knowledge of the participants' task representation beforehand. Information about a person's task representation can be acquired by testing them beforehand.

However, there are other occasions when it is possible to tell, solely from the discourse. Intersection differences are the easiest to identify. They manifest themselves as direct contradictions and they are the only ones, which are resolved by the discourse transaction "resolves". The other two inter-individual differences can also, on occasion, be identified from the discourse. Task focus differences are often resolved by one participant saying "oh yeah" or "of course" indicating they were unaware of something rather than they did not know it. Task representation differences may be resolved by someone saying "is that right" or other statements indicating they did not know something.

3.5.3.1 Task representation differences

Task representation differences can be resolved implicitly, with one participant simply accepting the new plan, goal or belief proposed by their partner. They can also be resolved explicitly and this can occur in several different ways. Take the hypothetical example of two apprentices dismantling an air compressor. In this example A is novice and B is the expert. Also A does not know that the flywheel must be removed before the drive wheel and B does. In the extract below A proposes to remove the drive wheel first. This conflicts with B's belief that the flywheel needs to be removed first and thus B challenges it with the proposal to remove the flywheel first. In this example, A accepts it because, as already mention, she knows that B is the expert and knows more about it than she does.

001	A	: Let's take the drive wheel off first
002	B	: No we've got to take the flywheel off first
003	A	: All right.

The second example shows how this difference is resolved if B had made the proposal first. A challenges this proposal because it conflicts with A's goal to remove the drivewheel first. A accepts the proposal after B supports it with the reasoning behind it, reasons which A did not know about (see line 004).

001	B	: Come on let's remove the flywheel
002	A	: No we have to remove the drive wheel first
003	B	: No, we can't until we remove the flywheel.
004	A	: Oh I didn't know that.

In both these extracts we can assume A's proposal was accepted because A realised B knew what to do and she did not.

The resolution of task representation differences can facilitate joint planning and subsequent individual planning because typically one participant knows something the other does not. If participants know different aspects of the task then joint planning will be particularly effective. The resolution of task representation differences will facilitate individual planning, because one participant has acquired new knowledge about the task. This point is shown in the example below. In this example B learns that you can't remove the drivewheel with the wrench because it will damage it.

001	B	: Pass the wrench so I can remove the drivewheel.
002	A	: No don't use the wrench, use the screwdriver.
003	B	: Why ?
004	A	: 'Cause the wrench will damage the drivewheel.

3.5.3.2 Intersection differences

Intersection differences can be resolved implicitly and explicitly. Implicit resolution occurs when one participant makes a proposal which contradicts the other participant's beliefs. If she then resolves this conflict using the internal resolution procedures for contradictions presented in the previous section and the result is that she agrees with the proposal, then this intersection difference will be implicit and will not appear in the discourse.

Intersection differences can be resolved explicitly in several different ways. In the extract below the two apprentices are trying to decide which size spanner to use. A believes they should use the 2.4 mm spanner and B believes they should use the 2.8 mm spanner. A makes a proposal to use the

2.4 mm spanner; B challenges it because it conflicts with B's belief that they should use the 2.8 mm spanner. A accepts this challenge, possibly because B appears more certain than A.

001	A	: Do we use the 2.4 spanner to remove the set screws ?
002	B	: No the 2.8
003	A	: Oh yeah

Another way of resolving this conflict is illustrated below. In this example A does not accept B's challenge and they resolve it by consulting the manual.

001	A	: Do we use the 2.4 spanner to remove the set : screws ?
002	B	: No the 2.8
003	A	: Are you sure? We'd better check the manual
	[checks in the manual]	
004	A	: No we are both wrong. It's the 3.6 spanner.

This difference could also have been resolved using the other hypothesis strategies or by using coordination.

The resolution of intersection differences can also facilitate joint planning and subsequent individual planning. The example above shows how. In that extract the participants have conflicting beliefs about which size spanner to use. This example shows the participants revising their beliefs about facts in the world, revisions which are both beneficial to joint planning and subsequent individual planning.

3.5.3.3 Task Focus differences

The resolution of Task Focus differences can be modelled using the internal resolution procedures and the discourse transactions proposed in this section. They can be resolved implicitly and explicitly in the discourse.

Implicit resolution occurs when one person makes a proposal which invalidates what the other person is thinking about.

Explicit resolution of task focus differences occur in several different ways. In the example below the two apprentices are trying to remove the drivewheel. A makes a proposal to remove the drivewheel. B challenges this because it conflicts with her goal to remove the flywheel first. A accepts the challenge because it brings into the dialogue focus the goal "remove the flywheel first". A shares this goal and for this reason she accepts the challenge.

001	A	: Let's remove the drivewheel
002	B	: No we have to remove the flywheel first.
003	A	: Oh yeah. Sorry I forgot.

Another way this task focus differences could have been resolved is shown below. B proposes that they remove the flywheel. A challenges it because it conflicts with A's goal "remove the drivewheel". B supports her proposal with the reason for removing the drivewheel first. A accepts the proposal after B supports it, because this brings into the dialogue focus the reason for removing the flywheel first, a reason A shares.

001	B	: Come on let's remove the flywheel
002	A	: No we have to remove the drivewheel first
003	B	: No we can't get to the drivewheel until we
		: remove the flywheel.
004	A	: Oh yeah that's right.

The resolution of task focus difference can make joint planning more efficient and facilitate subsequent individual planning. There are two reasons for this claim. First, individuals can make errors because they did not take the relevant facts into account, as illustrated above. In joint planning these errors can be detected. The example below demonstrates this point. In this example B detected the error in A's proposal (i.e. they could not take the distributor out before they had disconnected the battery).

001	A	: Could you take the distributor out
002	B	: But we haven't disconnected the battery yet
003	A	: Oh yeah.

In joint planning where there are two task foci, there is a higher probability that one or both participants will have the relevant facts to base their decisions on before carrying them out. Detecting errors in a plan before execution saves time and frustration. It saves the time that was taken to carry out the faulty plan and the time taken to detect the error and correct it. Finding the error in a plan once it has been executed is also difficult because it could be located in any of the steps which have already been carried out. Detection is especially difficult for novices because they do not have the prerequisite knowledge about the task to know which steps are likely to be all right and which ones could be faulty.

The second reason why the resolution of task focus differences can lead to more effective joint planning is because of the nature of individual planning. Young and Simon (1987) note that in an unknown and unpredictable world (which is the case when you know very little about a task) it makes little sense to construct a detailed plan before execution. Also constructing such a plan and imagining future states places a heavy demand on working memory. Therefore, they claim, it makes more sense to make a partial or incomplete plan. Plans can be incomplete in one of two ways, either horizontally incomplete if only a few steps of a multi-step plan are specified, or vertically incomplete by not specifying the lower levels of the plan.

Working jointly participants can construct different parts of the plan and therefore overcome the working memory limitations. Through having different task foci participants can spot harmful interactions between different parts of the plan before carrying them out, thus cutting down on the time needed to detect the interaction and correct it.

3.5.3.4 Complex Disagreements

More complex disagreements can be modelled as combinations of the three basic types of differences. Below is a case in point. It is a disagreement which is the result of two inter-individual differences: one intersection difference (lines 001 - 004) and one task focus difference (004-006).

001	A	: let's take the air filter out.
002	B	: does this model have one ?
003	A	: I'm not sure. Let's check the manual
	[checks the manual]	
004	B	: Yes it does, but don't we take the fan belt out first ?
005	A	: We have already
006	B	: Oh yeah

The three basic types of difference can also be embedded deep in a nested challenge. For example, in this example the disagreement in lines 001 to 002 is the result of a task representation difference, which is only apparent when A challenges B's challenge in line 003.

001	B	: Come on let's remove the flywheel
002	A	: No we have to remove the drive wheel first
003	B	: No we can't get to the drivewheel until we
		: remove the flywheel.
004	A	: Yes you can on this model. I'll show you
005	B	: All right

In sum, conflicts caused by the three types of inter-individual differences can be resolved by a set of discourse transactions and a set of internal resolution procedures. Their resolution can facilitate joint planning and subsequent individual planning. More complex disagreements are modelled as combinations of the three basic types of inter-individual difference.

3.6 Discussion and Conclusions

A dialogue model of the resolution of inter-individual conflicts was proposed in this chapter. Focus is an important idea in discourse understanding research and in order to incorporate this idea into the model a crucial distinction had to be made between the dialogue focus; the task focus and the task representation. This distinction was necessary as previous work on focus in discourse assumed participants shared the same task representation, an assumption which is obviously incompatible with any model of the resolution of inter-individual conflicts. The distinction made in the model allows participants to have different task foci and task representations whilst they share a common dialogue focus.

The dialogue model proposed also attempted to overcome the limitations of previous conflict based explanations of the facilitative effect of peer interaction. It was proposed in the model that inter-individual conflicts were caused by three different types of inter-individual difference; task representation differences, intersection differences and task focus differences. It was also shown in the model how these inter-individual differences can be resolved by a set of internal resolution procedures and a set of discourse transactions. More complex disagreements were modelled as a combination of these three differences. The model also explained how the resolution of these inter-individual differences can lead to more effective joint planning and subsequent individual planning.

In this model a number of general propositions were made.

1) The resolution of task representation differences can lead to more effective joint planning and subsequent individual planning.

2) The resolution of intersection differences can lead to more effective joint planning and subsequent individual planning.

3) The resolution of task focus differences can lead to more effective joint planning and subsequent individual planning.

The next three chapters test some of these claims. The first study had two aims. The first was to test whether peer interaction facilitated planning and subsequent individual planning. The second was to use the model proposed in this chapter to investigate that facilitative effect. The second and third experiments investigate the claims derived from the model about task representation differences.

Chapter 4 : The Muksters : an empirical study and analysis of the beneficial effects of peer interaction in a planning task.

4.1 Introduction

In Chapter 2 research on the facilitative effects of peer interaction was reviewed. The resolution of conflicts is a common explanation for this facilitative effect. Chapter 2 concluded that before we can use these conflict based explanations of learning to inform the design of computer supported collaborative learning, we need to understand more about what conflicts are; how they are resolved and how that resolution leads to learning.

In this chapter an experiment is reported which establishes that peer interaction can facilitate planning. The model proposed in Chapter 3 is used, then, to analyse the discourse and identify the conflicts taking place. The model proposes that conflicts are caused by three types of inter individual difference; task representation differences (see 3.4.1), intersection differences (see 3.4.2) and task focus differences (see 3.4.3). Their resolution the model claims, improves individual planning. Thus, the interaction will be examined for evidence of these conflicts and the manner of their resolution, because eventually these would be types of conflict and resolution processes which could be supported in computer based collaborative learning (Joiner 1989; Joiner & Blaye 1989).

The task used in this experiment was a planning task in the form of a computer based adventure game, implemented in Hypercard on the Apple Macintosh. It was presented as an adventure game because as Crook (1987) reports these games tend to promote discussion more than other types of computer based tasks - we need the participants' discussion to provide the dialogue for the study.

In sum, this study had two aims. One aim was to test whether peer interaction facilitates planning and whether this facilitative effect transferred to subsequent individual planning. Thus, this study tested the general proposition P1.

P1 Peer interaction facilitates joint planning and that this facilitative effect transfers to subsequent individual planning.

Two hypotheses can be derived from this general proposition.

H1 pairs plan more effectively than individuals: as measured by the success rate of the subjects.

H2 peer interaction facilitates subsequent individual planning: as measured by the success rate of the subjects on a post test.

The first aim was carried out in collaboration with Agnes Blaye and Paul Light (Blaye, Light, Joiner and Sheldon, 1991)

The second aim of the Muksters study, which is dependent on the first, is to understand more about when and how peer interaction facilitates planning, by using the model to identify critical aspects of the interaction.

4.2 Method

Design

The experiment is a between subjects design. The independent variable was paired vs individual work and the dependent variables were: the number of children who successfully completed the task in the allotted time; how far the children managed to get in the time given and the number of moves they made.

There were two conditions in this experiment, an *Individual condition* and a *Paired condition*. The conditions were matched for gender. In the paired condition the children were put into pairs by their class teacher, who was asked not to pair children who did not get along with each other. There were three sessions. In the first two sessions the children in the *Individual condition* worked on their own, whilst those in the *Paired condition* worked in their pairs. In the final session all the subjects had an individual post test.

Subjects

The subjects (n = 39) in this experiment were all eleven years old (mean 11yrs 4 months SD 3.5 months). They came from two classes of the same school. The school served a mainly working class catchment area. The *Paired condition* contained 26 children (16 girls and 10 boys) and the *Individual condition* contained 13 children (8 girls and 5 boys)

Equipment

The experiment requires two Macintosh SE computers with 20Mb hard disc and a camcorder.

Task

I designed the computer based task in a manner which I thought would lead to a peer facilitation effect. Decisions were made at both the task and interface level to ensure this.

i) The game was a planning task in the form of an adventure game specifically designed by me for this experiment called "The Muksters". The task was also made as highly motivating as possible to encourage discussion, which was needed to produce the dialogue for the study. The more the children actively engage in the task the greater the quality and quantity of the task relevant discussion.

The planning task was made complicated by including lots of interacting subgoals and requiring the children to integrate a lot of information in order to solve it. This was done deliberately because one reason for the beneficial effects of peer interaction is due to the fact that each participant can take into account a partial subset of the relevant information. The integration of these two subsets may be important in facilitating the performance of pairs and therefore subsequent individual performance.

The game was developed in Hypercard (V.1) on an Apple Macintosh SE. The goal of the task was to return the crown [at Fruggle] to the king [at Ashlan] with all the Muksters for a feast. The map of "Mukland" is shown in Figure 4.1. In the game there were four "Muksters" the driver, the captain, the guard and the pilot and they were all initially at Ashlan. There was a car which was also initially at Ashlan. It could take all four Muksters and the crown and could only be driven by the driver on the roads which are marked on the map. There was a plane which was initially at Hushley and could only be flown by the Pilot. It could take the pilot, one other mukster and the crown along the air routes marked on the map. There were two ships one was initially at Brockley and the other was at Crowmarket. They could only be sailed by the captain and on sea routes marked on the map.

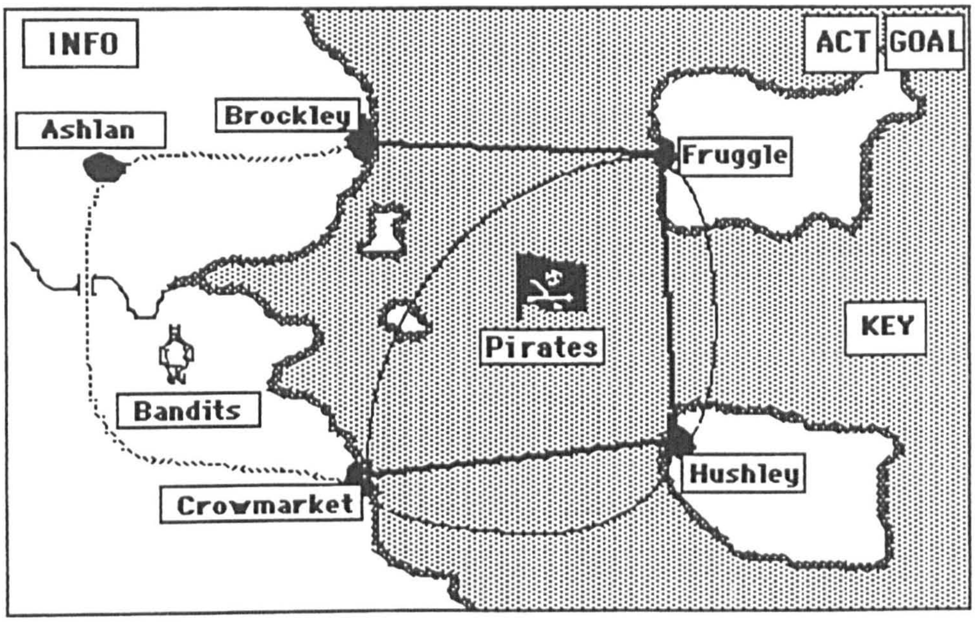


Figure 4.1 The Muksters World.

The task was complicated by the presence of the pirates and the bandits. The pirates would steal the crown if it was on a ship which had the consequence that the crown could only be transported across the sea by using the plane. The bandits would steal the crown if the guard was not present.

The optimal number of moves to solve the problem was 5 because of avoiding the constraint of the pirates. The first move would in fact not be to go to Brockley, but to go in the car with the captain, driver, guard and pilot to Crowmarket. The second move would be to take ship 2 to Hushley with the captain and the pilot. The third move would be to fly to Fruggle with the pilot and the captain to pick up the crown. The fourth move would be to fly back to Crowmarket with the pilot, the captain and the crown. The fifth and final move is to drive to Ashlan with the driver, the captain, the guard, the pilot and the crown.

ii) The Interface was mouse driven. This was preferred over a keyboard driven interface because the children have poor keyboard skills. This would lead to them taking a long time to key in instructions to the computer which could slow down the interaction and limit the discussion, but more importantly it could lead to marked role differentiation which is known to inhibit collaborative learning (Sheingold, Hawkins and Char, 1984; Hoyles and Sutherland, 1989).

When the subjects start the game they were presented with the map (see Figure 4.1). On this map were a number of buttons marked by rectangles. Clicking on the appropriate buttons revealed information concerning the pirates, the bandits and what is at a particular town. Clicking on the "info" button revealed the general information screen which contained more buttons accessing more information (see Figure 4.2). Clicking on the "Goal" button just revealed the goal of the game. Clicking on the "Key" revealed a Key to the map.

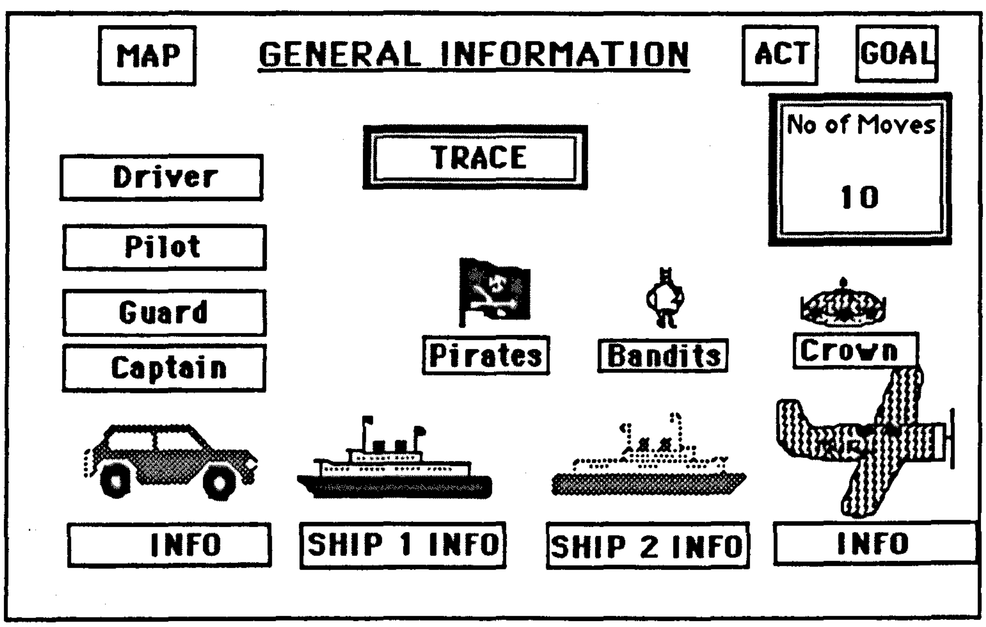


Figure 4.2 Information screen.

Clicking on the "act" button revealed a screen which enabled the children to access other screens to carry out actions with the four different means of transport (see Figure 4.3). For instance, clicking on the car actions revealed the screen shown in Figure 4.4 which allowed the children to move the car and take things on and off the car.

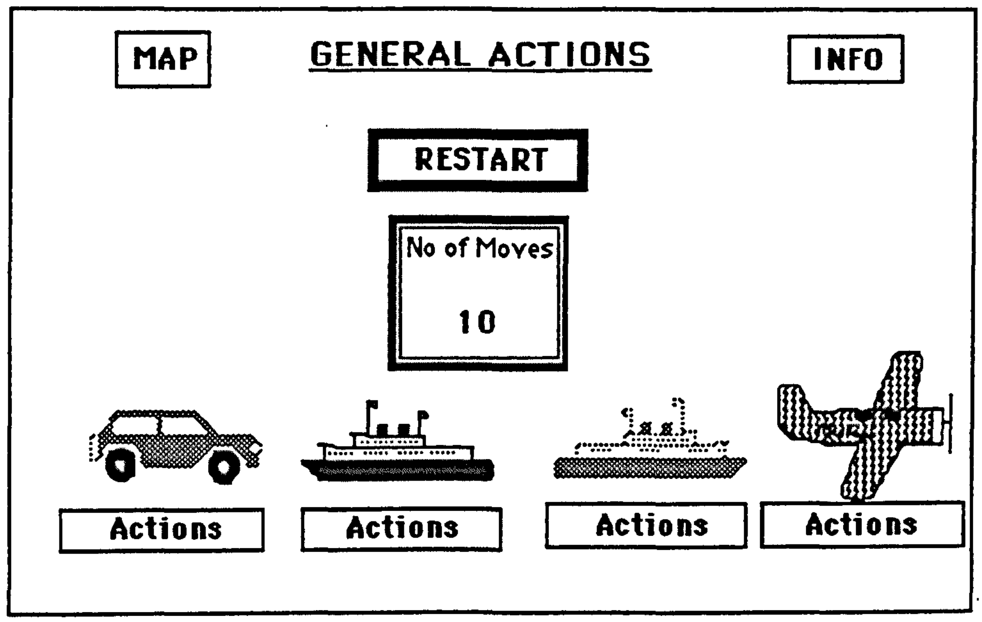


Figure 4.3 General Action card.

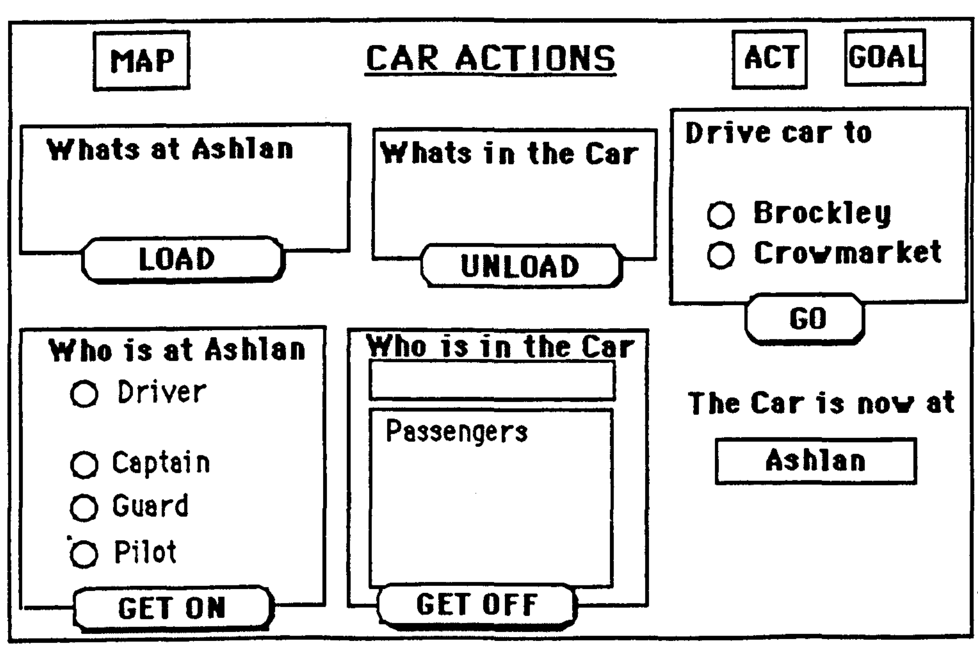


Figure 4.4 Car Action Screen.

After each move all the screens were automatically updated and the moves were recorded in a trace which could be accessed by the subjects. It was also possible to restart the game which resulted in resetting the move counter to zero and the game to its initial state.

Procedure

The children were taken either individually or in pairs to a quiet area of the school [i.e. the library] where an Apple Macintosh SE was set up with a Camcorder. The experimenter was present throughout all the sessions but sat well back from the computer and did not allow herself to be drawn into the game, intervening only in specific pre-defined situations. The children were told the goal from the outset but had to use the computer to obtain relevant information.

In the first session the children were first given some instruction by undertaking a practice task which was a simplified version of the main task. The children were guided through this in a tutorial fashion by the experimenter. The experimenter checked that the children knew how to use the mouse and that clicking on buttons accessed information. During the practice task the children were told how to get people on and off the vehicles and how to load objects onto vehicles. They were also shown what would happen if they tried to carry out an impossible action, the restart and the trace facility, and the move counter. At the end of the practice task the children could ask questions.

After the practice task the children were presented the main task. Before they started they were told that the King lived at Ashlan and he had lost his crown. The children were told they had to give orders to the King's subjects to retrieve the crown and to return with it for a great feast. They were told they only had 30 minutes and not to worry if they did not finish because they would have another go next week. When the children were working in pairs they were told that because there was only one mouse they should take turns and to agree on what they were doing before they did it.

The second session a week later also began with the practice task. The experimenter ensured that the children knew all about all the key features in the task. After the practice task the children were introduced to the main task and were told to complete the task in as few moves as possible trying to better their previous score. They were given 25 minutes to complete the task.

A week later all the children were given an individual post test. The main task was used again but this time the initial location of the people and the transport were different. They were told the goal was the same but also told that "this time the people and the transport are not in the same places as before so you will have to find out where they are before you decide what orders to give." They were further told to get as low as score as possible and given 20 minutes to complete the task.

During the first two sessions videotapes were made of both the individuals and the pairs. The computer also recorded all the moves the children made and the errors they made in all the three sessions for both individuals and pairs.

4.3 Results

4.3.2 Task Performance

The first aim of this study was test whether the same facilitative effects, noted in the literature reported in the previous chapter, are present in a computer based planning task. One of the hypotheses tested was that joint planning was more effective than individual planning as measured by whether the children successfully completed the task in the time allotted and the stage of the game they reach. The success rate of the pairs and the individuals is shown in Figure 4.5.

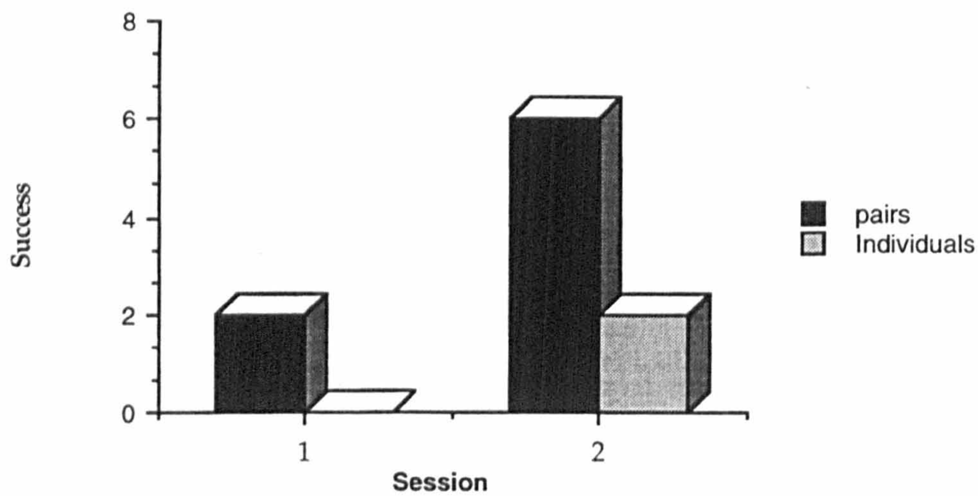


Figure 4.5: Success rate of individuals and pairs in Sessions 1 and 2.

In the first session, none of the children who worked alone succeeded in the time allotted, whilst 2 out of the 13 pairs succeeded. In the second session 2 out of 13 individuals, against 6 out of 13 pairs. The superiority of pairs over individuals in the first session was not significant, but by the second session it was marginally significant (Chi-squared = 2.889, df = 1, $p < 0.09$).

The stage of the game the pairs and the individuals reached is shown in Figure 4.6. All the children in the first session managed to move the car. Seven individuals versus 12 pairs moved the ship. Only one individual versus 8 pairs managed to move the crown, a highly significant difference (Chi-Squared = 8.327 df = 1 $p < 0.01$). In the second session only 3 individuals managed to move the crown against all 13 pairs, again a highly significant difference (Chi-Squared = 16.25 df = 1 $p < 0.001$).

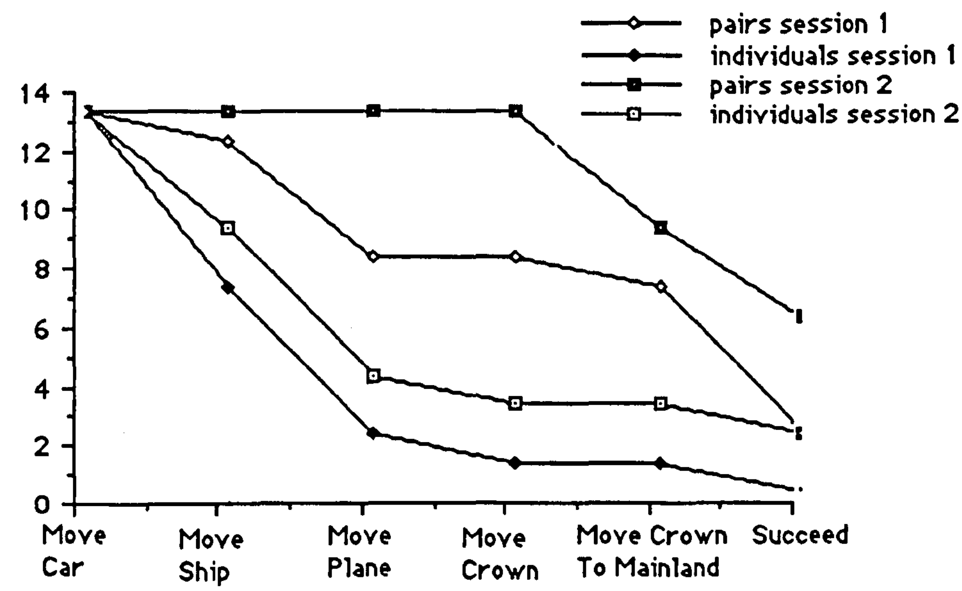


Figure 4.6: The stage of the game reached by the subjects.

The second hypothesis tested was that peer interaction facilitates subsequent individual planning as measured by the subject's success rate on an individual planning. The success rate of subjects in the post test is shown in Figure 4.7

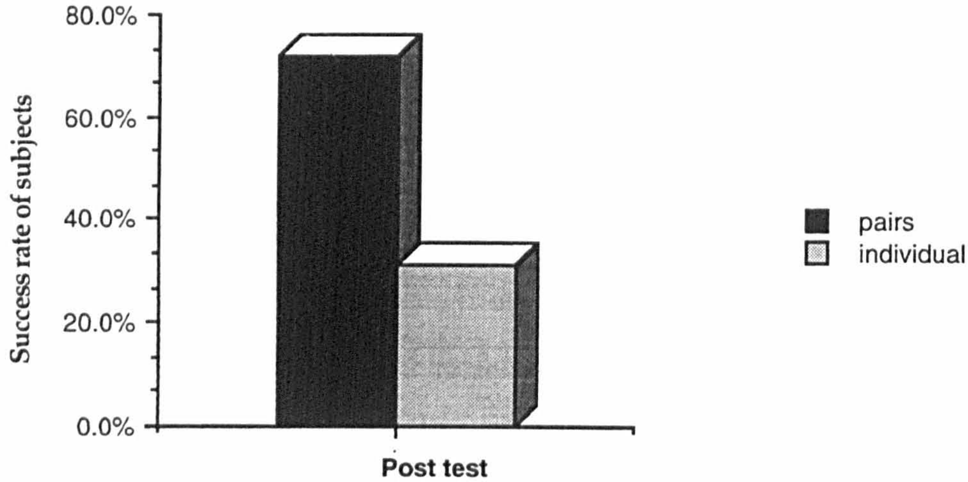


Figure 4.7: Success rate of subjects in the post test.

In the individual post test only 4 out of the 13 subjects in the individual condition succeeded. Of those subjects in the paired condition 18 out of 25 succeeded. The superiority of those subjects who had worked in pairs was significant (Chi-Squared = 5.21, df =1, $p < 0.03$).

Another measure of the children's performance is the number of moves taken by those children who were successful. In the post test the mean score of the individuals who worked in pairs was 11.8 (n = 18), the mean score of the individuals who only worked alone was 14.7 (n = 4). This difference was not significant.

4.3.1 Discourse Analysis

Having demonstrated that peer interaction does facilitate planning, the next step was to begin to understand why these benefits occurred by using the dialogue model proposed in the previous chapter. A preliminary analysis of the discourse from three pairs was undertaken in an effort to identify aspects of the interaction which, according to the model, are important.

The purpose of this analysis was twofold - first to analyse the dialogue itself to establish the absence or presence of intersection differences, task focus differences and the resolution strategies proposed in the dialogue model. Second it was to look at the role which the software played in the collaborative process and eventually to assess what features of the design are important in promoting collaborative work.

The first aim was achieved by examining the interaction for evidence of two conflict situations predicted from the model: inter-individual conflicts caused by *intersection differences* and those inter-individual conflicts caused by *task focus differences*. The model allows for a third conflict situation, which are inter-individual conflicts caused by *task representation differences*. This conflict situation would not arise in this study because the participants were given the same information about the task. Although they may interpret this information differently (i.e. have intersection differences) and have different information in their task foci (i.e. have task focus differences), they will not have different information (i.e. have task representation differences).

Before I present some examples identified in the transcripts, it is first necessary to indicate how these conflict situations will be identified in the discourse. An inter-individual conflict arising from a task focus differences is when, for example, a challenge invalidates another's proposal and is accepted (see 3.43).

A : Lets go to Ashlan to get the car

B : we can't it's at Brockley.

A : Oh yeah.

This is also the way task representation differences are resolved, but in this experiment as I have already explained, task representation differences are unlikely to occur.

Intersection differences are identified in the transcripts when the participants have conflicting beliefs (see 3.4.2). Therefore in the analysis an example was classified as an intersection difference when there was either a direct contradiction or negation.

For example

A : The crown is at Hushley

B : No it's at Fruggle.

In total 35 conflicts were identified (see Table 4.1). The analysis for all of them is reported in Appendix A. Twenty five of them could be successfully explained by the dialogue model (i.e. 71%). Of the remaining 10, 3 were self criticisms; 6 were not interpretable and the remaining one revealed a mistaken assumption in the model. This conflict will be examined later. Seventeen of the inter-individual conflicts were due to task focus differences and 8 were due to intersection differences.

Inter Individual Differences	Pair 1	Pair 2	Pair 3	Total
Intersection Differences	7	1	0	8
Task Focus Difference	4	8	5	17
Unexplainable	4	2	4	10
Total	15	11	10	35

Table 4.1 : Number of Conflicts Identified in transcripts.

Table 4.2 shows that the intersection differences were resolved by the methods proposed in Chapter 3 (see 3.5.4).

Resolution Methods	Pair 1	2	3	Total
Hypothesis testing	6	1	0	7
Coordination	1	0	0	1
Total	7	1	0	8

Table 4.4 : Resolution of Intersection differences.

Hypothesis testing can be broken down further into the different sub-methods. One example of "try it and see" was identified and six examples of "information seek" were identified. No examples of "asking someone" were identified for the simple reason the children were not allowed to ask anybody

In the remainder of this section I will present seven examples of conflict. Each illustrates a different aspect of the model. The first four are examples of intersection differences. The fifth and sixth are examples of task focus differences. The final example is one example not predicted in the model - it is a dialogue focus difference. It was not predicted because in the model it was assumed that each participant shared the same dialogue focus.

The transcript conventions are as follows. Each new line may be interpreted as a new utterance and anything in [ ] is an action carried out by one of the participants.

Example I : Hypothesis testing : information seeking

Example I was one of the four examples of hypothesis testing by information seeking found in the transcripts and is example 1.1 in Appendix A. The participants have not yet made a move. They are at the start of the session and have decided to search for information. The example was classified as a intersection difference because the challenge in line 012 is a direct contradiction (i.e an intersection difference). The participants have conflicting beliefs about how many people the car will take.

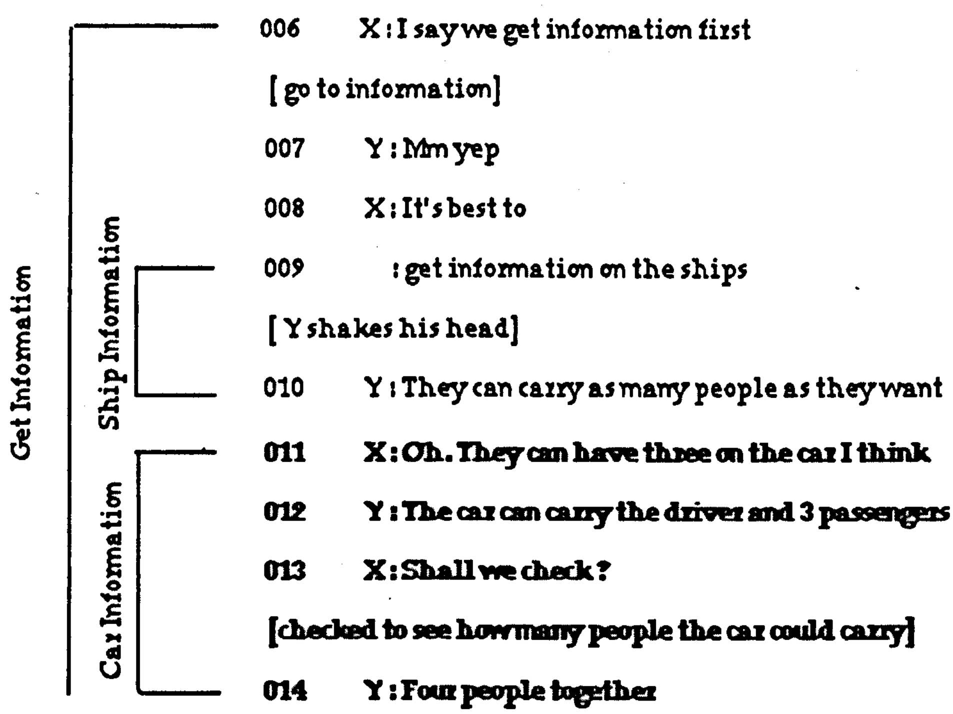


Figure 4.8 shows the dialogue focus at line 011. There are at least two open focus spaces 'Get Information' and 'Car Information'. The active focus space is 'Car information' and there is at least one closed focus space 'Ship 'Information'.

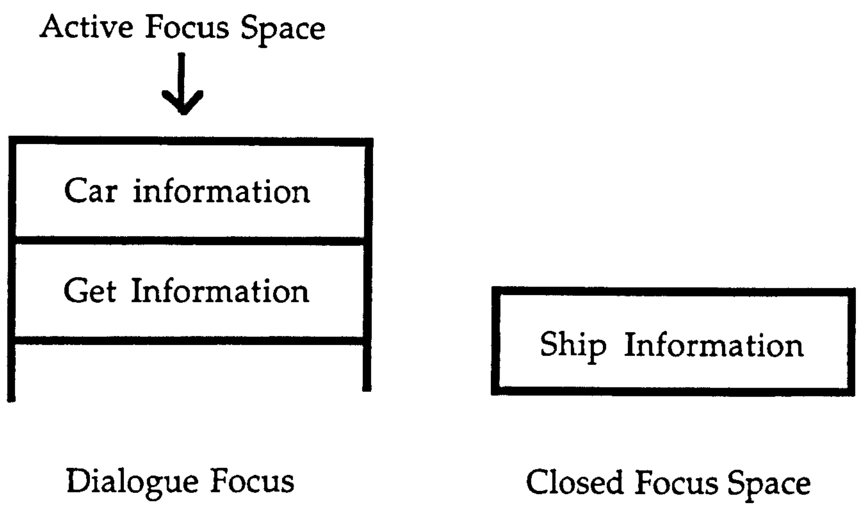


Figure 4.8 Dialogue focus at line 011.

This change in dialogue focus brings into Y's task focus the contradictory belief that the car can carry the driver and 3 passengers. Evidence for this comes from line 013 when X communicates this contradiction to Y. They resolve this conflict by searching for some information (utterance 013) about the car and finding out that the car can take four people.

Example II : Hypothesis testing : try it and see

Example II (1.15 in Appendix A) is the only example of the resolution strategy "try it and see" identified in the transcripts. The participants in this example have nearly finished the game. All they have to do is take everybody back in the car with the crown. It was identified as a intersection difference because the challenge (line 181) is a direct contradiction (i.e an intersection difference). In this example, the participants have conflicting beliefs about how many people will fit into the car. It is resolved by X trying to see how many people she can fit onto the car and finds out she can put everybody on the car.

Go to A in the car

Get Everyone on the Car

180 X: Right then, everybody on

181 Y: We can't fit them all on

182 X: Oh yes we can

[attempts to and succeeds at loading everybody onto the car]

183 : Right then.

X changes the dialogue focus to Figure 4.9 in line 180. The dialogue focus contains at least two focus spaces 'Go to A in the car' and 'Get everyone on the car'. The active focus space is 'Get everyone in the car'.

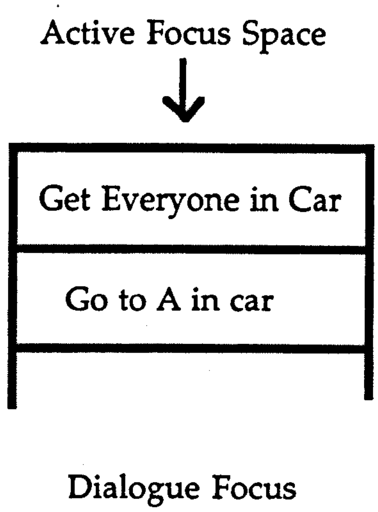


Figure 4.9 The dialogue focus at line 180.

This change in the dialogue focus brings into Y's task focus the contradictory belief that "the car can't take everybody". Evidence for this comes from line 181 when she communicates this belief to X. They resolve this conflict by trying to see how many people they can fit into the car and finding they can fit everybody.

Example III : Coordination

Example III (1.2 in Appendix A) was the only example of resolution by coordination identified in the transcripts. This example is only a few lines on from example 1. The challenge in line 020 is a direct contradiction and therefore this example was classified as an intersection difference. The participants have conflicting beliefs about where they went last time. It is resolved by X coordinating the two beliefs into the belief "that they went to C and had to come back" (line 22).

Get Information

Car Info

015 Y : The crown three passengers and the driver
016 X : The car is at A
017 : we can go to B or C

Go To C

018 Y : C
019 X : We went to C last time
020 Y : The car had to go to B first
021 X : Yes
022 : because we went to C and then had to go back.

In line 018 X changes the dialogue focus to Figure 4.10. There is at least one focus space which is 'Go to C' and this is the active focus space. There are no fewer than two closed focus spaces, which are 'Get information' and 'Car Information'.

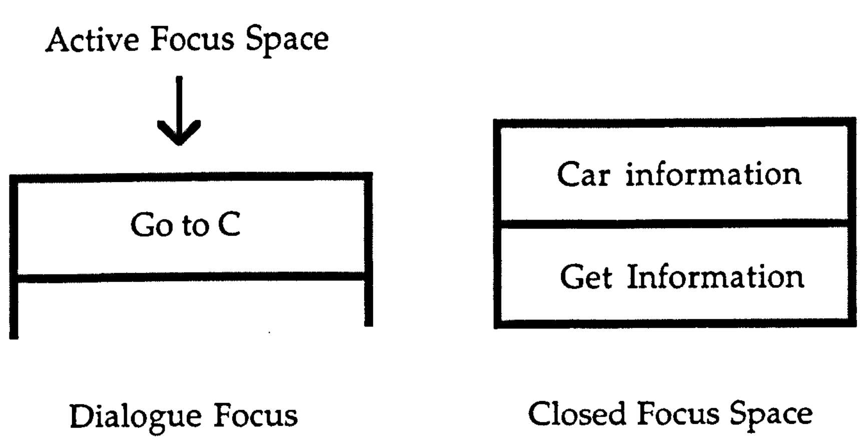


Figure 4.10 The dialogue focus at line 018.

Y changes her task focus to correspond to the change in dialogue focus and finds it conflicts with her belief that "they went to B first". Evidence for this comes from line 022 when she communicates this to X . Y changes her task focus and this reveals she also believed they went to B first. Evident when she says "yes" in line 021. She coordinates this with her first belief that they went to C by claiming "they went to C first and then had to go back" in line 022.

Example IV : Task focus difference

This is example 2.4 in Appendix A. It is a good example of a task focus difference. The children have made their second move which was to transport the guard, the pilot and the driver on ship 1 to F from B. They have just decided to leave the crown at C and are now trying to work out how to do it. Y proposes they use the ship to transport the crown. X challenges this plan in line 053 by saying that the pirates will get them. This challenge brings into Y's task focus the problem of the pirates and because of this she accepts X's challenge. She then goes onto to propose a solution to the problem of the pirates in line 058.

Take Crown to C

044 Y* : Do we leave the crown there ? (F)

045 R : No

046 : we leave the crown at C, remember

047 Y* : C yes

048 : Shall we go down there (C) ?

049 R : is that a plane route ?

Take Crown by Ship

050 Y* : shall we go down there [points to H]

051 : by sea and by sea ?

052 X : OK

[went to card key]

053 : No

054 : but the pirates can get us

055 Y*: Yeah well

056 : If we ...

057 X : Right I know

Take Crown by Plane

058 Y*: we take the guard and the pilot by plane with

: the crown, yes?

059 X : Yeah

Y proposes they use the ship to transport the crown. Although, Y does not explicitly propose this in line 050, I interpret this to be what Y meant because of the previous discussion in lines 044 to 050 regarding where to leave the crown. The dialogue focus at line 050 is shown in figure 4.11. The active focus space is 'go by ship to H' and there is at least one other open focus space which is 'take crown to C'.

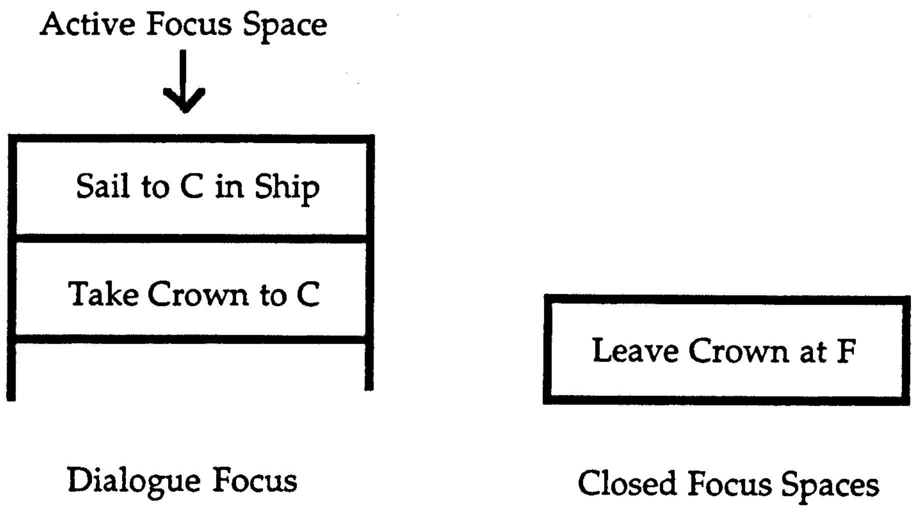


Figure 4.11 Dialogue Focus at Line 050.

Example V : Task Focus Difference

This is example 1.5 in Appendix A and is another example of when one participant detects an error in the other's proposal. The participants in this example have just moved everyone in the car from A to B. Y challenges X's proposal with a belief in line 067 which invalidates X's proposal. X accepts the challenge with an "oh yeah" in line 069. This acceptance appears to signify that she also knew that the pirates would not attack them in the plane. In terms of the model this would be interpreted as a task focus difference because both participants had the belief that "pirates can't attack planes" but only Y had it in her task focus when X made the proposal.

We need who off the car

Pilot and Captain

060 Y : Right then we need who off the car ?

063 : the pilot and the captain I think

064 X : The pilot

065 Y : And the captain I think

Guard

066 **X : Take the guard with us for the plane**

067 **Y : No because no one can attack us up there.**

068 **: anyway we'll take**

069 **X : Oh yeah**

X proposes they take the guard on the plane in line 066. The reason for this is to protect the crown from the pirates, although this is never said. The dialogue focus at line 066 is shown in figure 4.12. The active focus space is 'get guard off'. There is one closed focus space, which is 'Get Pilot and Captain off"

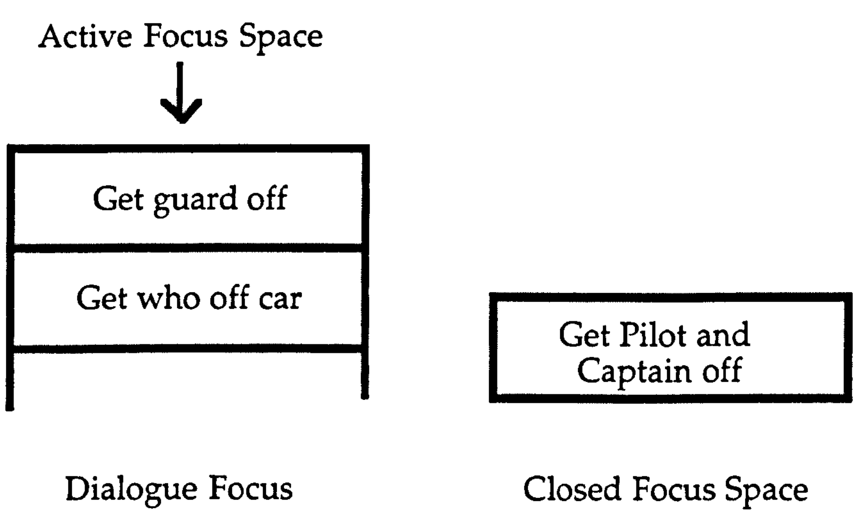
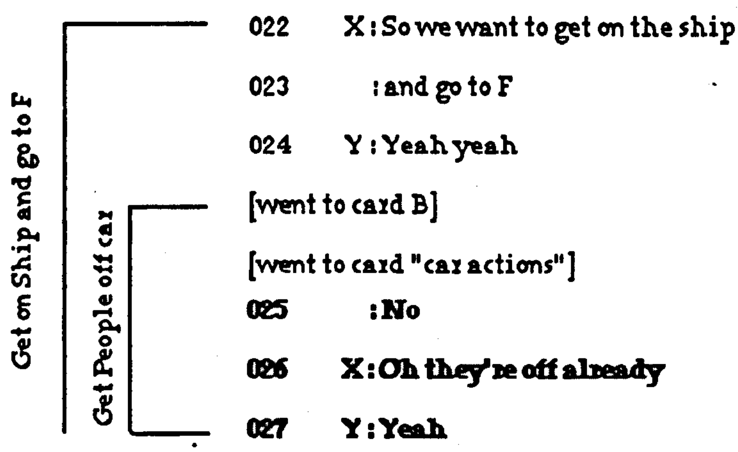


Figure 4.12. The dialogue focus at line 066.

When X changes the dialogue focus to Figure 4.12, Y shifts her task focus accordingly to reveal her belief that the pirates can't attack them in the plane and therefore there is no need to take the guard. Evidence for this comes from line 67 when Y challenges X's proposal. X changes her task focus to correspond with Y's challenge. This change reveals her belief that the pirates can't attack the plane and she therefore accepts X's challenge that there is no need to take the guard on the plane, as evidenced in line 069.

Example VI : Task Focus Difference

This is example 2.2 in Appendix A and is the third example of a task focus difference found in the transcripts. It is just after the start of the session and the participants have just taken the captain, guard, pilot and driver in the car to B. The people are off the car and they have now decided to get them on the ship. The disagreement is over whether they should get the people off the car first.



X decides to take everybody on the ship, as indicated in line 022. X then decides to get everyone off the car first, as shown when she goes to car actions. This action changes the dialogue focus to Figure 4.13. There are two focus spaces 'get everyone on the ship' and 'get everyone off the car'.

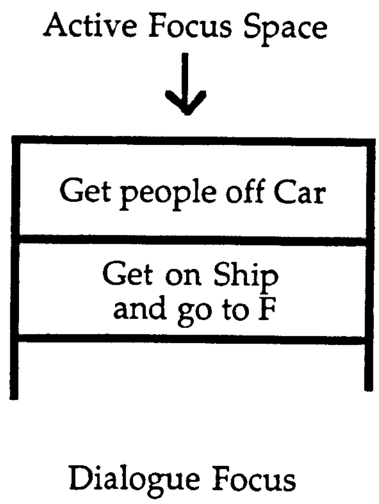
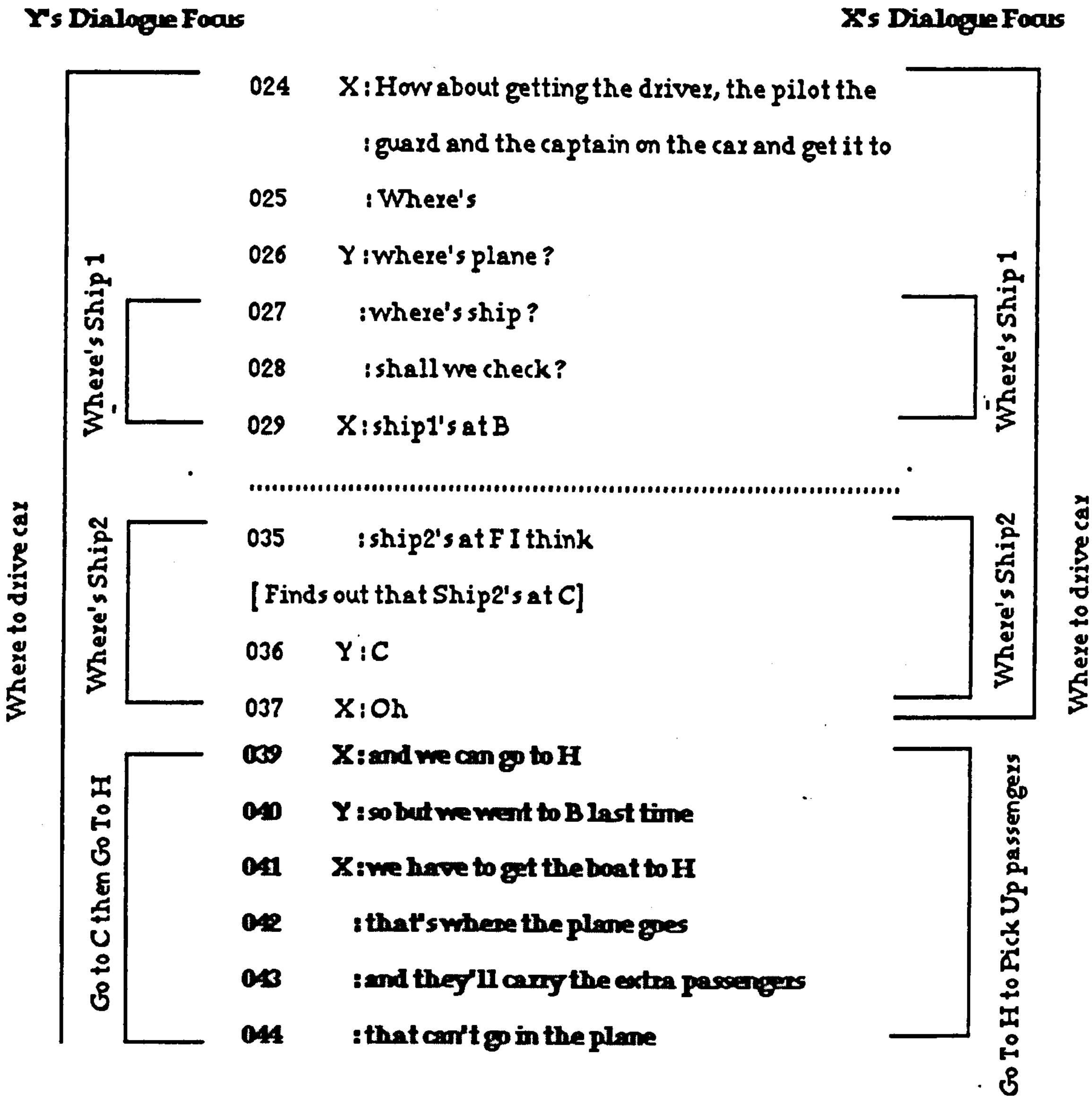


Figure 4.13 The dialogue focus at line 025.

Y follows this change in the dialogue focus, but it reveals the inconsistent belief that everyone is off the car and so there is no need to take the people off the car. The evidence for this is in line 025 and from X's explanation of Y's challenge in line 026. Y does not indicate why she disagrees with X but it makes X search for an explanation (i.e. change her task focus) This search reveals her belief that everybody is off the car and therefore she accepts Y's challenge. Evidence for this comes from line 026.

Example VII : Dialogue Focus Difference

Example VII is example 1.4 in Appendix A. It revealed a mistaken assumption in the model, where it was assumed that the participants shared the same dialogue focus. It is an example of an inter-individual conflict which was the result of the participants having different dialogue foci. In this example the children are at the start of the game and are trying to decide where to go when they realise they do not have enough information. The disagreement (marked in bold) is about whether they should go to H.



X changes the dialogue focus to "and we can go to H" in line 039. Y's perception of the new dialogue focus is shown in Figure 4.14. She perceives the dialogue focus as having at least two focus spaces. The active focus space is the proposal "to go to C from A and then go to H".

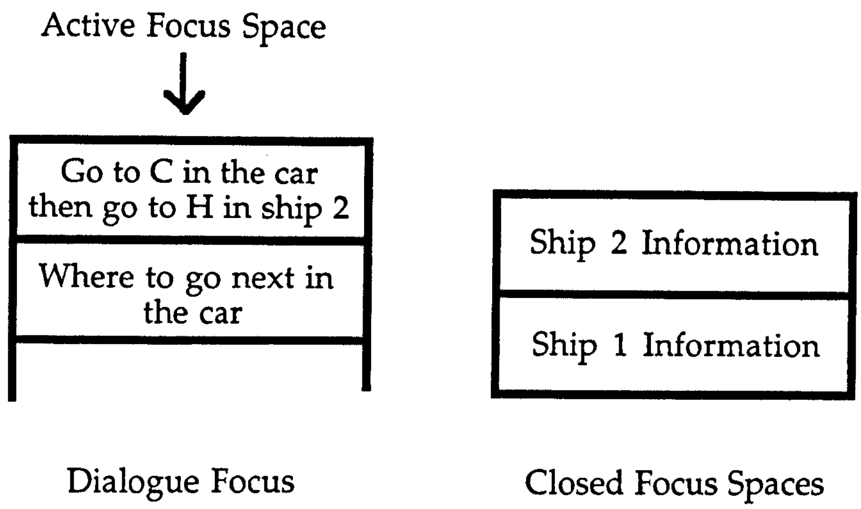


Figure 4.14 : Y's Dialogue Focus at line 039.

Y changes her dialogue focus to Figure 4.14. after X's proposal in line 039. It has at least two focus spaces and Y perceives the active focus space as the proposal "to go to C from A and then go to H". The reason for this interpretation is because she is following the maxim that at any point in the discourse only one part of the speaker's plan will be in focus and, unless explicitly stated, subsequent utterances will be related to that part. The part of the plan in focus before utterance 039 was "where are they to drive the car". If this utterance is related to that plan then X must be proposing that they go to C in the car and then take ship 2 to H.

Y changes her task focus to correspond to her perception of the new dialogue focus and this reveals the inconsistent belief that they did not go to C from A last time. Evidence for this interpretation comes from the challenge in line 040.

However Y's perception of the dialogue focus was not what X intended. X was not proposing they should go to C from A and then go to H. She was not making a proposal which was related to the plan "where do they drive the car" which was what Y thought she was doing. A quite reasonable interpretation considering that X had not explicitly marked the complete change in the dialogue focus (see Figure 4.15).

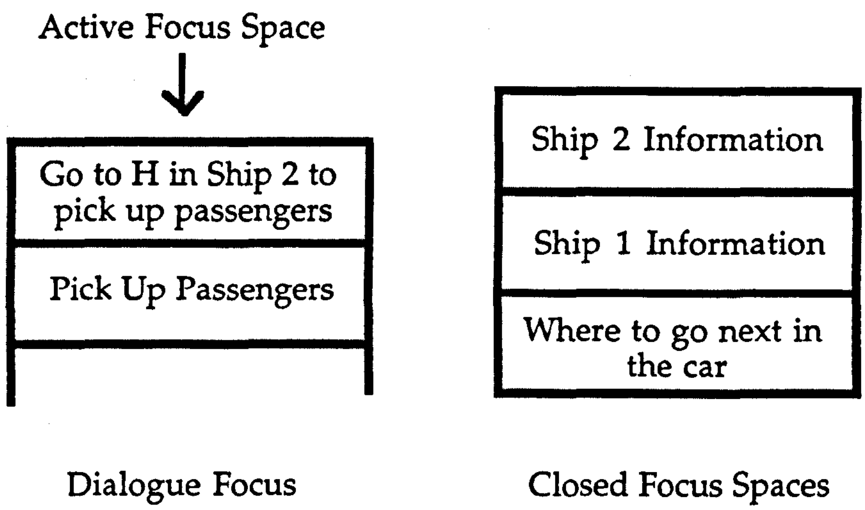


Figure 4.15 X's dialogue focus in line 039.

X's intended dialogue focus had two focus spaces and she had closed the focus space 'where to go in the car'. The active focus space was 'that they go to H to carry the extra passengers which can't go in the plane'. Evidence for this interpretation comes from lines 42-45 when she says that they will use Ship 2 to go to H and carry the extra passengers which cannot go in the plane.

4.4 Discussion

One of the aims of the model proposed in the previous chapter was to understand the nature of conflicts in a planning task and begin to explain why, in certain circumstances, they might facilitate individual planning. The first step of the experiment reported in this chapter was to demonstrate that peer interaction was beneficial. This study showed that pairs were twice as likely to succeed as individuals. Furthermore in the second session 12/13 pairs moved the crown compared to only one individual. Joint planning was also found to facilitate subsequent individual planning On the individual post test those subjects who had worked in a pair were again twice as likely to succeed as subjects who had only worked alone.

Having demonstrated the beneficial effects of peer interaction, the next step was to begin to understand when and how it facilitates individual planning, by using the model proposed in the previous chapter to identify key aspects of the interaction. In the model, I propose that conflicts arise because of three types of inter-individual difference; task representation differences, intersection differences and task focus differences and that their resolution can in certain circumstances facilitate subsequent individual planning. This study investigated two conflict situations. Those which are caused by intersection differences and those which are caused by task focus differences. The third conflict situation (i.e. conflicts which are the result of task representation differences) was not investigated in this study because of methodological reasons discussed in section 4.3.2. It is examined in later experiments

Using the model several intersection differences and a number of task focus differences were identified, with twice as many task focus differences as intersection differences. A possible reason for the small number of intersection differences identified in this study is because the participants always stayed in the same pairs and therefore had similar experiences.

All the methods for resolving conflicts proposed in the model were identified, except for "resolution by asking someone" which was not present due to experimental restrictions. However, one critical conflict revealed the possibility of dialogue focus differences. The model cannot account for this because it assumes both participants share the same dialogue focus. This difference and its significance are discussed in the conclusion.

In the dialogue model proposed in Chapter 3 I claimed that the resolution of intersection differences facilitates individual planning. The examples of intersection differences reported in section 4.5 support this claim. The first two examples are resolved by Hypothesis testing, which results in one or both of the participants changing their beliefs about the world. The next example of a intersection differences was resolved by coordination, which also results in one of the participants changing their beliefs about the world. The reliability of this last method is dependent on the belief which is accepted. If it is ill-founded these methods can have regressive effects as shown by Tudge (1985, 1989, 1992).

Before moving on to discuss task focus differences it is interesting to return to resolution by hypothesis testing. Example III clearly indicates how dependent it is on the task environment. In example III the disagreement is over where they went last time. It is a disagreement which can not be resolved by hypothesis testing because the information about where they went last time was not available to them. This is an important point and is discussed later in the implications for the design of computer supported collaborative learning reported in the conclusions.

In the model it was claimed that the resolution of task focus differences facilitates individual planning. Examples IV, V and VI lend some support to this claim. In examples IV and V one participant detects a problem in the proposal of the other. In example VI one participant detects the other participant making a slip. Detection of problems before execution it is claimed from the model is both a benefit to joint planning and subsequent individual planning.

The final example of inter-individual conflict is an example of a dialogue focus difference. It is interesting because it revealed the possibility of participants having different dialogue foci, a possibility the model did not account for because it assumed the participants shared the same the dialogue focus.

Chapter 5 : The Shmuksters : an empirical study investigating the resolution of task representation differences using distributed learning environments.

5.1 Introduction

The last chapter reported that peer interaction facilitated both planning and subsequent individual planning on a computer based planning task. The model proposed in Chapter 3 was then used to investigate the interaction to identify points in the interaction, which according to the model might be responsible for this facilitative effect. The model proposes that conflicts are caused by three types of inter-individual difference; intersection differences, task focus differences and Task representation differences (see section 3.4). The resolution of all three, the model claims, facilitates individual planning (see section 3.6). Three types of conflict situation were identified in the interaction. Most were the result of task focus differences, some were the result of intersection differences and one, which was not predicted in the model, was the result of a dialogue focus difference. No conflict situations were identified which were the result of Task representation differences because of the experimental design employed. Evidence was reported which supported the claim made in the model that the resolution of task focus differences and task representation differences benefits individual planning. This chapter reports an experiment which investigates the third conflict situation described in the model (i.e. conflicts caused by task representation differences) and seeks further evidence of dialogue focus differences .

In section 3.2.3 a participant's task representation was defined as the goals, beliefs and plans a participant has about a task. A <u>task representation difference</u> occurs when one participant has a goal belief or plan which the other does not have. An inter-individual conflict is the result of a task representation difference, if participants have a shared dialogue focus and the difference in task representation occurs in the task focus.

To test the proposition made in the model that the resolution of task representation differences facilitates planning, a computer environment was designed to engender these differences by forcing the participants to adopt inter-dependent roles and providing them only with information relevant to those roles (Joiner 1992). Thus a task representation difference in the context of this experiment occurred because one participant had a piece of information their partner did not.

Roles are inter-dependent when decisions require input from both roles. Examples are the driver-navigator roles observed by Blaye et al., (1991). They observed that in some pairs one participant would carry out the actions and the other would criticise and provide the relevant information. Inter-dependency is important because participants will share in the decision making, which will result in them having a shared dialogue focus. This is a prerequisite of conflicts which are the result of task representation differences (see section 3.3)

The roles chosen to engender task representation differences in a new version of the Muksters (called the Shmuksters) were the guard and driver roles from the Muksters. The role of the guard was to protect the Muksters and the crown. The participant who was the guard had access to information which was only relevant to the guard (e.g. information about the pirates). The role of the driver was to deliver the Muksters and the crown. The participant who had this role only had access to information relevant to the guard (e.g. information about the transport). In the Muksters these roles were inter-dependent because in order to protect the crown it was sometimes necessary to take alternative transport to go round obstacles (e.g. the pirates).

In sum, this experiment had two aims. The first aim was to investigate the proposition below,

P1 The resolution of task representation differences can lead to more effective joint planning and subsequent individual planning.

by testing the following hypotheses,

H1 Pairs forced to adopt the guard-driver roles in the Shmuksters will be more effective at joint planning. This will be reflected in their success rate and for those who succeed in the number of moves they take.

H2 Pairs forced to adopt the guard-driver roles in the Shmuksters will be more effective at subsequent individual planning. This will be apparent in their success rate and for those who succeed in the number of moves they take.

These hypotheses are based on the following premise

p1 Subjects who are forced to adopt the driver guard roles will have more task representation differences as evidenced by their greater propensity to introduce role specific information into the conversation.

The second aim of this experiment was to examine the interaction for further evidence of dialogue focus differences and their resolution.

5.2 Method

Design

The experiment employed a between subjects design. The independent variable was using a piece of software which supported a certain type of role division versus using a piece of software which did not. The dependent variables were the number of children who successfully completed the task in the allotted time; how far the children managed to get in the time given and the number of moves they made.

There were two conditions in the experiment, a *role division* condition and a *control* condition. Children in the role division condition used a computer environment which enforced a certain type of role division. This environment it was argued in the introduction should lead to more task representation differences. Children in the control condition used a computer environment which did not enforce any type of role division.

There were two sessions in the experiment; an *experimental session* and a *individual post test.* In the experimental session the children worked in pairs. Children were paired with their "response partner". Response partners were partners who wanted to be together and worked well together. It was a strategy used by the teacher to support collaborative work in the classroom. It resulted in same sex and same ability pairs. The second session was an individual post test

Subjects

The subjects (n = 30) in this experiment were all aged between 11 and 12. They came from one class in a school serving a mixed catchment area. The *Role Division condition* contained 14 children (6 boys and 8 girls) and the *control condition* contained (8 girls and 8 boys)

Equipment

The experiment requires two Apple Macintosh SE computers with 2 Mb RAM and 20 MB hard disk, as well as an audio tape recorder with an external microphone.

Procedure

In the *experimental session* the children were taken in pairs to a quiet area of the school, where two Apple Macintosh SE computers were set up along with an audio tape recorder and an external microphone. Each child was assigned a computer which they were told only they were allowed to control. They were also told to work together and inform each other when they were going to make a move.

The children were then familiarised with the program interface by attempting two practice tasks. These were simplified versions of the main task. At this stage the computers were set up to allow the children to see each other's screens (see Figure 5.1).

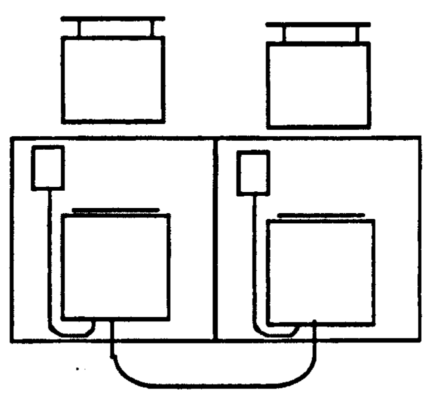


Figure 5.1 : Arrangement of computers in practice task.

During this phase the children were shown how to access information and how to carry out actions. Children in the *Role division* condition were randomly assigned a role and were shown the role specific information they had access to and the role specific actions they could carry out. At the end of the practice tasks the children were allowed to ask questions.

After the practice tasks, approximately 15 minutes later, the children attempted the experimental task. They were allowed 30 minutes to complete the task. In the experimental task the computers were set up to prevent the children seeing each other's screens whilst still allowing them to see each other (see Figure 5.2). Before the children started they were told that the king lived at Aran and had been given a statue by his brother and that they had 30 minutes to get the two robots to collect the statue and return it to the King. They were reminded to work together and inform each other when they were going to make a move. During the session the children could ask for help if they were having problems with the interface and the experimenter would also intervene if they were having difficulties with the interface.

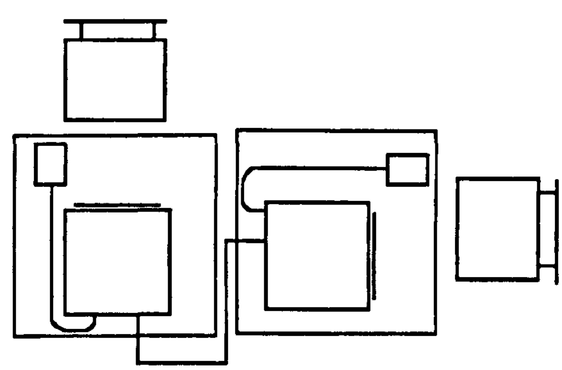


Figure 5.2 : Arrangement of computers in experimental task.

The *individual post test* was a week later. The main task was used but this time the initial location of the robots and their vehicles had been moved. The children were given 30 minutes to complete the task and they were told that the robots and vehicles were not in the same place as before.

Tasks

In the *experimental session* the children used a task set in an imaginary world shown in Figure 5.3. The goal was to get the statue, which is at "Croft" to the king, who is at Aran. To achieve this the children have two robots (a driver and a guard) and two vehicles (a jeep and a truck). The guard protects the robots from the Bandits and loads and unloads the "statue" from the vehicles. The driver can drive either of the two vehicles available. The truck can only go along the roads and the jeep can only go along the tracks. Initially the robots and the truck are at Aran and the jeep is at Dunn.

The presence of the Dragon (marked on the map) and the Bridge makes the task complex. The Dragon will eat the statue if the children take it in the Truck anywhere from "Croft". The implication of this is that it is necessary to use the jeep to get past the Dragon. The Bridge (on the track between Croft and Brock) cannot take the weight of the statue. The consequence of this is that the truck has to take the statue to Aran once the children have got the statue passed the Dragon. The final obstacle is the bandits who will attack people travelling through the "Badlands" unless the guard is travelling with them.

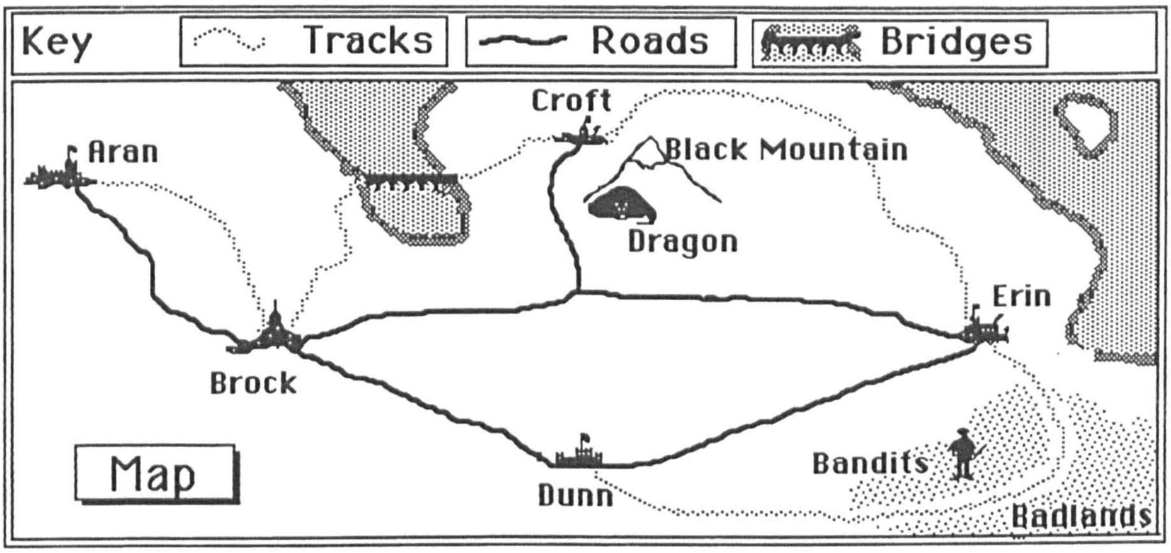


Figure 5.3 : Experimental Task.

Due to these obstacle the obvious route to go directly to "Croft" and pick up the statue and return will not succeed. The optimal route is to take the Truck with the Guard and the Driver to "Dunn" via "Brock" and transfer to the Jeep. The next stage is to take the jeep to Croft via "Erin" and pick up the statue and return to "Dunn" via "Erin", to transfer the statue and the Robots back onto the Truck and return to "Aran". In total there are 8 moves in the optimal route

In the *Post Test* the goal remained the same but the people locations and the vehicles locations were different. The guard, the driver, the truck and the statue were at Croft, whilst the jeep was at Aran. Although appearing simpler the task is actually more complicated and the optimal route takes 14 moves. The route consists of going to Aran in the truck with the guard and the driver via Brock to pick up the jeep. Go back to Croft in the jeep to pick up the statue and then go to Erin to drop the statue off. Return back to Aran via Croft and Brock in the jeep and transfer to the truck. Once everything is on the truck return to Erin via Brock and Dunn, pick up the statue and go back to Aran via Dunn and Brock.

Computer Environments

Two computer environments were built for this experiment both in Hypercard, one for each condition. Children in the *Role division condition* used an environment which tried to engender task representation differences by distributing the roles of guard and driver between the two computers. One computer controlled the guard and the other controlled the driver. Children using the computer that controlled the guard could get the guard on and off either vehicle and load the statue on either of the vehicles. Figure 5.4 shows the action card at the start of the game for the guard. Only black buttons are actions which can be carried out immediately. White buttons are actions which can not be carried out in this particular state of the game (i.e the action "get on jeep" can not be carried out because the jeep and the guard are at different locations).

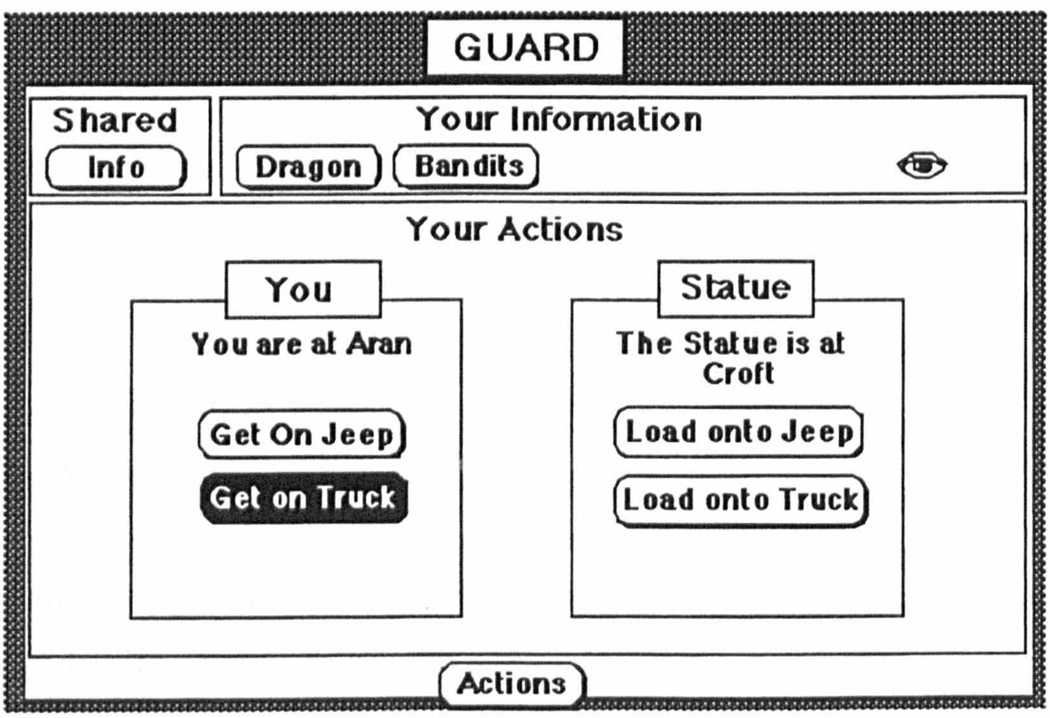


Figure 5.4 Action Card in Role Division Condition.

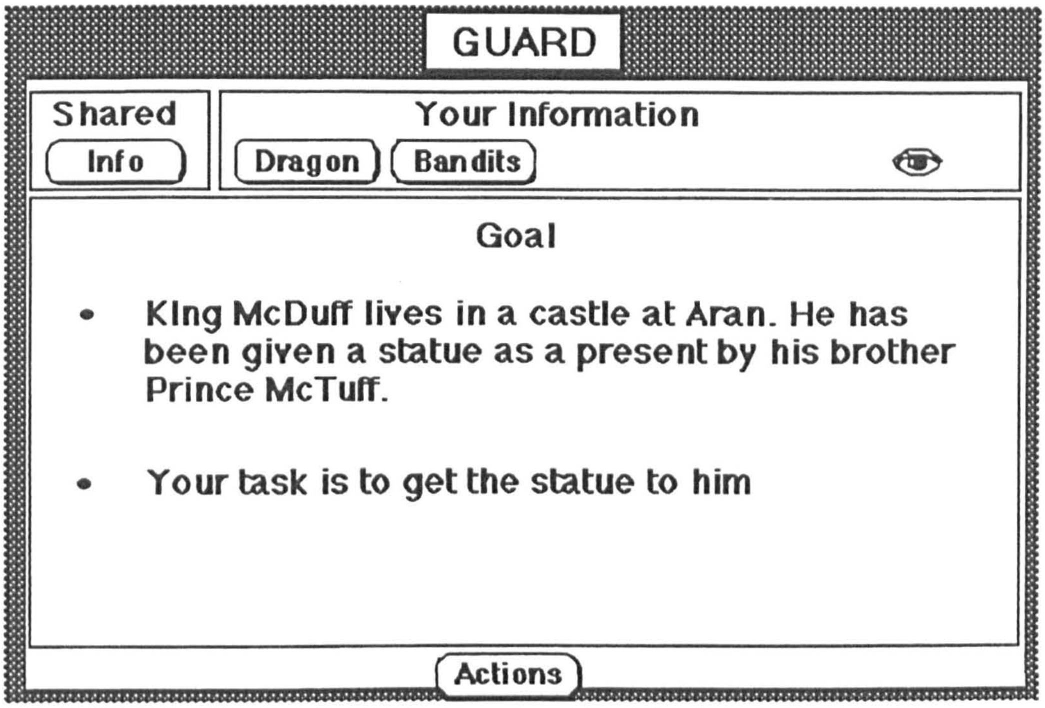


Figure 5.5 Goal Card in Role Division Condition.

They could also access general information by clicking on Info which reveals a pop-up menu giving access to other information - such as the goal card (see Figure 5.5). They can also access information relevant to the guard, such as information about the dragon and the bandits.

Children controlling the driver could get the driver on and off either of the vehicles and drive either of the vehicles. They could also access general information and information relevant to the the driver, (i.e. about the bridges, the jeep and the truck).

The roles in the computer environment used by children in the *Control condition* were not distributed between the machines. Either child controlling either of the machines could access all the information and carry out all the actions.

5.3 Results

5.3.1 Task performance

First Hypothesis

The first hypothesis tested in this experiment stated that those in the role division condition will be more effective at joint planning than those in the control condition, as measured by their success rate and the number of moves they take. There was no difference between the two conditions on the first measure. As Figure 5.6 shows, in the experimental session 6/7 pairs in the role division condition completed the task in 30 minutes as against 6/8 pairs in the control condition. The average number of moves taken to complete the task was 35 sd. 8.39 for the pairs in the role division condition versus 35.833 sd. 15.381 in the control condition. None of these differences were significant.

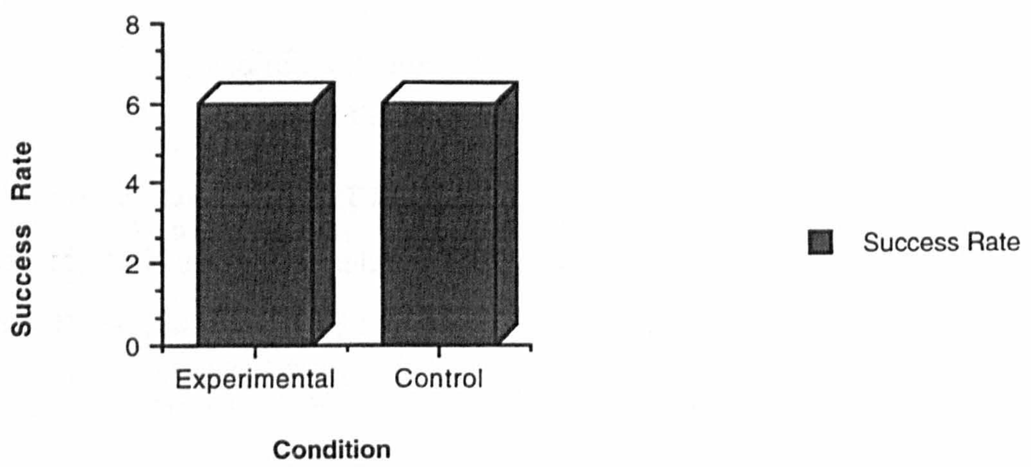


Figure 5.6 Success rate in experimental session.

No gender differences were found in the experimental session. Across both conditions 6/8 girl-girl pairs succeeded against 6/7 boy-boy pairs. Figure 5.7 shows that in the role division condition 3/3 boy-boy pairs succeeded against

3/4 girl-girl pairs, whilst in the control condition 3/4 boy-boy pairs succeeded compared with 3/4 girl-girl pairs.

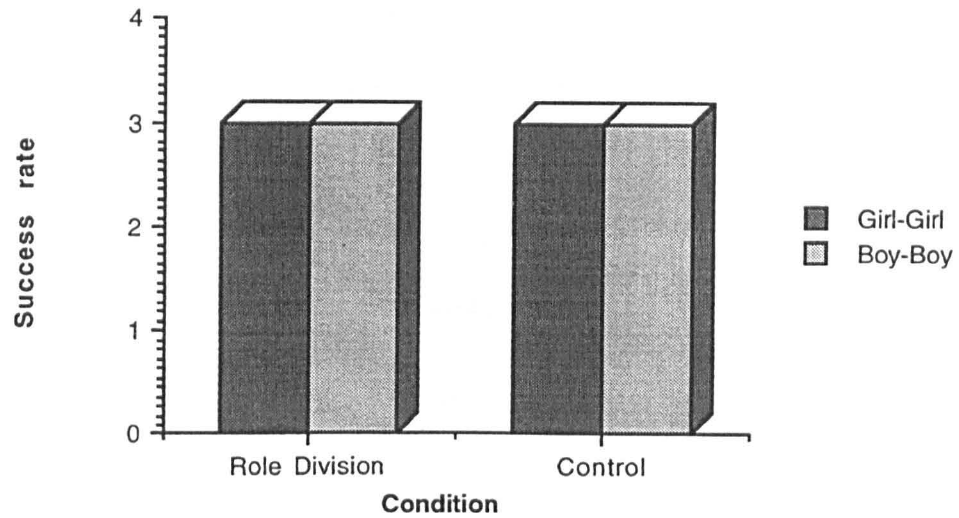


Figure 5.7 Gender differences in experimental session.

Second Hypothesis

The second hypothesis which was tested in this experiment stated that those subjects in the role division condition will be more effective at subsequent individual planning than those subjects in the control condition, as measured by the number who succeeded and the number of moves they take. On the first measure there was no difference. In the individual post test 9/14 children completed the task in 30 minutes in the role division condition as against 8/16 in the control condition (see Figure 5.8). Similarly, there was no difference between conditions on the second measure. The average number of moves taken to complete the task was 21.67 ; SD 5.268 for the children in the role division condition and 24.125 SD 13.799 for the children in the control condition. As for the first hypothesis none of these differences were significant.

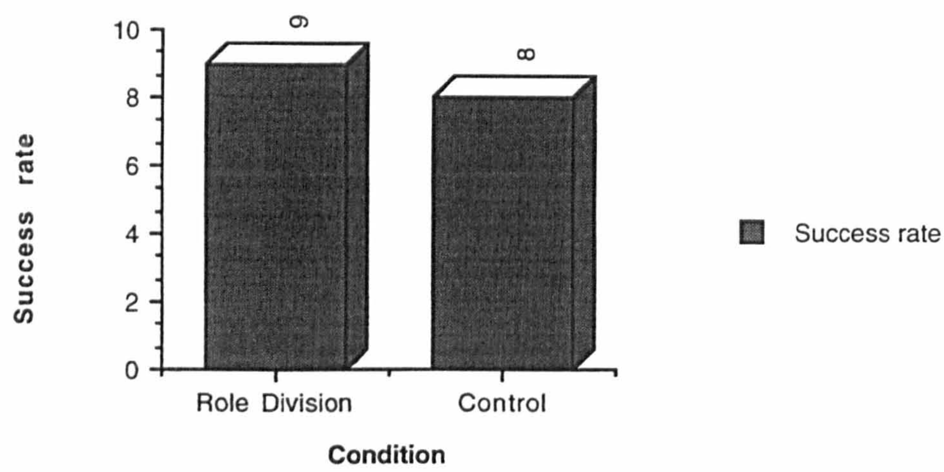


Figure 5.8 Success rate in post-test.

No gender differences were found at post test. Overall 9/14 boys succeeded at post test compared with 8/16 girls. Figure 5.7 show the results broken down by condition. In the control condition 3/8 girls succeeded at post test compared with 5/8 boys, whilst in the role division condition 4/6 boys succeeded at post test compared with 5/8 girls.

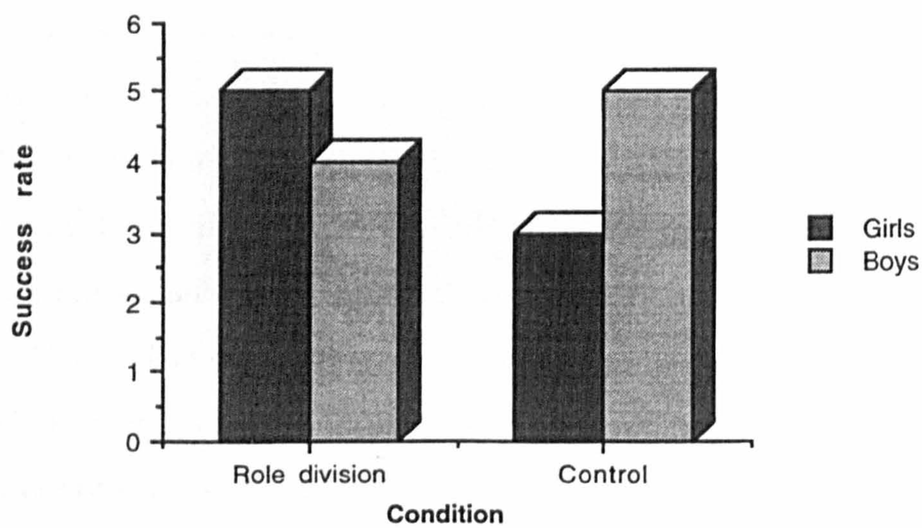


Figure 5.9 Gender differences in the Post-Test.

Figure 5.10 shows the performance of those children who were guards in the experimental session compared with those children who were drivers in the same session. No differences were found at post test, between these two groups - 5/7 guards succeeded at post test compared with 4/7 drivers.

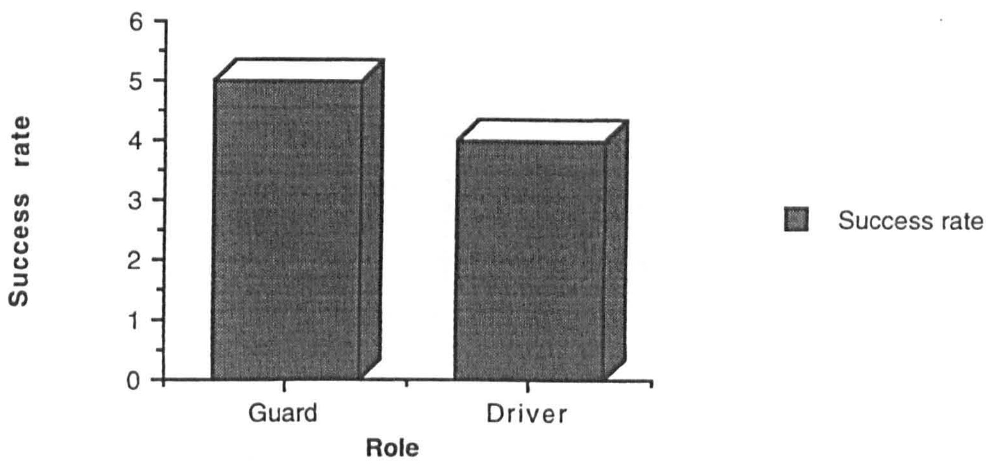


Figure 5.10 Role differences at Post-test.

5.3.2 Discourse Analysis

Premise

The discourse was analysed to investigate the premise on which the two hypotheses tested in this experiment were based. This premise states that subjects who adopt the guard/driver roles in the role division condition will have more task representation differences than pairs in the control condition. Task representation differences are evident whenever role specific information is introduced into the conversation. In the context of this experiment role specific information consists of guard specific information about the dragon and the bandits; and driver specific information about the bridges.

This premise can be investigated by examining the number of pairs who discussed the bandits, the dragon and the bridge in the experimental session. Figure 5.11 shows that there is no difference between the conditions. In the role division condition all the pairs discussed the dragon, the bandits and the bridges, whilst in the control condition 7/8 pairs discussed the bridges and the dragon, and all the pairs discussed the bridges.

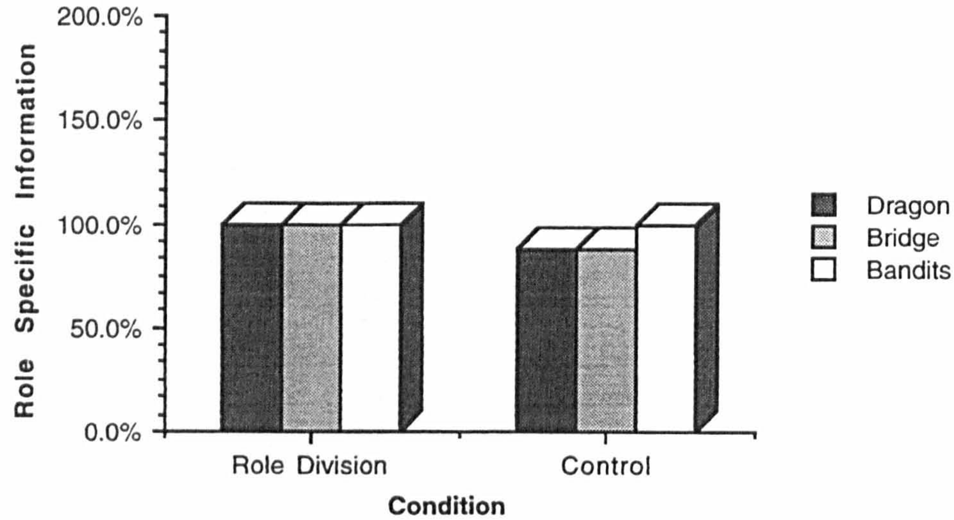


Figure 5.11 Number of pairs who discuss Role specific information.

The above finding might have occurred because pairs in the control condition only discussed the dragon, the bridge or the bandits when these obstacles prevented them from carrying out an action.

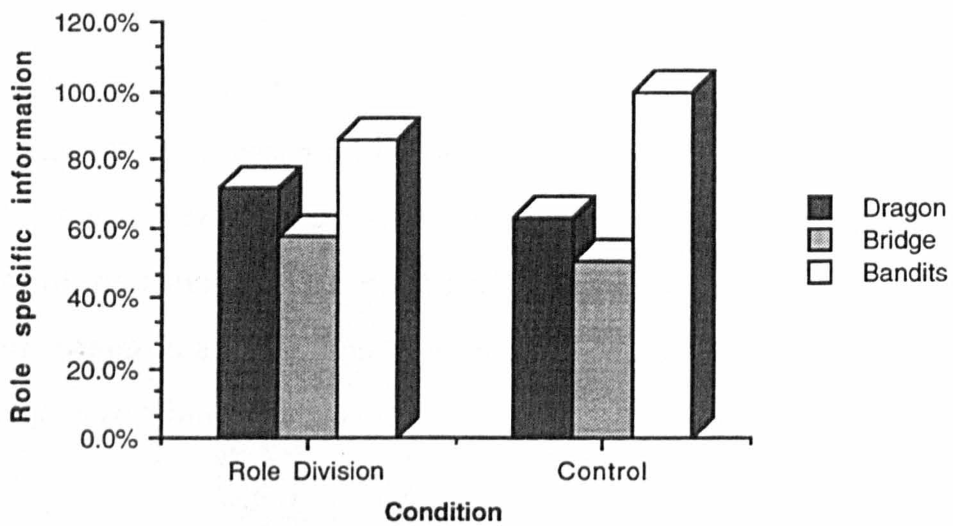


Figure 5.12 Pairs who discuss role specific information before meeting the obstacle.

Figure 5.12 shows the number of pairs in both conditions who discussed the dragon, the bandits or the bridge before any of these obstacles prevented them from carrying out an action and illustrates that there are no differences between the conditions. Pairs from either condition are just as likely to discuss the dragon, the bridge or the bandits before they encountered them.

In the experimental condition 4/7 pairs discussed the dragon; 5/7 pairs discussed the bridge and 6/7 pairs discussed the bandits before they encountered them. A similar picture emerges in the control condition with 4/8 of the pairs discussing the dragon; 5/8 pairs discussing the bridge and 8/8 pairs discussing the bandits before they encountered them.

Dialogue Focus Differences

The other aim of this experiment was to investigate the interaction for any more evidence of dialogue focus differences. In the previous chapter an inter-individual conflict was discovered which was the result of a dialogue focus difference. In this study a further dialogue focus difference was observed.

This example is taken from the transcript of a pair who were in the control condition. The two children have only just started playing the game. They have driven the truck from Aran to Croft via Brock and have just loaded the statue onto the truck. They are now discussing where to go next. Both children are looking at the map screen. The dialogue focus difference is partly caused because Erin and Aran (two towns in the game) have a similar pronunciation.

The transcript conventions are the same as those used in Chapter 4. A new utterance is represented as a new line and anything in [ ] is an action carried out by one of the children.

001 X We've got to go to Brock then back to Aran.

002	Y	Can't we get to Erin from Croft ?
003	X	No 'cos you've got to go to Brock first
004	Y	Why ?
005	X	'Cos Brock
006		are you on the Map ?
007		go to Map
008	Y	I'm on the map
009	X	are
010	Y	You can go to Erin from Croft on the Tracks
011	X	Oh yeah
012	Y	yeah
013	X	No 'cos you have to go to Brock first
014	Y	Yeah but there's a track down to Erin
015	X	We have to get to Aran don't we ?
016	Y	That's it
017	X	No let's just go to Brock, right ?
018	Y	Go to driver actions
019	X	Yeah

There are actually two dialogue focus differences in this example. Once when X proposes they go to Brock and then go to Aran (utterance 001) and Y interprets this as X suggesting they go to Brock and then to ERIN. Y challenges this proposal by suggesting they go straight to ERIN, (utterance 002). The second dialogue focus difference arises when X thinks Y is proposing they go to ARAN straight from Croft. X then challenges this proposal (utterance 013). This carries on for a number of exchanges until they both decide to go to Brock. This is indicated by Y's utterance 018 which is an implicit acceptance of X's previous utterance.

5.4 Discussion

The experiment in this chapter had two aims. The first was to investigate the proposition made in the model that the resolution of task representation differences can lead to more effective joint planning and subsequent individual planning. The experiment reported in this chapter tested two hypotheses derived from this proposition. The first was that pairs in the role division condition would be more effective at joint planning than pairs in the control condition. The second was that subjects in the role division condition would be more effective at subsequent individual planning than subjects in the control condition. Both hypotheses were based on the premise that the role division condition would lead to more task representation differences than the control condition. Therefore any improvement by subjects in the role division condition would be due to the resolution of task focus differences.

Unfortunately no evidence was found to support either hypothesis. Pairs in the role division condition did not solve the problem significantly better than pairs in the control condition. Also those pairs in the role division condition who did solve the problem did not complete the task in fewer moves than those pairs who succeeded in the control condition. A similar result was found in the post test. Those children in the role division condition were not significantly more successful than those children in the control condition. Also those children in the role division condition who succeeded at post test did not solve the problem in fewer moves than those children who succeeded in the control condition.

A possible reason for these findings was the invalidity of the premise on which the hypotheses were based. It was assumed that the role division condition would lead to more task representation differences. Task focus difference would be evident in the experimental session by the discussion of role specific information in the discourse. Analysis of the audio tapes revealed that pairs in the control condition were just as likely to discuss role specific information as pairs in the role division condition. Therefore the pairs in the control condition were just as likely to have task representation differences as the pairs in the role division condition.

There are probably several reasons for why the role division condition in this experiment did not promote task representation differences. First the subjects at the start of the interaction session knew nothing about the task and consequently subjects in the role division condition knew nothing about their roles. In other words these children did not have any task representations to have any differences about. During the session they did not develop a full understanding of their roles, in particular they did not realise they were inter-dependent. The sessions were very short, which left no time for the subjects to familiarise themselves with task.

Another reason for the failure of the role division condition to promote task representation differences was because the children in this condition found the computer environment difficult to use. Although marked on the screen and pointed out to them in the practice session most of the children did not understand what their roles were and did not realise that they had role specific information.

The fact that children in both conditions could not see each other's screens caused a lot of unforeseen problems. Most children at one stage or another would have liked to have seen what the other child was doing and many communication problems could have been prevented if the children could have seen what the other child was doing and what she was looking at. The children in both conditions often tried to view on their screen what their partner was looking at. Even in the control condition this was a difficult task but in the role division condition it was impossible when one child was looking at role specific information.

The other aim of this experiment was to analyse the interaction for further evidence of dialogue focus differences. One further conflict was identified which was the result of a dialogue focus difference, in which participants used the same term to refer to different objects.

In conclusion this experiment failed to investigate the proposition made in the model about task focus differences because the method of creating task focus differences was ineffective due to problems both with the interface and the fact that the children knew nothing about the task. The computer environments developed for this experiment did not support collaborative problem solving very well. The two machines appeared to have disrupted the delicate communication and coordination patterns between the children. They often had problems communicating with each other when using these environments, mainly because they could not see each other's screens. It would have been useful to have included an individual control in the design of this study, to tested if there was still a peer facilitative effect.

The next chapter reports a study which further investigates this proposition but this time a more reliable method of engendering task representation differences is used.

Chapter 6 : The Jugs : a further empirical study investigating the resolution of task representation differences in a planning task.

6.1 Introduction

The previous chapter reported an experiment which tried to investigate the claims made in the model about task representation differences. Unfortunately, it did not succeed because the manipulation failed to generate enough of these differences. This experiment attempts to do the same, but this time Luchin's (1942) water jugs problem is used (Joiner 1993). It involves emptying jugs and filling them up to achieve a desired amount of water. This problem is used rather than the Muksters because it is easier to experimentally generate task representation differences in this task.

Task representation differences in the water jugs problem correspond to the participants having different cognitive sets; where a cognitive set is taken to be a strong prior preference for using one particular strategy for solving the problem. Thus, the participants have different strategies in their task representation.

Different task representations or cognitive sets can be generated in the water jugs problem by giving the participants different training programs. Luchin's showed that by giving a child problems which can only be solved by adding the contents of the smaller jugs to the larger one generates in that child a strong preference to use an adding strategy. Alternatively giving the child problems which are solved by subtracting the contents of the smaller jugs away from the larger jugs creates a strong preference in that child to use a subtractive strategy.

In this experiment it will be assumed that task representation differences occur when one participant proposes a strategy which the other participant has not been trained on. Subtractive task representation differences will be the particular task representation difference investigated in this experiment. They occur when one participant proposes a subtractive strategy and the other participant has been trained to use the adding strategy.

This experiment had two aims. The first was to compare the joint planning and subsequent individual planning of pairs who had subtractive task representation differences against pairs who did not have subtractive task representation differences. This comparison was made by splitting the children into two groups, the mixed training group and the same training group. Pairs in the first group had mixed training, which is when one member is trained to use the subtractive strategy and the other is trained to use the adding strategy. The pairs in this group had a high probability that they will have a subtractive task representation difference. The probability is not 100% because the child trained to use subtractive strategy may not propose it in the interaction. Pairs in the second group had the same training, which is when both members of the pairs are trained to use the adding strategy. In this group the probability of having a subtractive task representation difference will be low because both members are trained to use the adding strategy. The probability is not zero because one member may discover the subtractive strategy for themselves.

So, in this first aim the following proposition was investigated.

P1 The resolution of task representation differences can lead to more effective joint planning and subsequent individual planning by testing the following hypotheses:

H1 Pairs where one member proposes a subtractive strategy will be more effective at joint planning. This will be reflected in the the number of problems they solve.

H2 Subjects whose partner proposed a subtractive strategy will be more effective at subsequent individual planning. This will be indicated by the number of problems solved and the range of strategies used.

These hypotheses are based on the following premise

p1 Task representation differences will become apparent in this experiment when one participant proposes a subtractive strategy to solve the problem

The second aim of this experiment was to investigate whether task representation differences are actually resolved by the set of discourse transaction proposed in the model (see section 3.5). Recall that when one participant (A) makes a proposal which leads to a task representation difference in the other participant (B) this can be resolved in several different ways. Firstly B can resolve it internally and simply accept A's proposal. This appears in the discourse as:

A : Proposal

B : Accepts

An alternative method was for B to challenge A's proposal; A then to support her proposal and B then to accept it after A's support. This appears in the discourse as the following:

A: Proposal

B: Challenges

A: Supports

B: Accepts.

This experiment investigated whether task representation differences are resolved by the set of discourse transactions proposed in the model by noting how may of them were resolved using these transactions.

6.2 Method

Design

The experiment used a between subjects design. The independent variable was the presence or absence of a proposed subtractive strategy in the interaction session. There were two dependent variables. One, successful solution of the subtractive problems in the interaction session and the post-test and, two, use of the subtractive strategy in the post-test.

The experiment had four sessions, a training session, a pre test, an interaction session and a post test. The teacher was asked to pair the children. She was told that each pair had to consist of children who got on well with each other; who were the same sex and who were roughly of the same ability. Once paired the children were split into two groups, a *mixed training group* and a *same training group* The two groups were matched for sex and ability. Children in the mixed training pairs were given different training.

Subjects

The children in the study were taken from three classes of children from two schools. Both schools served a mixed catchment area. All members of the class who could be paired were used in the experiment. The children were aged between 9 and 11 years old (mean 10 years 5 months) . The children were divided into two groups of 36 [20 boys and 16 girls] and 30 [12 boys and 18 girls]. The children were assigned to each group by random allocation. Achieving a total gender balance was not possible due to the different proportion of girls and boys in each class.

Equipment

The experiment requires two Apple Macintosh SE computers an audio tape recorder, a camcorder and two external microphones.

Procedure

In the experiment the children were taken in their pairs to a quiet area of the school (i.e. the television room) where two Apple Macintosh SEs were set up, a video camcorder, an audio tape recorder and two external microphones. Both children were asked to sit beside the nearest computer and told that the experiment was not a test. They were then familiarised with the program.

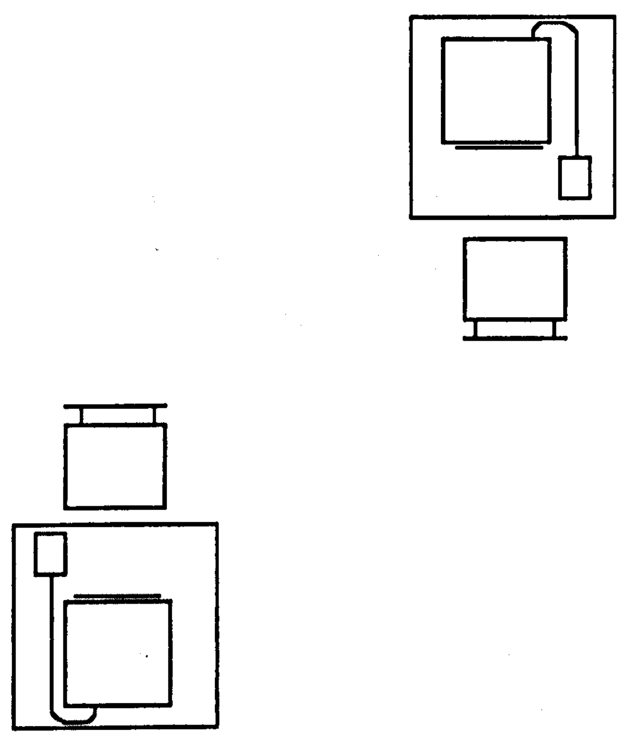


Figure 6.1 Computer layout for the Jugs Experiment.

There were four sessions in this experiment and during them all the computer kept a record of every move the children took. In the training session the children worked on their own. They each had a computer and the computers were set up in the same room, as shown in Figure 6.1, so that neither child could see the other.

The children were then given 5 problems. The problems they received depended on which group they were in. Children in the same training group were trained on *the Adding strategy.* They were trained on problems which could only be solved by adding the contents of the smaller jugs to the largest one. More detailed descriptions of this strategy and others are given in the next section. Children in the Mixed Training group were trained on different strategies. One child was trained on the *adding strategy* and the other child was trained on the *subtracting strategy*. Children trained on the subtracting strategy were given problems which could only be solved by subtracting the contents of the smaller jugs from the largest one. In this session the experimenter gave them some assistance.

The *Pre-Test* was directly after the training session. As in the previous session the children worked on the problems on their own, but unlike the previous session the children were given no assistance by the experimenter. They were given a further five problems. All the children received the same problems. These problems could be solved by either using the subtracting or the adding strategy. The pre-test was used to check how effective the training had been.

The third session, immediately after the first, was the *interaction session*. In this session the children tackled the problems in pairs. Before they attempted the problems the children were told to share control of the mouse and to discuss things with each other before they did anything. The children were then given three more problems. The first and the last problems could only be solved by the using the subtracting strategy and the second problem could only be solved by using the adding strategy. The children were only given 5 minutes per problem. During this session the children were audio and video taped.

The *Post test* was immediately after the interaction session. In this session the children were given 3 more problems to do, but this time on their own. Again the computers were set up as shown in Figure 6.1. They were only given 5 minutes per problem. The first problem and last problem could only be solved by using the subtracting strategy and the second problem could only be solved by using the adding strategy

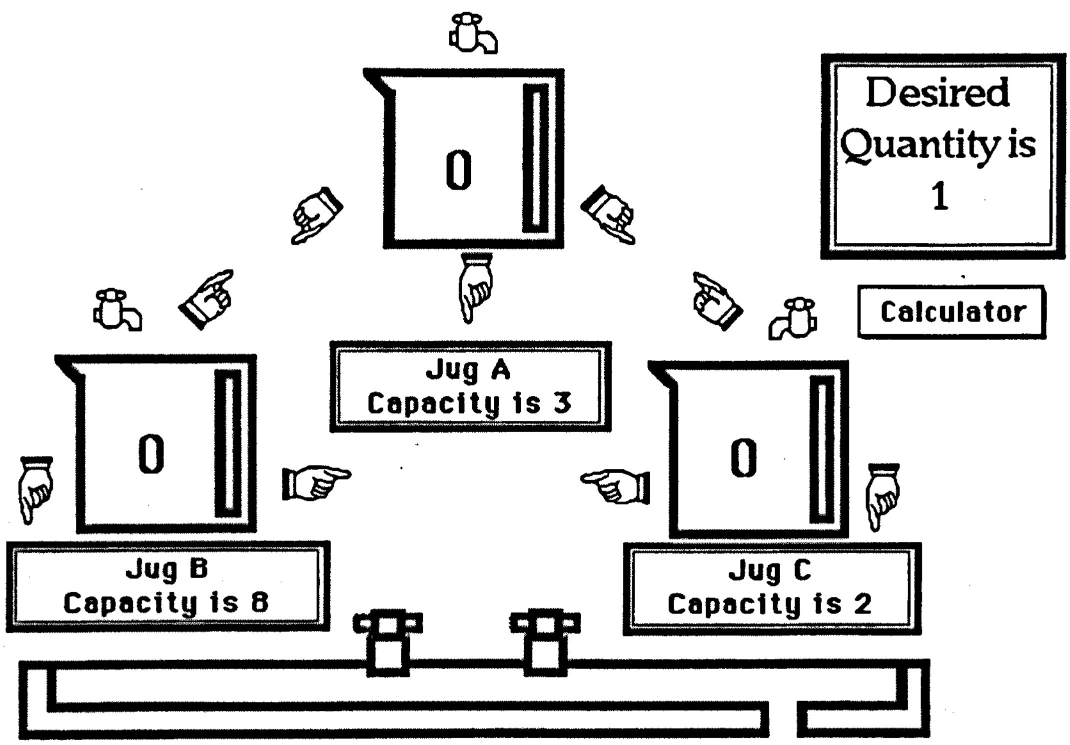


Figure 6.2 Computer Version of Jugs task.

Task

The task was a standard 3 jug problem implemented in Hypercard. The task as presented to the children is shown in Figure 6.2. I implemented this task in a manner, which I thought would be highly motivating and encourage discussion. The interface was mouse driven. It could have been keyboard driven, but this was thought inadvisable because the children's poor keyboard skills would slow down the interaction and limit the discussion. There were a lot of sounds used in this implementation of the task. When the jugs were emptied there was a sound of water going down a plug hole. This was done to make the task as engaging as possible.

It consists of three Jugs A,B, and C, plus a calculator which the children could access by clicking on the button "Calculator". The aim of the task was to fill one jug up to the desired amount, as indicated in the box up in the top right hand corner. To achieve this the children could fill up the jugs (by clicking on the tap icons); empty the jugs (clicking on the hand icons that point down) and pour the contents of one jug into another jug (clicking on the hand icon that points from the jug you are pouring from to the jug your pouring to). In each problem the capacities of the jugs changed along with the desired amount.

During the experiment the children faced three types of problems. The first type of problem were those problems which could only be solved by using the adding strategy. They could only be solved by filling up Jug A twice and pouring it into Jug B and then filling up Jug C and pouring it also into Jug B. The second type of problem were problems which could only be solved by using the subtracting strategy. These problems could only be solved by filling up Jug B; filling up Jug C from Jug B twice and then filling up Jug A from Jug B. The third type of problem were those problems which could be solved by either strategy.

6.3 Results

6.3.1 Task Performance

The first aim of this study was to test the proposition made in the model that the resolution of task representation differences would facilitate joint planning and subsequent individual planning. From this proposition two hypotheses are derived.

H1 Pairs where one member proposes a subtractive strategy will be more effective at joint planning. This will be reflected in the the number of problems they solve.

H2 Subjects whose partner proposed a subtractive strategy will be more effective at subsequent individual planning. This will be indicated by the number of problems solved and the range of strategies used.

First Hypothesis

The first hypothesis was tested by comparing those pairs in the same training group where one member had spontaneously proposed a subtractive strategy (known as the *proposal group*) with those pairs in the same training group where neither member had proposed a subtractive strategy (known as the *Non Proposal group*). The measure used was the success rate of these pairs on subtractive problems, because neither of the members of this pair had been trained on these type of problems.

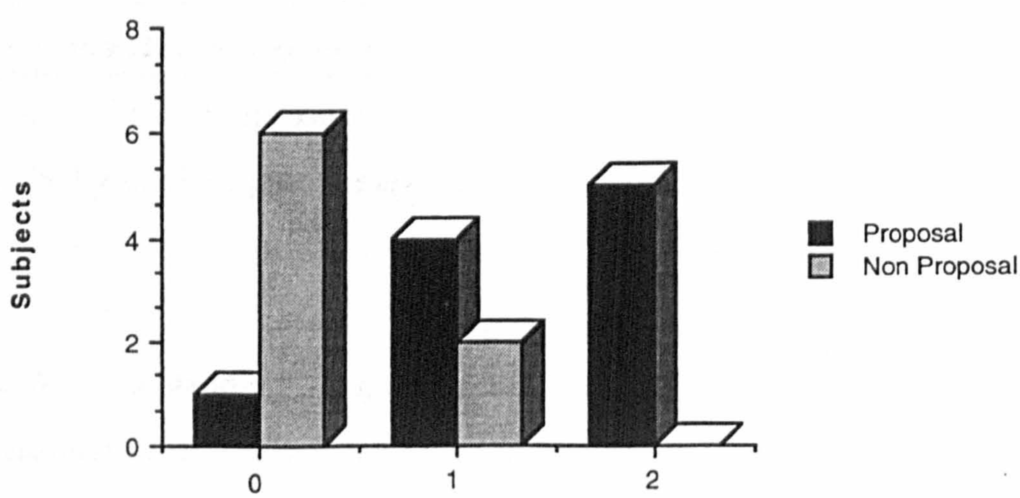


Figure 6.3 Success rate in the interaction session on subtractive problems.

As Figure 6.3 shows the proposal group are performs a lot better than the non-proposal group. In the interaction session 5/10 pairs in the proposal group solved two subtractive problems; 4/10 pairs solved one subtractive problem and one pair in the proposal group solved none. In the non proposal group no pairs solved two subtractive problems; 2/8 pairs solved one subtractive problem and 6/8 pairs solved none of the subtractive problems.

	Succeed on 2	Succeed on 1	Solve 0
proposal	5	4	1
non proposal	0	2	6

Table 6.1 Success on subtractive problems in interaction session.

To find if this difference is significant the Fisher-Exact test for two independent samples has to be used rather than Chi-Squared because not all expected frequencies are greater than 5 in table 6.1 (Siegel and Castellan, 1988). Fisher-Exact can only be used on 2 x 2 tables, therefore it is necessary to collapse the three columns of table 6.1 into two - shown in tables 6.2 and 6.3.

	Succeed on 2	Succeed on 1 or 0
proposal	5	5
non proposal	0	8

Table 6.2 Success on subtractive problems in interaction session.

Using Fisher-Exact on table 6.2 there is a significant difference between the two groups ($p < 0.03$).

	Succeed on 1 or 2	Succeed on 0
proposal	9	1
non proposal	2	6

Table 6.3 Success on subtractive problems in interaction session.

There is also a significant difference between the two groups in table 6.2 (Fisher-Exact $p = 0.012$)

In sum, I found evidence to show that the resolution of task representation differences facilitates joint planning. A task representation difference was assumed to have occurred when one participant proposed a subtractive strategy. Children in pairs where one participant proposed a subtractive strategy solved significantly more subtractive problems than children in pairs where neither participant proposed a subtractive strategy.

Second Hypothesis

The second hypothesis was tested by comparing a *Conflict Group* with a *Non Conflict Group*. The *Conflict Group* consisted of children who had been members of pairs where their partner had proposed the subtractive strategy (i.e they had a task representation difference). This was either because their partner was trained to use it or because their partner spontaneously invented it. The *Non-Conflict Group* consisted of individuals from same training group, where neither member of the pair had proposed a subtractive strategy. Plus one individual trained on adding problems, who had been a member of a mixed training group pair, but whose partner had not proposed a subtractive strategy. Figure 6.4 illustrates the results.

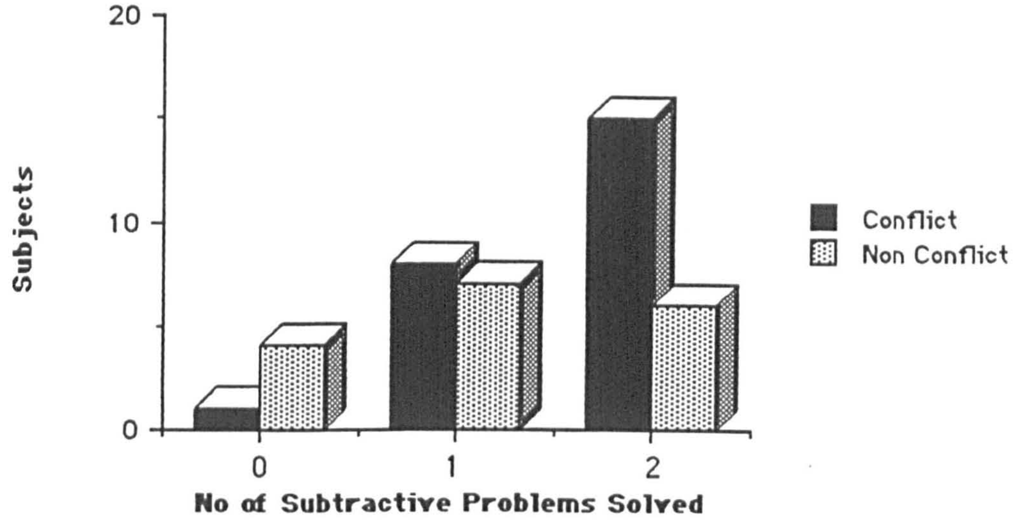


Figure 6.4 Success rate of the Conflict group and the Non-Conflict group at post test.

In the Conflict group 15/24 solved both subtractive problems; 8/24 solved one of the subtractive problems and only 1/24 solved none of the subtractive problems. In the Non-Conflict group 6/17 solved both of the subtractive problems; 7/17 solved one of the subtractive problems and 4/17 solved none of the subtractive problems. Although there is a difference in the predicted direction it is not significant (X = 2.9 DF = 2 P < 0.1).

A much bigger difference was found when I examined the children's use of the subtractive strategy.

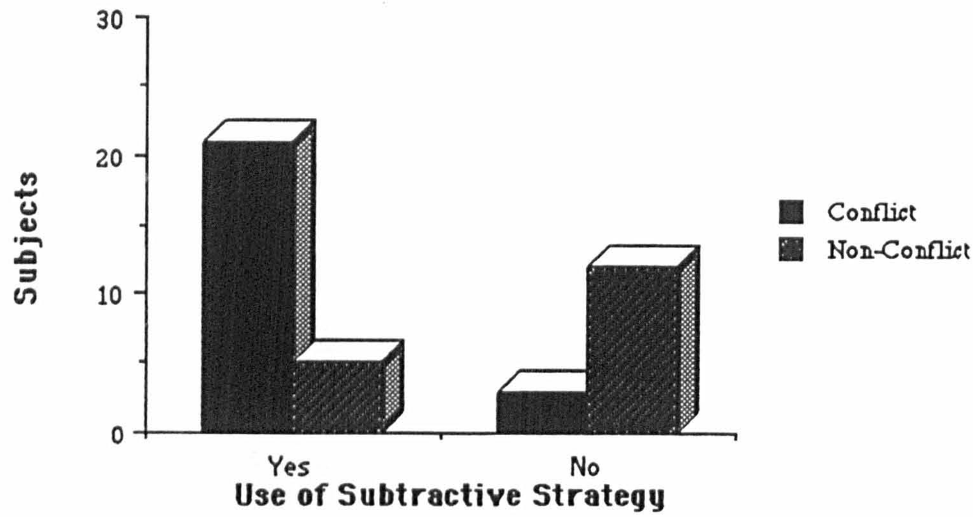


Figure 6.5 Use of Subtractive strategy by the Conflict group and the Non-Conflict group.

Figure 6.5 shows that 5/17 individuals in the non-conflict group used the subtractive strategy compared with 21/24 individuals in the conflict group. This is a very significant difference (Chi-Squared =14.5 DF=1 P< 0.001).

To summarise, I found evidence to show that the resolution of task representation differences facilitates subsequent individual planning. A task representation difference was said to have occurred when one child proposed a subtractive strategy. Children trained to use the adding strategy and whose partner proposed a subtractive strategy, solved more subtractive problems in the post-test, than those children whose partner did not. They were also significantly more likely to use the subtractive strategy at the post-test.

6.3.2 Discourse Analysis

The second aim of the study was to investigate the set of discourse transactions proposed in the model to resolve task representation differences.

The first step was to analyse the discourse after a proposed subtractive strategy. A subtractive strategy was proposed in 24 pairs a total of 58 times. The transcripts were coded by two independent coders and they had to classify 97 utterances using a coding scheme which was derived from the dialogue model proposed in Chapter 3. The coding scheme consisted of 7 functional categories.

Challenge	- e.g. "no" , "no that's too much", "No lets put two 20's and a 9"
Support	- e.g. "Yes I know but you can take some out"
Hesitation	- e.g. "wait", "hold on"
Question	- e.g. "why", "huh", 120?
Exclamation	- e.g. "120!", "Wow"
Accept	- e.g. "yes" "ok" "alright"
Ignore	-To carrying on without responding to previous utterance

The coding scheme also included a framework to guide the coders which is shown in Figure 6.6.

Participant						
A		B		A		B
Utterance						
0		1		2		4
Proposal	->	Accept				
Proposal	->	Hesitation	->	Ignore		
				Support	->	Accept
Proposal	->	Exclamation	->	Ignore		
				Support	->	Accept
Proposal	->	Question	->	Ignore		
				Support	->	Accept
Proposal	->	Challenge	->	Ignore		
				Accept		
				Support	->	Accept

Figure 6.6 The Coding Framework

The coding framework indicates that the first utterance after a proposal can only be classified as either an accept, hesitation, exclamation, question or a challenge. The classification of second utterance is dependent on the classification of the first, but generally it can only be classified as either a support or an ignore. Only if the first utterance was classified as a challenge can the second utterance be classified as either an accept, an ignore or support. The third utterance can only be classified as an accept.

The transcripts are partially transcribed to aid the coders. Each proposed subtractive strategy is marked on the transcripts as "Proposal 1". Subsequent utterances relating to that utterance are given a number either 1.1, 1.2, or 1.3. The first 1 in "1.1" indicates that it relates to "Proposal 1". The second 1 in "1.1" indicates its the first utterance relating to "Proposal 1". Utterance 1.2 means its the second utterance relating to "Proposal 1" and utterance 1.3 means its the third utterance relating to the "Proposal 1". The second digit links in with the coding framework.

The dialogue model allows for nested challenges (see Chapter 3), which is when a challenger challenges another challenge. To cope with this in the coding scheme sometimes a challenge is coded as carrying out two functions. The first function is to make a challenge; the second is to make a proposal. The coders only have to classify the first function. The second is already coded for them. For example the second utterance below is shown as it would appear to the coders.

A	Lets fill Jug B
	Proposal 1
B	No lets fill Jug A
	1.1 ....
	Proposal 2

Now the second utterance can be treated as a proposal (i.e. Proposal 2) and as such it can also be challenged. Utterances relating to proposal 2 will have the code 2.1, 2.2 or 2.3 in the transcripts. A challenge to proposal 2 can itself be challenged and it would then be coded as a challenge and proposal 3. The nesting of challenges can go on indefinitely but in this study it rarely went beyond 3 levels.

A problem in coding is when subjects immediately change their mind without a response by their partner, as illustrated below.

A	Fill Jug B up
B	No don't do that
	Yeah alright

In this example B's immediate response is to challenge A's proposal and then before A has a chance to respond B changes her mind and accepts it. In the transcripts the above example would appear on the transcripts as the following.

A	Fill Jug B up
	Proposal 1
B	No don't do that
	1.1a ....
	Yeah alright
	1.1b ....

1.1a indicates it is B first response to proposal 1 and 1.1b indicates B's has changed that response.

Table 6.4 shows the inter-coder reliability of the analysis categories. Most reach adequate levels of reliability (i.e. above 75%) except for Questions and Ignore.

Transaction	Coder A %	Coder A No	Coder B %	Coder B No	Inter Coder %	Inter Coder No
Challenge	86%	18/21	90%	19/21	82%	19/23
Support	91%	10/11	81%	9/11	85%	6/7
Accept	90%	44/49	95%	47/49	80%	41/51
Question	71%	5/7	57%	4/7	80%	4/5
Hesitation	100%	2/2	100%	2/2	100%	2/2
Exclamations	100%	4/4	75%	3/4	75%	3/4
Ignore	33%	1/3	33%	1/3	33%	1/3
Total	87%	84/97	87%	85/97	80%	76/97

Table 6.4 Inter Coder Agreement.

Examination of the transcripts reveals possible reasons for the low inter-coder reliability for categorising Questions and Ignores. Questions are difficult to classify because the distinction between questions and other categories can be vague especially when the classification is from a written transcript of a verbal interaction. For example an utterance such as "Add the 60" when it follows the following proposal "Now add the 60", with no markers indicating what it is, could be either a question acceptance, exclamation or a challenge depending on the intonation.

Similarly, Ignore is a difficult category to identify as illustrated below.

001	X	(X empties Jug C)
002	Y	What the heck did you do that for ?
003	X	Put that in there.

X's utterance after Y's could be seen as X ignoring Y's exclamation or X beginning to explain to Y the rational behind emptying Jug C.

The next step was to analyse the immediate responses to a proposed subtractive strategy. Table 6.5 shows how the proposed subtractive strategies were immediately responded to. The most frequent responses to a proposed subtractive strategy was to accept it, with over 57 % of proposed subtractive strategies being accepted immediately.

Transaction	Number		
	Mixed	Same	Total
Accept	19	14	33
Challenge	12	2	14
Question	3	2	5
Exclamation	2	2	4
Hesitation	1	1	2
Total	37	21	58

Table 6.5 Immediate Response to a Proposed Subtractive Strategy.

I shall now give examples of each of the five responses to a subtractive strategy identified in the transcripts. The transcript conventions are that a new line represents a new utterance and anything in [ ] is an action carried out by a child.

Challenges

Out of the 58 proposed subtractive strategies 14 were directly challenged. Of these 6 were simple challenges which follow the pattern proposal-challenge-support-accept. Below is an example where Y challenges the proposed subtractive strategy by doubting its validity. Y thinks that X intends to add Jug B to the others which she quite rightly realises will not work because none of the others can take the desired amount which is 76.

001 X Fill that one (Jug B) up 'cos its the biggest

002	Y	76 is not going to fit in the others
003	X	Yes I know
004		you fill that one up and empty it into the others
005	Y	Ok

Three challenges were accepted. Below is an example

001	X	What I usually do is fill that up (B)
		tip it into there (C) and that (A)
002	Y	What I do is put 2 of them (C) into there (B)
003	X	Yeah

The five remaining challenges were complex challenges and can last over several utterances. A case in point is shown below.

001	X	Get 60
002	Y	No
003	X	Just get 60
004	Y	[fills Jug A up]
		Where are you going to put the 60
005	X	Ok
006	Y	12 + 12 = 24
007	X	Now add the 60
008	Y	Add the 60?
009	X	Then we can take some out
010	Y	[fills Jug B up]

In the example above X proposes to "add or get 60" three times and each time Y either challenges it (line 002) or questions it (lines 004 and 008) and each time X fails to explain the reasoning behind adding 60. Eventually in line 009 X finally explains her reasoning. The fact that Y then fills up Jug B is taken to be an acceptance.

Question

5 out of the 58 proposed subtractive strategies were questions. Below is an example of a proposed subtractive strategy being questioned. In this example Y questions the validity of the X's proposal to fill Jug B up. X answers her query by making explicit the subtractive strategy.

001	X	Fill up that (B)
002	Y	Why ?
003	X	If you fill that up you can give bits out.

Exclamation

Children made exclamations to a proposed a subtractive strategy 4 times out of the 58 observed. In the example below Y exclaims "oh no" when X fill Jug B up which provokes X into making explicit the subtractive strategy.

	[X fills Jug B up]	
001	Y	Oh no
002	X	lets take that out.

Hesitation

Only two responses to a proposed subtractive strategy were classified as hesitation. Below is an example.

001	X	Fill the 60 up
002	Y	Steady on
003	X	If you do the highest number first right You can keep taking away. Its a lot easier

Acceptances

By far the biggest response to a proposed subtractive strategy was a straight acceptance - 33 out of the 58 proposed strategies identified were accepted straight away. Below is an example where Y explicitly accepts X's proposed subtractive strategy.

001	X	Fill up B
002	Y	Ok

In summary, I analysed the resolution of task representation differences to investigate whether they are resolved by the discourse transactions proposed in the model. Forty seven of the task representation differences identified in this study were resolved in the way the model predicted. Of theses, 33 were resolved implicitly and 14 were resolved explicitly. Leaving 11 conflicts or 19% resolved in ways not predicted in the model.

6.6 Discussion

The first aim of the study reported in this chapter was to investigate the proposition made in the model that the resolution of task representation differences leads to more effective joint planning and subsequent individual planning. This proposition was assessed by testing two hypotheses. The first hypothesis tested was that the resolution of subtractive task representation difference would lead to more effective joint planning. Evidence was reported which showed that such a resolution was associated with more effective joint planning.

The proposition was also evaluated by testing the hypothesis that the resolution of task representation differences would lead to more effective subsequent individual planning. This hypothesis was tested by comparing those individuals in pairs whose partner had proposed a subtractive strategy with individuals in pairs where neither participant had proposed a subtractive strategy. Two measures were used, the success rate of individuals at post test on subtractive problems and the use of the subtractive strategy at post test. On the first measure no significant difference was found, although the comparison of the success rate of these two groups of children did show a tendency to go in the direction predicted. On the second measure there was a difference between the two groups in the direction predicted. Children who were members of pairs whose partner had proposed a subtractive strategy were more likely to use a subtractive strategy than children in pairs where neither participant had proposed a subtractive strategy. In this experiment one partner proposing a subtractive strategy was taken to be evidence of a subtractive strategy. Thus I have found that the resolution of task representation differences facilitates the acquisition of problems solving strategies.

The second aim of this experiment was to investigate whether task representation differences are resolved by the methods proposed in the model. According to the model children can resolve task representation differences by either simply accepting them or challenging them. A task representation difference was assumed to have occurred in this experiment when a subtractive strategy was proposed. The analysis of the children's response to a subtractive proposal (see table 6.2) revealed that 81% of them were resolved in the manner outlined in the model; 24% (14/58) of the responses to a proposed subtractive strategy were in the form of challenges and 57% (33/58) of them were acceptances. Nineteen percent (11/58) of the responses to a proposed subtractive strategy were not predicted in the model. Participants not only accepted and challenged these proposals they also hesitated over them, questioned them and made exclamations about them.

The implications of this result and the others reported in chapters 4 and 5 for computer based collaborative learning will be discussed in the next chapter.

Chapter 7 : Conclusions

In this chapter, I conclude the thesis by reviewing its contributions and limitations. The contributions include a discussion of the achievements and the implications for developmental psychology, teaching practice and software design. Finally I make a number of suggestions for further work. These consist of extensions to the model, several more experimental studies and future research directions.

7.1 Achievements

The following was achieved in this thesis:

- A comprehensive review of the role of inter-individual conflicts in learning and development.
- A dialogue model of the resolution of inter-individual conflicts in joint planning.
- An empirical study and analysis of the beneficial effects of peer interaction in joint planning.
- An empirical study investigating the resolution of task representation differences using distributed learning environments.
- A further empirical study which investigated the beneficial effects of the resolution of task representation differences in a planning task.

7.1.1 A comprehensive review of the role of inter-individual conflicts in learning and development

A comprehensive review of research into the role of inter-individual conflicts in learning and development. Peer interaction was shown to facilitate learning and development in certain circumstances. The resolution of conflicts is a common explanation for this facilitative effect. I argued that this explanation was inadequate for the purposes of guiding the design of computer based collaborative learning, because we need to understand more about the nature of conflicts; how they are resolved and how that resolution leads to learning.

7.1.2 A dialogue model of the resolution of inter-individual conflicts

Developed a dialogue model of the resolution of inter-individual conflicts in planning. In this model, I propose that conflicts are caused by three types of inter-individual difference: (i) intersection differences; (ii) task representation differences and (iii) task focus differences. These inter-individual differences are resolved by a set of discourse transactions and a set of internal resolution procedures and in certain circumstances their resolution facilitates planning and subsequent individual planning.

The development of definitions and terminology for labelling different types of inter-individual differences is a worthwhile contribution because such distinctions are not made in the literature and I have found them useful. Most other researchers are working with primitive and undifferentiated notions of conflict. With this set I have started to unpack the notion of conflict and began to understand when the resolution of conflict is beneficial.

7.1.3 An empirical study and analysis of the beneficial effects of peer interaction on joint planning.

Showed that unstructured peer interaction can facilitate learning in a computer based planning task. The Muksters study compared pairs with individuals on a computer based planning task and found that pairs were superior to individuals and that this superiority carried over to individual planning at post-test.

Began to explain this facilitation effect with the model proposed in this thesis. A corpus of conflicts was collected. Most of them were either caused by task focus differences or intersection differences. Analysis of these conflicts supported the claim made in the model that their resolution facilitates both joint planning and subsequent individual planning. No task representation differences were identified because of methodological constraints.

One conflict was identified in the corpus which had not been predicted from the model. I had been assumed in the model that participants always shared the same dialogue focus but this conflict was the result of the participants having different dialogue foci.

7.1.4 An empirical study investigating the resolution of task representation differences using a distributed learning environment.

A study was conducted to investigate the beneficial effects of the resolution of task representation differences. This was done by comparing children using a distributed learning environment where they had inter-dependent roles, with children using a system where they had no restrictions. This is only the second study which has been carried out to investigate the educational benefits of multi-user systems. Although no facilitative effects were found, this study did reveal some problems with using these systems.

Analysis of the discourse in this study also revealed another conflict, which was the result of a dialogue focus difference.

7.1.5 A further empirical study which investigated the resolution of task representation differences.

This study found that the resolution of conflicts can facilitate individual planning. The jugs experiment reported that individual's performance was facilitated when they resolved task representation differences.

Another important finding was that counting explicit conflicts in the discourse was shown to be an unreliable method of identifying conflicts in the discourse. Only 25% of the task representation differences identified in the jugs experiment were in the form of explicit conflicts.

7.2 Implications

There are three areas this work has implications for:

- Developmental psychology.
- Teaching and classroom practice.
- Software design to promote collaborative learning.

I will discuss each in turn.

7.2.1 Implications for Developmental Psychology

This research has a number of implications for developmental psychology both theoretically and methodologically. One of the main theoretical implications is that there are different types of inter-individual conflict in peer interaction. Previous work assumes that the underlying cause of all inter-individual conflicts is the same. For example in Doise and Mugny's (1984) theory inter-individual conflicts are caused by the participants having different centrations. One of the conclusions of this thesis is that inter-individual conflicts, at least in planning tasks, are caused by four different types of inter-individual difference, task focus differences; task representation differences; intersection differences and dialogue focus differences.

Another important theoretical implication is that the resolution of certain types of conflict will not lead to progress. In contrast to Doise and Mugny (1984) who argue that the resolution of all inter-individual conflicts will lead to learning, as long as they are resolved positively (i.e. not by compliance). One of the most interesting and surprising findings was the discovery of dialogue focus differences. The resolution of dialogue focus differences, even positively, will not lead to learning, but just to the maintenance of a shared dialogue focus.

With regards to the methodological implications, one method of testing conflict based explanations (see section 2.3.2), is to investigate whether there is a relationship between the number of explicit conflicts in the discourse and subsequent learning. (Doise and Mugny, 1984 Chapter 5; Light and Glachan, 1985; Forman and Cazden, 1985; Bearison et al, 1986; Blaye, 1988 and Blaye et al, 1991). If few conflicts can be identified (Blaye et al, 1991) or if the number of conflicts does not positively correlate with learning (Blaye, 1988) the authors have concluded that the resolution of conflicts is not a mechanism of learning in the task they used. It was argued in Chapter 2 that this method is unreliable.

Evidence in reported in Chapters 4, 5 and 6 supports this argument. First some of the explicit conflicts identified may have been due to dialogue focus differences and therefore their resolution does not lead to learning. Second some of them may have been resolved by one participant complying with the other, which again would not lead to learning. Third some of the conflicts may have been implicit and thus not apparent in the discourse. For instance, in the jugs experiment 57% of the conflicts identified were implicit (see table 6.2) and a further 19% of them were either hesitations, exclamations or questions which would not have been identified as conflicts. A similar point was made by Draper and Anderson (1991). Therefore, the method of testing conflict based explanations of learning in peer interaction by counting the number of explicit conflicts identified in the discourse is unreliable.

The only method which has a high probability of identifying all the conflicts in the interaction is the one used in the experiment reported in Chapter 6. In this experiment identification of implicit conflicts and conflicts which manifested themselves as questions, exclamations or hesitations was only possible because each child's knowledge of the task was known before interaction. Knowing this made it possible to identify comments made by one child, which would cause the other child to experience a conflict.

7.2.2 Implications for Teaching Practice

The jugs experiment reported in Chapter 6 found that pairing children together who had different strategies was only beneficial when they articulated those differences. This has a number of important implications for the organisation of collaborative learning in the classroom. First, it shows teachers that pairing children together who have different problem solving strategies can facilitate individual planning. Previous research into the resolution of inter-individual differences has only shown this to be the case for conceptual tasks such as physics (Howe, Tolmie, and Mackenzie, in press) or conservation (Perret-Clermont, 1980). Second, it begins to outline the conditions under which those benefits occur. Pairing children together who have different strategies but who do not articulate those differences is not going to be beneficial. Thus if a teacher pairs two children together, who have these differences, they must feel comfortable enough in the relationship/interaction to be able to articulate and resolve them.

7.2.3 Implications for Design

There is very little research which can be used to inform the design of software to support collaborative learning. Research by Clements and Nastasi has shown that different types of computer environments influence the way conflicts are resolved. They have demonstrated that collaborative learning in a Logo environment results in more constructive resolution of cognitive conflicts than in a problem solving game (Nastasi, Clements and Battista, 1990) or with computer based writing (Nastasi and Clements 1992). They claim this resolution of cognitive conflicts fosters "cognitive growth". Unfortunately they do not indicate what design features of Logo are responsible for this beneficial effect.

The development of the dialogue model and the research reported in this thesis have a number of important implications for the design of computer based collaborative learning environments. These have been distilled into nine design principles.

One of the most important findings in this thesis was that that unstructured computer based collaborative planning can facilitate individual planning (see Chapter 4). Previous research has always found that the benefits of computer based collaborative planning were dependent on structuring the interaction between the children (Light and Glachan, 1985; Light, Foot, Colbourn and McClelland, 1987). There are several important features in the software/task which contributed to this finding.

1) If designers want to encourage discussion use an appropriate task.
One of the most important is the nature of the task. The model proposed in this thesis suggests that the facilitative effects of peer interaction are dependent on the quality of the dialogue. Thus a task was developed which

encouraged discussion. This was achieved by designing it in the form of an adventure game. Crook (1987) has observed that the amount of talk around a computer is highly dependent on the type of software used. The richest discussions were produced when the children were playing an adventure game.

2) If designers want to encourage discussion then make the task as motivating as possible so that it engages the children.

Another important reason for the observed facilitative effect of peer interaction was that the children found the task engaging. The more children actively engage in the task the greater the quality and quantity of the task relevant discussion. In this endeavour the task used in the Muksters succeeded. All the children said they enjoyed playing it and there was hardly any task irrelevant discussions.

3) If designers want to encourage discussion make inputting commands or actions as simple as possible.

Another critical feature of the software was that it was mouse driven. If the interface had been keyboard driven this could have reduced the benefits of peer interaction by affecting the quality of the interaction and its organisation. Children's typing skills at the age range I tested were very limited. Typing commands into the computer would have taken both a considerable amount of time and effort, which would have slowed down the interaction and limited the discussion. Both effects would have the limited the facilitative effects of peer interaction. It also could have lead to a greater differentiation of roles, similar to ones observed by Sheingold, Hawkins and Char (1984). They observed two girls writing a Logo program, where one girl was the "typist" and the other was the "thinkist". Whilst this was an efficient way to proceed it was not an effective method of interaction for learning. There was little exchange of information and hardly any discussion about alternative courses of action.

4) If designers want to promote learning then support the resolution of conflicts.

Another important finding was reported in Chapter 6. A study was conducted which compared the subsequent individual planning of children who had task representation differences with those who did not. The result was that the resolution of task representation differences facilitated individual planning. Thus this study shows that supporting the resolution of conflicts in planning can be beneficial.

The model proposed in this thesis can be used to suggest how to design systems to support the constructive resolution of conflicts. There are several ways of resolving intersection differences but only one of these methods is guaranteed to facilitate individual planning and that is resolution by hypothesis testing. Other methods, such as resolution by coordination and resolution by confidence will lead to learning only if the view which is accepted is more advanced than the previous one held, but there is no guarantee that this will be the case. Finally resolution by compliance as Doise and Mugny and others have said will never lead to learning.

5) If designers want to support the resolution of conflicts then support resolution by hypothesis testing.

The one method which is certain to lead to progress is resolution by hypothesis testing which does facilitate individual planning. Thus systems can be designed to support hypothesis testing in a number of ways. These are best illustrated in the three examples reported in Chapter 4.

6) If designers want to support hypothesis testing then store the relevant information and make it easy to access.

One method of hypothesis testing is by seeking information. An example of this is shown in example 1 (shown below). The participants have not yet made a move. They are at the start of the session and have decided to search for information. The participants have conflicting beliefs about how many people the car will take.

Get Information

Ship Information

006 X: I say we get information first

[go to information]

007 Y: Mm yep

008 X: It's best to

009 : get information on the ships

[Y shakes his head]

010 Y: They can carry as many people as they want

Car Information

011 X: Oh. They can have three on the car I think

012 Y: The car can carry the driver and 3 passengers

013 X: Shall we check?

[checked to see how many people the car could carry]

014 Y: Four people together

This intersection difference was resolved by one participant finding the correct piece of information. This strategy can be supported on the computer by storing the relevant pieces of information and making them easy to access. It is interesting to note that in example III (shown below) this method of resolution was not supported.

Get Information — Car Info

015 Y: The crown three passengers and the driver

016 X: The car is at A

017 : we can go to B or C

Go To C

018 Y: C

019 X: We went to C last time

020 Y: The car had to go to B first

021 X: Yes

022 : because we went to C and then had to go back.

In this case the participants were having a disagreement over where they went last time, a piece of information not available to the children.

Making the information accessible to the children is not an easy task and it may be necessary to store relevant information in multiple locations. What maybe an obvious search path for the designer may be completely opaque for the children. For example, some children using the Muksters would look for the crown by searching at each location. They would eventually find its location, but a quicker search strategy would be directly access the crown information. In the Muksters, storing relevant information in different locations supported children's different search strategies. This in turn supported the interaction between the children, which was a key factor in the facilitative effect reported.

7) If designers want to support hypothesis testing then it is to make it easy to test out ideas.

Another hypothesis testing strategy is to try out one of the ideas to see if it will work. This method was illustrated in Example II.

Go to A in the car
Get Everyone on the Car

180 X : Right then, everybody on

181 Y : We can't fit them all on

182 X : Oh yes we can

[attempts to and succeeds at loading everybody onto the car]

183 : Right then.

This intersection difference is resolved by one participant trying out their idea. This method of resolution is one ideally suited to computer based learning for several reasons. First, on a computer it is possible to test ideas which would be difficult or even impossible to test in the real world. An example of this is SharedArk (Smith et al, 1991) where it is possible to change the laws of physics. Second it is easy to undo actions on a computer, which may be impossible to undo in the real world. This facility is important if when trying out one of the ideas it is found to be wrong. Finally it is possible on a computer to return to a previous state of the world. The return facility is important because trying out one idea may involve several actions and if it is found to be wrong and the participants decide to go back they may be unable to remember how to return to where they had the conflict. A return facility would allow them to return instantly to the point of conflict.

8) If designers want to support hypothesis testing then make it easy to ask someone.

A further hypothesis testing strategy is to ask someone. Unfortunately there was not an example of this strategy reported in Chapter 4 due to methodological constraints. However, one way of supporting this strategy is by setting up a help line which the students could use to seek help from the teacher or other students who are tackling similar problems. The main problem with this method is that it may lead to conflicting advice which would only confound the original conflict.

The research reported in this thesis also has implications for the design of distributed learning environments. Research into computer based collaborative learning has tended to investigate systems which were designed for single users. There are systems available, now which support multiple users and these offer different ways of collaborating around a computer (Smith et al., 1991). It is an open question whether these systems will provide better collaborative learning environments but very little research has been conducted to answer this question.

But, the experiment reported in Chapter 5 is one of the few to investigate the potential of distributed learning systems. It was not very successful, but it still revealed some interesting problems concerning the design of these environments.

9) If you want to support different roles on a computer it is necessary to make sure the children know these roles before hand.

In the experiment reported in Chapter 5 I attempted to supported certain types of roles in an effort to engender task representation differences, but unfortunately this was not very effective for a number of reasons. The main one being because the children did not take readily to their roles. They did not realise they could carry out actions their partner could not, nor did they realise that it required both of them to solve the problem.

10) If you are designing distributed learning environments then make sure that both children can see each other's screens.

The computer environments developed for this experiment did not support collaborative problem solving very well. The children often had problems coordinating and communicating with each other when they were using these environments, mainly because they could not see each other's screens.

Thus, this study shows that there is still a lot of research to be carried out investigating how to design and develop effective distributed learning environments.

7.2.4 Summary

This section has outlined the implications this research has had on the fields of developmental psychology, teaching practice and the design of software for supporting collaborative learning . The next section makes several suggestions for further work which directly follow on from this research

7.3 Further Work

This section makes a number of suggestions for furthering the research reported in this thesis. One is to extend the model to include dialogue focus differences. The other is to empirically test the propositions made in the model about intersection differences and task focus differences, using the successful methodology employed in the jugs experiment.

7.3.1 Extensions to the Model

One of the most surprising findings was the discovery of dialogue focus differences. An obvious extension to the model is to include this type of inter-individual difference. Only two examples were reported one in the Muksters and further one in the Shmuksters, but they have also been observed by Grosz (1981) in her work on discourse focus. They are generally the result of participants using the same term to refer to different things and thus can be seen as breakdowns in co-reference.

An amusing example is found in Umberto Eco's "Name of the Rose" (1984). In this example the main character in the book, Severinus, is talking about truffles.

"..... a lord in my country knowing I was acquainted with Italy, asked me why, as he had seen down there, some lords went out to pasture their pigs; and I laughed realizing that on the contrary, they were going in search of truffles. But when I told him that these lords hoped to find the "truffle" underground to eat it, he thought I said they were seeking "der teufel,' the devil, and he blessed himself devoutly, looking at me in amazement. Then the misunderstanding was cleared up and we both laughed at it." p 288

This example illustrates a dialogue focus difference which is the result of the participants using the same term (i.e. "der teufel") to refer to different things.

Using the formalism outlined in the model, I will show that dialogue focus differences can fall between two different extremes. At one extreme are dialogue focus differences, which occur when the participants' task representations do not overlap (see Figure 7.1). The resolution of these dialogue focus differences is probably impossible because the participants have no common language in which to communicate and resolve their differences.

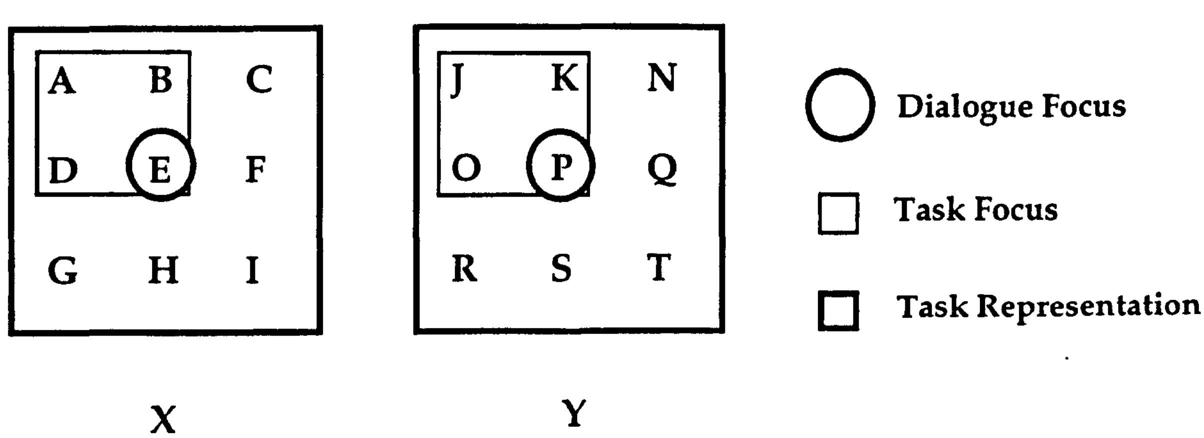


Figure 7.1 A No Overlap Dialogue Focus Difference.

The other extreme is when the participants share the same task representations, but do not share the same dialogue focus (see Figure 7.2). These differences can be resolved because the participants share a common language (i.e. task representation), which enables them communicate and resolve their difference.

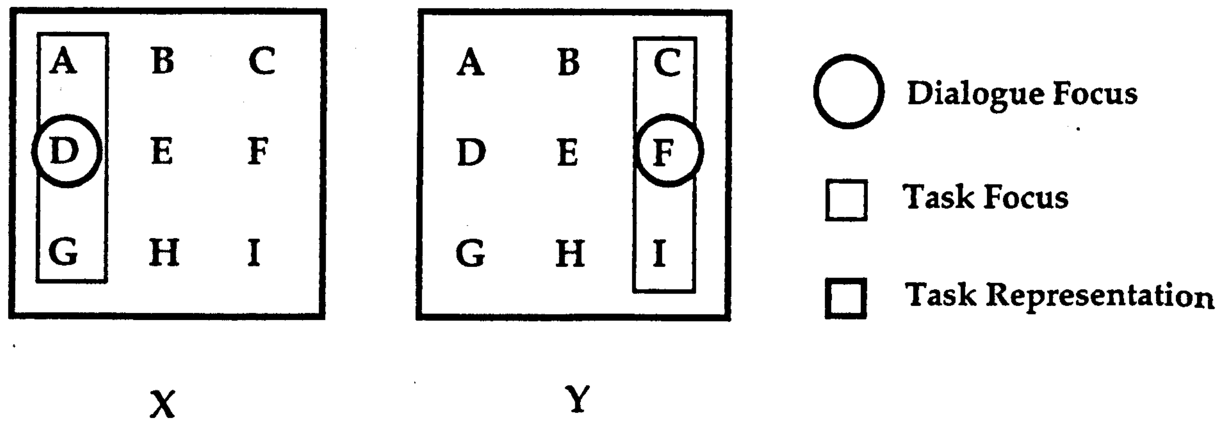


Figure 7.2 A Total Overlap Dialogue Focus Difference.

Most dialogue focus differences fall somewhere between these two extremes and the ability of the participants to resolve them will depend, in part, on the amount of overlap there is between their task representations and how the dialogue focus shifts during the discourse.

The resolution of dialogue focus differences leads to the maintenance of a shared dialogue focus which is essential for successful communication. Successful communication is essential for effective joint problem solving. If communication is difficult or impossible then this will prevent the successful resolution of inter-individual differences which in turn will inhibit learning. Therefore the successful resolution of dialogue focus differences may not lead to learning, but the failure to do so will inhibit it.

7.3.2 Further Experimental Work.

Not only can the model be extended, but further studies could also be carried out to test claims made in the model. Evidence was reported in Chapter 4 supporting the propositions made in the model about task focus differences and intersection differences, but there was no direct evidence which showed that the resolution of these two inter-individual differences could lead to learning. Further experimental studies, similar to the study reported in Chapter 6, could be carried out to test these propositions.

7.3.2.1 An investigation into the resolution of Intersection differences

One proposition made in the model was that certain methods of resolving intersection differences can lead to more effective joint planning and subsequent individual planning. It could be evaluated by using the method employed in the jugs experiment to investigate the resolution of task representation differences. Task representation differences were engendered in the Jugs experiment by giving each member of a pair different training. This method could also be used to engender intersection differences by training each member of a pair to have different and conflicting beliefs about how to solve a particular detour problem.

The task used in this study could be quite simple and a map of a possible candidate is shown below in Figure 7.3. The goal of this task would be to get some honey and some bread (at D) for a picnic at A in the shortest route possible. The task is made more difficult by the presence of a monster who will steal the honey and a Giant who will steal the bread.

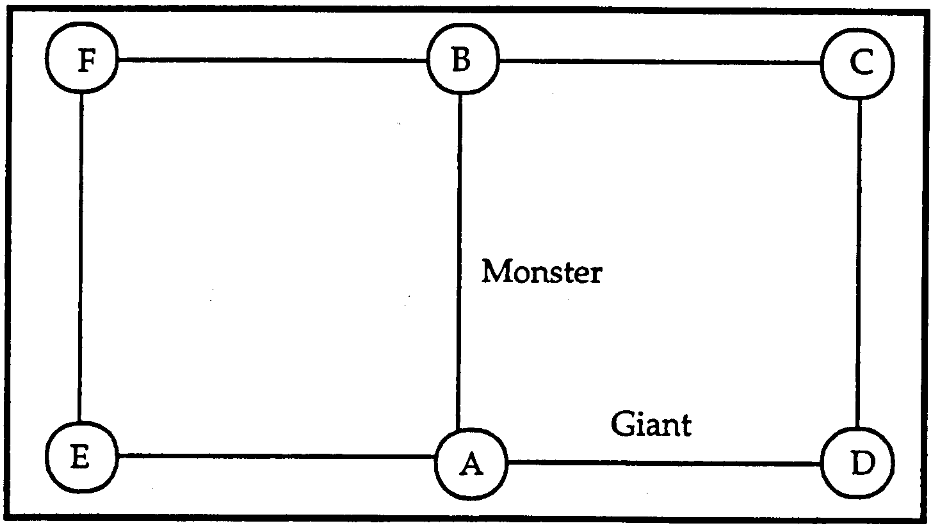


Figure 7.3: Map of task world.

One child would be trained to believe incorrectly that the monster will steal both the honey and the bread and trained correctly to believe the giant will steal the bread only. Thus to get the bread with this belief set will necessitate going the long route from A to E to F to B to D. The other child would be trained incorrectly to believe the giant will steal both the bread and the honey and trained correctly to believe the monster will only steal the honey. A child with this belief set would have to get the Honey by going from A to E to F to B to D.

Pairs with mixed training would be compared with pairs with the same training. It is expected that if pairs with mixed training resolve their conflicting beliefs by hypothesis testing then they will discover that some of their old beliefs are incorrect, whilst the pairs with the same training will never discover this. Thus the pairs with mixed training who resolve their conflicts by hypothesis testing will take shorter routes than pairs with the same training and it is expected that this positive effect should transfer to subsequent individual planning.

Thus this experiment would test two hypothesis derived from the intersection difference proposition.

H1 Pairs who resolve intersection differences by hypothesis testing will be more effective at joint planning. This will be reflected in the number of moves taken to solve the problem.

H2 Pairs who resolve intersection differences by hypothesis testing will be more effective subsequently at individual planning. This will be reflected in the number of moves taken to solve the problem at post test.

7.3.2.2 An investigation into the resolution of Task focus differences

Another experiment could be carried out to test the claims made in the model about task focus differences. The model claimed that the resolution of task focus differences would facilitate joint planning and subsequent individual planning. This claim could be investigated by using a distributed computer version of the "missionary and cannibals" task. The aim of this task is to find the smallest number of moves possible to transport three missionaries and three cannibals from one side of the river to the other in a boat which can only take two people. The only constraint is that if the cannibals outnumber the missionaries, the cannibals will eat the missionaries.

It is proposed that by giving participants different task focii this should make joint planning more effective and this beneficial effect should transfer to subsequent individual planning. Hutchins and Levin (1981) reported that participants adopt an implicit point of view which places them mentally on one side of the river. A person's task focus will correspond to this point of view. Pairs will be given different points of view by distributing the task over two machines; one participant will use one computer which has the view from one bank and the other participant will use the other computer which has the view from the other bank. Hutchins and Levin (1981) report that people make more mistakes; are less likely to detect them and are more likely to get stuck when they have the inappropriate viewpoint. Thus this experiment would test two hypothesis derived from the task focus proposition.

H1 Pairs with different viewpoints (i.e. task focii) will be more effective at joint planning than pairs with the same viewpoint. They will make fewer errors and will be less likely to get stuck.

H2 The subsequent individual problem solving of pairs with different viewpoints will be more effective than subjects who were in pairs with the same viewpoint. This will be reflected in the number of mistakes and number of times subjects get stuck.

So, in sum this section made a number of suggestion for furthering the research reported in this thesis. It was proposed that the model could be extended to include dialogue focus differences. Two experiments were proposed to test the claims made in the model about intersection differences and task focus differences. The next section outlines more long term future research directions which emerge from work reported in this thesis.

7.4 Future Research Directions

This section examines future research directions, which follow on from work reported in this thesis. This thesis has shown the benefits of understanding the dialogue processes involved in the resolution of inter-individual conflicts. Other more detailed dialogue models could be developed. Two different models are discussed in this section. Another important aspect to emerge was the difficulty of making distributed learning environments and the lack of research into the design and evaluation of these environments.

7.4.1 More Detailed Dialogue Model

One possible future direction is to make a more detailed dialogue model of the resolution process. This could be achieved in several ways. One is to develop a more complex description of focus. The model of focus proposed in this thesis assumes there is only one dialogue focus at a given time. This assumption is an over simplification because in everyday discourse people often have more than one focus which they can switch between without any problem. As the simple example below illustrates.

A	: lets remove the drive shaft
B	: could you pass the 2.4 spanner ?
A	: Great match on the TV last night
B	: Yeah, the second goal was brilliant
A	: I thought it was offside
B	: Could you pass the extension ?

In this example the participants switch from talking about assembling the drive shaft to talking about a football match on television last night with no problems.

Similarly further work is needed to explain how inter-individual conflicts are perceived. This is a complex process as the example, taken from the Muksters experiment, shows below. A and B are trying to decide who to take on the plane. The interesting utterance is 066, where A proposes they take the guard with them for the plane. B challenges it by saying that no one can attack them up there and A accepts this challenge. The interesting question is why did B make the challenge.

One interpretation is that the reason A proposes to take the guard on the plane is to protect them. Although this reason is not said, B infers it and thinks it's invalid because she/he believes no one can attack them when they are in the plane. She/he then challenges B, in line 067.

060	B	: Right then we need who off the car
063		: the pilot and the captain I think
064	A	: the pilot
065	B	: and the captain I think
066	**A**	**: take the guard with us for the plane**
067	**B**	**: no because no one can attack us up there.**
068		**: anyway we'll take**
069	**A**	**: Oh yeah**

This interpretation illustrates how perception of conflicts require complex plan inference. Recent A.I. models of plan recognition in discourse might help explain this process.

7.4.2 Goals Beliefs and Plan conflicts.

Another direction to pursue is to examine the resolution of goal, belief and plan conflicts. In the dialogue model, the task is represented with goals, beliefs and plans, but I did not examine the differences between the resolution of conflicts which were due to the participants having different beliefs and those which were the result of the participants having different goals and/or plans. But there is a fundamental difference between these two types of conflicts. The belief conflicts observed in this thesis only concerned the validity of the beliefs. For instance in example II reported in Chapter 4 the conflict was only about whether the car could take everybody.

Goal or plan conflicts can be about the validity of the plan, where for instance a conflict may be about whether a particular precondition is satisfied. But they also have plan conflicts concerning whether a particular plan is going to be successful or which plan is the most effective. For instance quite often in the Jugs experiment, when participants had a task representation difference, they would amicably resolve it by one participant accepting that their partner's method was valid, but this still left them with the problem of which method to choose. In this task, they could not tell from the outset which one would achieve the goal. They just had to select one arbitrarily. Thus, future research could investigate how participants resolve goal or plan conflicts concerning efficacy and how they resolve goal or plan conflicts concerning validity.

7.4.3 Distributed Learning Environments

Research to date on computer based collaborative learning has only investigated the effects of collaboration around computers, which were designed for single users[1]. However, numerous systems have been developed to support synchronous co-present cooperative work. There are also several computer games, both for home computers and in computer arcades which support collaborative play. But there has been very little research into the educational uses of such multi-user systems.

With multi-user systems you could investigate the issue of role division in collaborative learning. Views on this in the literature are divided as to whether role division is beneficial or whether it is detrimental. Future research could investigate the effects of different types of role division; the issue of role exchange and examine the allocation of roles, should the children decide or the designer/teacher ?

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[1] The few notable exceptions are Shared Ark (Smith et al, 1991) and the Shmuksters (see chapter 5).

7.5 Summary

In summary, the main aim of the thesis was to develop a dialogue model of the resolution of inter-individual conflicts in joint planning which could be used to guide the design of computer based collaborative learning.

Research indicates that in certain circumstances peer interaction facilitates learning. The resolution of inter-individual conflicts is a common explanation for this facilitative effect and research indicates that in certain circumstances it does lead to learning. But I argued that unless we understand more about the nature of conflicts, especially in planning tasks, this explanation will be limited in its usefulness to inform the design of software to support collaborative learning. To overcome this a dialogue model of the resolution of inter-individual conflicts in joint planning is proposed. There are three key components in this model; the Task Representation, the Task Focus and the Dialogue focus. Participants share the same dialogue focus, but can have different task focii and task representations. From this model three types of inter-individual differences are derived; *Task representation differences, Intersection differences and Task Focus Differences.* All three types of inter-individual difference can be resolved with a set of discourse transactions and a set of internal resolution procedures. It is proposed that the resolution of all three differences can facilitate joint planning and subsequent individual planning.

Three experiments were reported which investigate these claims. The first experiment found that peer interaction facilitated learning in joint planning. The model proposed in the thesis was then used to investigate this facilitative effect. A corpus of inter-individual conflicts was collected Most of the conflicts identified in this corpus were either intersection differences or task focus differences and evidence was reported which supported the claims made in the model that their resolution can lead to learning. However one critical conflict revealed a mistaken assumption in the model which is that participants always share the same dialogue focus. The second and third experiments investigated the claims made in the model about task representation differences. The final study showed that the resolution of conflicts, in the form of task representation differences, facilitated individual planning.

In the conclusion this thesis has several implications for developmental psychology and teaching practice. It also has important implications for the design of computer based collaborative learning. These are that unstructured peer interaction can facilitate planning and subsequent individual planning and that the resolution of conflicts in joint planning is similarly beneficial.

Appendix A : Analysis of Conflicts in the Muksters

This appendix gives all the disagreements found in the transcripts analysed in the muksters experiment.

Intersection differences	
Hypothesis testing	
Information seeking	1.1, 1.3, 1.6, 1.7, 1.12, 2.6
Try it and see	1.15
Coordination	1.2
Task Focus Differences	1.5, 1.8, 1.9, 1.13, 2.1, 2.2, 2.3, 2.4, 2.8, 2.9, 2.11, 2.10, 3.4, 3.5, 3.6, 3.8, 3.9
Dialogue Focus Difference	1.4
Intra-individual	3.1, 3.2, 3.3
Not Interpretable	1.10, 1.11,1.14, 2.5, 2.7, 3.7

The transcript conventions are as follows. Anything in [ ] is an action carried out by a child. New lines can be interpreted as a new utterance. The participants are labelled X and Y. An asterisk after X and Y (e.g. X*) indicates who is holding the mouse.

Pair 1 Greig and Paul (Successful)

Example 1.1 : Hypothesis testing : information seeking

Example 1.1 is the first of four examples of hypothesis testing by information seeking found in the transcripts.

Context

The participants are at the start of the game and have decided to search for information.

Analysis

The example was classified as an intersection difference because the challenge in line 012 is a direct contradiction (i.e intersection difference). The participants have conflicting beliefs about how many people the car will take. They resolve this disagreement by finding out how many people the car will take.

Get Information

006 X : I say we get information first

[go to information]

007 Y : Mm yep

008 X : It's best to

Ship Information

009 : get information on the ships

[Y shakes his head]

010 Y : They can carry as many people as they want

Car Information

011 X : Oh They can have three on the car I think

012 Y : The car can carry the driver and 3 passengers

013 X : Shall we check

[checked to see how many people the car could carry]

014 Y : Four people together

Example 1.2 : Coordination

Example 1.2 was the only example of resolution by coordination identified in the transcripts.

Context

This example is only a few lines on from example 1.1

Analysis

The challenge in line 020 is a direct contradiction and therefore this example was classified as an intersection difference. The participants have conflicting beliefs about where they went last time. It is resolved by X coordinating the two beliefs into the belief "that they went to C and had to come back" (line 22)

Segment	Line	Utterance
Get Informatim / Car Info	015	Y : The crown three passengers and the driver
	016	X : The car is at A
	017	: we can go to B or C
Go To C	**018**	**Y : C**
	019	**X : We went to C last time**
	020	**Y : The car had to go to B first**
	021	**X : Yes**
	022	**: because we went to C and then had to go back.**

Example 1.3 : Hypothesis testing : information seeking

This is the second example of an intersection difference resolved by information seeking.

Context

In this example, the children are still at the start of the game. All the characters and the means of transport are in their initial location. The children are trying to decide where to go, by finding out information about where the ships are.

Analysis

The disagreement, indicated in bold, is over the location of ship 2. The challenge in line 036 is a direct contradiction to X's proposal in line 034 'that ship 2 is at C'. It is resolved by X viewing the screen which indicates that ship 2 is at C.

Where to drive car		024	X : How about getting the driver, the pilot the
			: guard and the captain on the car and get it to
		025	: Where's
		026	Y : where's plane
	Where's Ship 1	027	: where's ship
		028	: shall we check
		029	X : ship1's at B
		030	Y : Better check
			[go to ship 1 information]
		031	X : Yes
	Ship 1 to F	032	Y : It can go to F
		033	X : Ship 1 to F
			[go to card information]
	Where's Ship2	**034**	**: and ship 2 is at F I think.**
			[go to card ship 2 information]
		035	**: and can go to H**
		036	**Y : C**
		037	**X : OH**
		038	**Y : Its at C.**

Example 1.4 : Dialogue Focus Difference

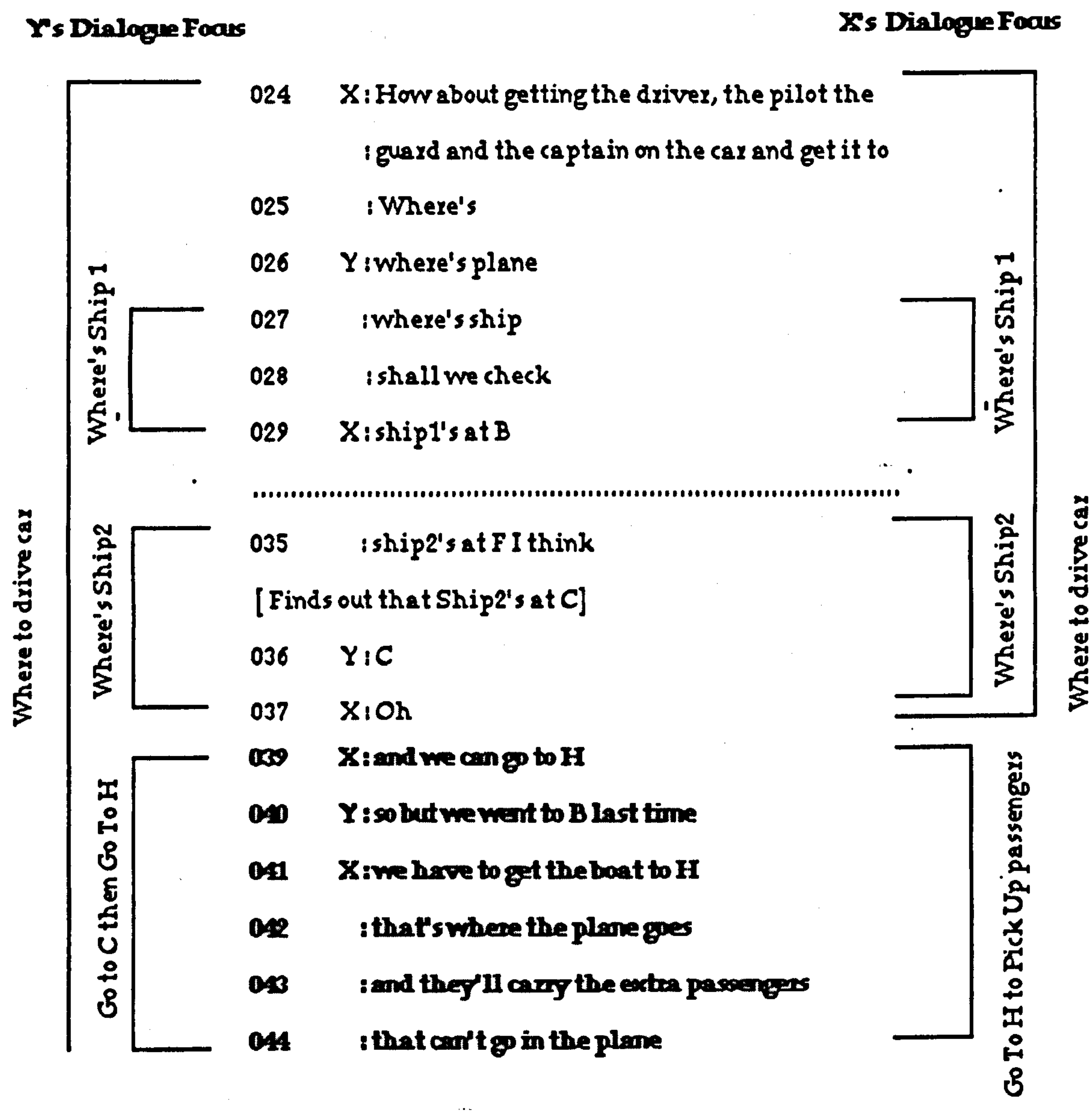
Example 1.4 revealed a mistaken assumption in the model, where it was assumed that the participants shared the same dialogue focus. It is an example of an inter-individual conflict which was the result of the participants having different dialogue foci.

Context

In this example the children are at the start of the game and are trying to decide where to go when they realise they do not have enough information.

Analysis

The disagreement (marked in bold) is about whether they should go to H.



X changes the dialogue focus to "and we can go to H" in line 039. Y's perception of the new dialogue focus is shown in Figure A.1.

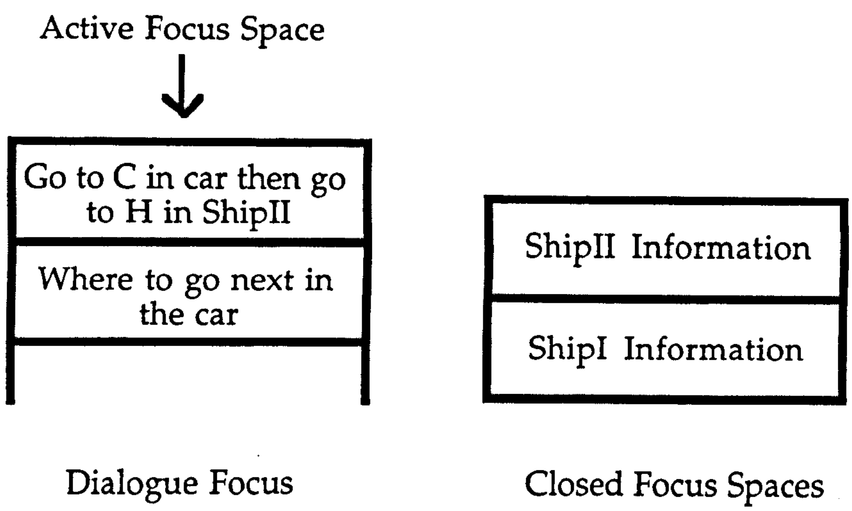


Figure A.1 : Y's Dialogue Focus at line 039.

Y changes her dialogue focus to Figure A.1 after X's proposal in line 039. It has at least two focus spaces and Y perceives the active focus space as the proposal "to go to C from A and then go to H". The reason for this interpretation is because she is following the maxim that at any point in the discourse only one part of the speaker's plan will be in focus and, unless explicitly stated, subsequent utterances will be related to that part. The part of the plan in focus before utterance 039 was "where are they to drive the car". If this utterance is related to that plan then X must be proposing that they go to C in the car and then take ship 2 to H.

Y changes her task focus to correspond to her perception of the new dialogue focus and this reveals the inconsistent belief that they did not go to C from A last time. Evidence for this interpretation comes from the challenge in line 040.

However Y's perception of the dialogue focus was not what X intended. X was not proposing they should go to C from A and then go to H. She was not making a proposal which was related to the plan "where do they drive the car" which was what Y thought she was doing. A quite reasonable interpretation considering that X had not explicitly marked the complete change in the dialogue focus (see Figure A.2).

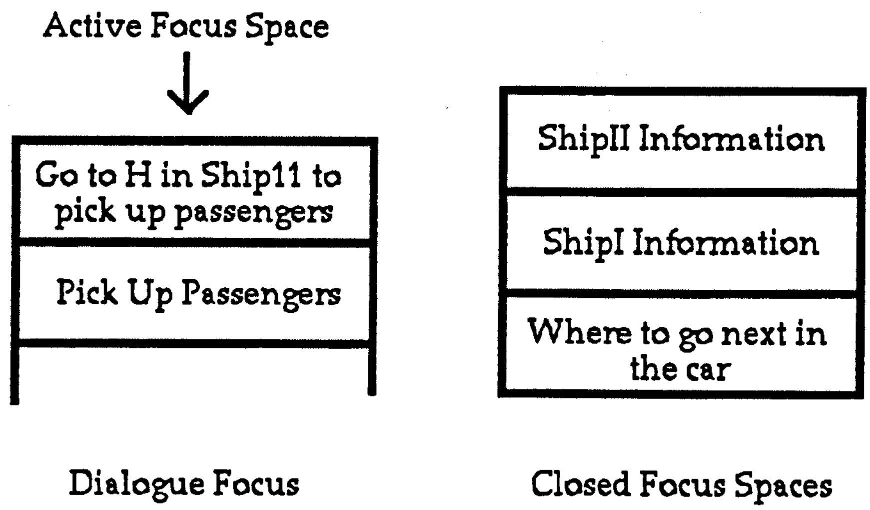


Figure A.2 X's dialogue focus in line 039.

X's intended dialogue focus had two focus spaces and she had closed the focus space "where to go in the car". The active focus space was "that they go to H to carry the extra passengers which can't go in the plane. Evidence for this interpretation comes from lines 42-45 when she says that they will use Ship 2 to go to H and carry the extra passengers which cannot go in the plane.

Example 1.5 : Task Focus Difference

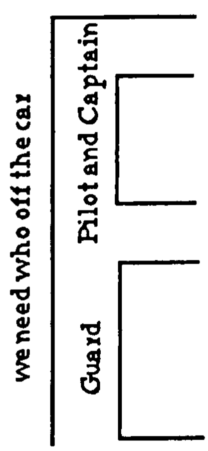
This is an example of a task focus difference where one child detects an error in their partner's proposed plan.

Context

The children have made their first move, which is to drive everyone in the car from A to B. They are now trying to decide who they need to take off the car.

Analysis.

It is an example of a task focus difference. Y challenges X's proposal with a belief in line 067 which invalidates X's proposal. X accepts the challenge with an "oh yeah" in line 069. This acceptance appears to signify that she also knew that the pirates would not attack them in the plane. In terms of the model this would be interpreted as a task focus difference because both participants had the belief that "pirates can't attack planes" but only Y had it in her task focus when X made the proposal.



060 Y : Right then we need who off the car
063 : the pilot and the captain I think
064 X : The pilot
065 Y : And the captain I think
066 X : Take the guard with us for the plane
067 Y : No because no one can attack us up there.
068 : anyway we'll take
069 X : Oh yeah

Example 1.6 : Hypothesis testing : information seeking

This is the third example of an intersection difference which is resolved by information seeking.

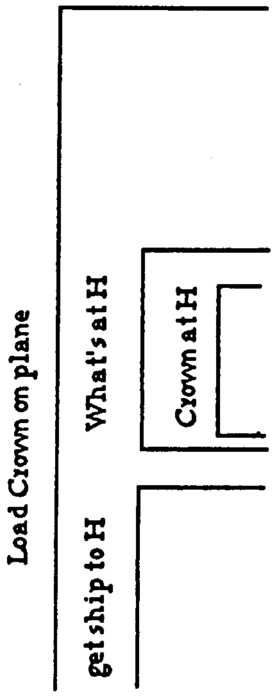
Context

The children have just transported the captain, the guard and the pilot to F in ship 1. The driver is still in the car which is at B. They are now trying to load the crown on the plane.

Analysis

The disagreement is whether the crown is at H. It is classified as an intersection difference because the challenge in line 090 is a direct contradiction to X's proposal that the crown is at H. This occurs because when they go to card plane actions this also tells them if the crown is at H.

This is first noticed by Y who draws X's attention to this fact in line 090, because the evidence is on the screen X accepts Y's challenge.



085 X : Right we want the crown on the plane

[go to card actions]

086 Y : mm yes

[go to card plane actions]

087 X : What's at H

088 : It should be the crown,

089 : Oh the plane's at H

090 Y : and the crown isn't

091 X : We'll have to get the ship to H

Example 1.7 : Hypothesis testing : information seeking

This is the fourth example of a intersection difference which is resolved by information seeking.

Context

It follows on closely from the previous example. The children want to load the crown on the plane, but have found out that the plane is at H and the crown is at F. They have decided to get a ship to H.

Analysis

The disagreement is over whether Ship 1 can get to H. It is classified as an intersection difference because in line 094 Y contradicts an assumption of X's which is that Ship 1 can go to H. They resolve this conflict by finding out if it can.

What's at H
Crown at H
get ship to H
get Ship 1 to H

085 X : Right we want the crown on the plane

[go to card actions]

086 Y : mm yes

[go to card plane actions]

087 X : What's at H

088 : It should be the crown,

089 : Oh the plane's at H

090 Y : and the crown isn't

091 X : We'll have to get the ship to H

092 Y : Ship2 to Hushley

093 X : Ship1.... I think

094 Y : I don't think it can

095 : Shall we get some information about that

[go to card information]

[go to card ship1 information]

096 X : Ship1 can go to Hushley

097 :Yeah

098 X : Oh good

Example 1.8 : Task Focus Difference

Context

The children have completed two moves. The first move was to drive the driver, the captain, the pilot and the guard to B. The second was to sail the captain, the guard and the pilot to F. They have just decided to sail Ship 1 to the plane which is at F and are now loading the ship.

Analysis

The disagreement is over whether they need the captain. At first X proposes they load the captain and actually selects the captain but then decides not to take the captain and unselects him. Y challenges this move by saying they need the captain for the ship. X immediately accepts this. This acceptance appears to signify that X also knew that the ship needed the captain. In terms of the model this would be interpreted as a task focus difference because both participants had the belief that "ship needs the captain" but only Y had it in her task focus when X made the proposal in line 105.

take ship 1 to F
Need captain for Ship

101 X: Now the palne is there (F)
102 : So we have to have ship 1
[went to card ship 1 actions]
103 : Captain,
[selects captain]
104 : no
105 : not Captain
[unselects captain]
106 Y : Yes we need the captain for the ship don't we
[loaded capt guard pilot]
107 X: Yeah yeah

Example 1.9 : Task Focus Difference

Context.

The children have just made their third move which was to take the guard the pilot and the captain to F from H in ship 1. This was so they could fly the plane which they know is at F.

Analysis

X tries to load the passengers on the plane by going to plane actions. Y challenges this in line 113 by saying they need to get them off the plane first. This is classified as a task focus difference. X and Y went to H to use the plane. Once there X tries to load the plane. When X tries this it conflicts a with Y's task focus because Y believes that before you load the plane you have to unload the ship. Y communicates this to X. X accepts by going to ship actions (i.e. the first step in unloading the plane). This immediate acceptance implies that X also knew that you have to unload ship 1 first but did not have it in his task focus when he went load the plane.

Use Plane | Load Plane | Unload Ship 1

[Went to H in ship1 with the captain, the guard and the pilot]

[went to press button plane actions]

114 Y : No

115 : we need to get them off the ship first

[went to card : ship 1 actions H]

116 : we want

[selects guard]

117 : Them all off really

Example 1.10 : Not Interpretable

Context

The children have just sailed the captain, the guard and the pilot in ship 1 to H, in order to pick up the plane. They are now deciding who to take off the ship.

Analysis

This is a difficult example to analyse. Y proposes they take everyone of the ship. X challenges this in line 118 by saying that the captain needs to stay on. Y counters by saying that they need to take everyone back, but X ignores this and only takes the guard and the driver off. It is difficult to classify this conflict because X does not indicate why he disagrees with Y.

[Went to H in ship1 with the captain, the guard and the pilot]

Use Plane

Load Plane

[went to press button plane actions]

114 Y : No

115 : we need to get them off the ship first

[went to card : ship 1 actions H]

116 : we want

[selects guard]

Unload Ship 1

117 Y : Them all off really

[selects pilot]

118 X : Well not really

119 : the captain is to stay on

120 Y : Well seing as we have got to taken them all : back

[load pilot and guard]

121 : Yeah

[select F]

[went to Fuggle in the plane with the guard and the pilot]

Example 1.11 : Not Interpretable

Context

The children have just completed their fourth move by flying back to F from H in the plane with the guard and the pilot.

Analysis

This example is difficult to analyse. They have just gone to F and Y challenges this move by saying that they have just been there in line 129. X explains this move by saying "he knows but we've got to get the plane". This is not an intersection difference because no one is contradicting each other. It would be classified as a task focus difference if Y explicitly accepted X's explanation, but he does not. So it is not clear why he accepted it.

Go to f in plane

[select F]

Why go back to F

[went to F in the plane with the guard and the pilot]

129 Y : we've just come from F

130 X : I know

131 : but we've got to have the plane.

load Crown

[went to card plane actions]

[select crown]

[load crown]

Example 1.12 : Hypothesis Testing : Information Seeking.

Context

The children have just completed their fifth move which was to fly from F to C in the plane with the guard, the pilot and the crown. they are now trying to work out where the plane is.

Analysis

This inter-individual difference was classified as an intersection difference because Y makes a direct contradiction to X's suggestion that they went from H to C in the plane. They resolve this intersection difference when they examined the trace of the moves they made.

Where is the plane

148 X : Hey hold on the plane is where now?

149 : Crowmarket

Where did we go

150 : We took the plane from Hushley to Fruggle

151 : Then to Hushgley to Crowmarket didn't we

152 Y : I'm not sure if we took it to Crowmarket

153 X : Want to do a quick trace on it

[went to card info]

[went to card trace]

154 X : The plane went from Fruggle to Crowmarket

155 Oh thats ok yeah

156 Y : Yeah

Example 1.13 : Task Focus Difference

Context

The children have just made their fifth move, which was to fly the pilot, the guard and the crown from F to C. They have left the car with the driver in B and the captain in the ship at H. they are now trying to get everyone back to A.

Analysis

This disagreement was classified as a task focus difference. Both children agreed to go to B in Ship 1 proposed by X in line 162. Then Y proposes it in line 167. X challenges it by saying they need to go to F, but when Y queries this in line 169 this brings X initial proposal back in his task focus and thus he quickly accepts it.

Go to Brockley in Ship 1 (lines 162–171)

What's on Ship 1 (lines 164–166)

162 X : So we want the ship 1 to go back to B
163 : Ship 1
164 : What's on Ship 1
[went to card ship 1 info]
165 : the captain ok
166 : Act
167 Y : So we need to go to Brockley
168 X : Fnuggle
169 : Fnuggle?
170 X : No
171 Y : Brockley Yeah

Example 1.14 : Not Interpretable

Context

They have got the crown, the pilot and the guard at C. The driver and the car are at B, whilst ship 1 and the captain are at H. They are now trying to get the captain back with the others and are discussing whiter to go to C or F.

Analysis

This again is a difficult disagreement to analyse. It appears that X proposes that they go to C and then changes his mind, but is finally convinced by Y's persistence questioning about the need to go to C. The problem is that it is not clear why X changes his mind in line 187 and whether Y had anything to do with it.

Go to C in Ship 1

179 X : lets got to C
180 : No hold on
181 Y : No
182 X : We can't go
183 Y : Take him back to C with the others
184 X : can't
185 : the ship can't go to F
186 : can't go
187 : Ship1 go to C because its at H
188 Y : yeah
189 X : Go to C
[Selects C]
[sails to C with the captain in Ship 1]

Example 1.15 : Hypothesis testing : try it and see

Example 1.15 is the only example of the resolution strategy "try it and see" identified in the transcripts.

Context

The participants in this example have nearly finished the game. All they have to do is take everybody back in the car with the crown.

Analysis

It was identified as an intersection difference because the challenge (line 181) is a direct contradiction. In this example, the participants have conflicting beliefs about how many people will fit into the car. It is resolved by X trying to see how many people he can fit onto the car and finds out he can put everybody on the car.

Go to A in the car

Get Everyone on the Car

180 X : Right then, everybody on

181 Y : We can't fit them all on

182 X : Oh yes we can

[attempts to and succeeds at loading everybody onto the car]

183 : Right then.

Pair 2 Leighanne and Sara (Successful)

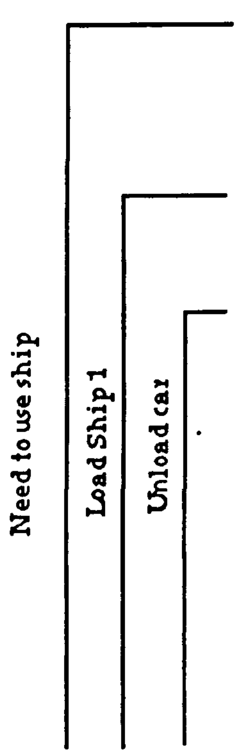
Example 2.1 : Task Focus Difference

Context

The children are at the start of the game they have just driven the car with the driver, the guard, the captain and the pilot from A to B. They realise they need the boat.

Analysis

This is an example of a task focus difference. The children have agreed to use the boat. Y has control of the mouse and goes to card ship action. X challenges this in line 014 by proposing they need to get the people off the car first. Y's quick attempt to press actions suggests that she also knew that they needed to get them off the car first but had forgotten. In terms of the model she did not have it in her task focus until X challenged her.



009 Y* : Oh we need the boat don't we

010 X : The boats at B

011 Y* : Oh yeah

012 : Right go for actions

[went to card Ship actions]

013 X : No

014 : because we have to take them off the car

[went to press buton actions]

015 : No

016 : Go back to Brockley

017 Y* : mm

018 X : Right actions on the car

[went to card car actions]

Example 2.2 : Task Focus Difference

Context

The children have just made their first move, which was to transported the driver, the guard, the pilot and the captain in the car from A to B. They have unloaded the card and have decided they need to use ship 1.

Analysis

This is an interesting example of a task focus difference. The children have decided to use the ship. The mouse controller Y goes to unload the car by going to card car actions. X's "no" in line 025 is enough to make her realise that there is no need to do that because they have already unloaded the car. In terms of the model, X's challenge brings into Y's task focus the fact that they have already unloaded the car. This example is interesting because all X says is no but this enough for Y to change her task focus and see her error.

Unload car

get on ship

009 Y* : So we want to get on the ship
010 : and go to F
011 X : yeah yeah
[went to card car actions]
015 X : No
016 Y* : Oh they're off allready
017 X : yeah
[went to card: Brockley]

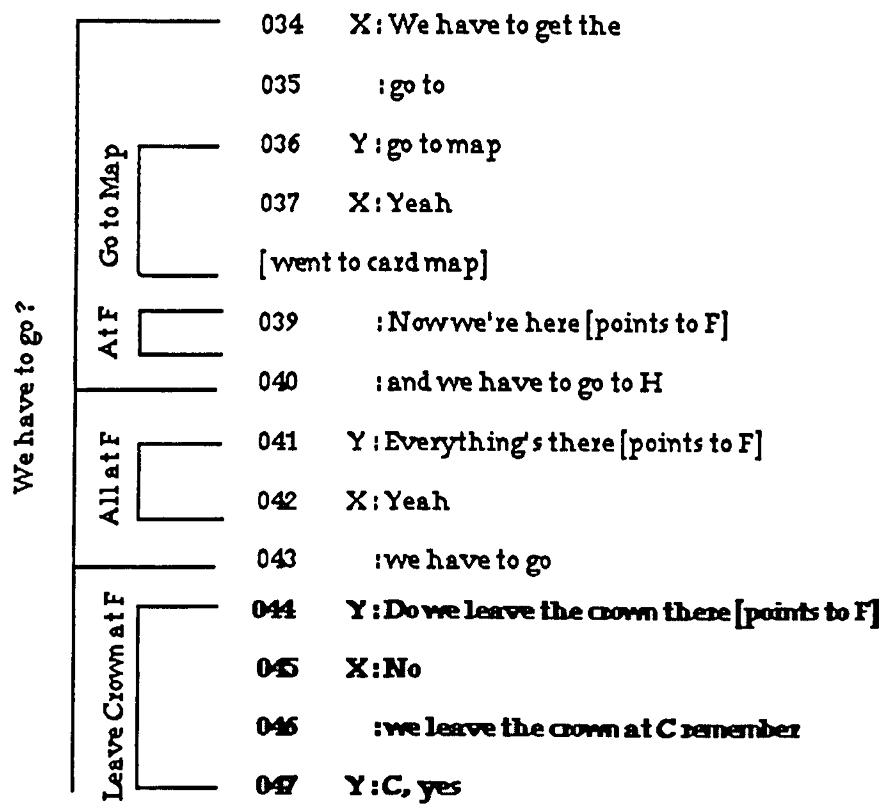
Example 2.3 : Task Focus Difference

Context

The children have made their second move, which was to transport the captain, the guard, the pilot and the driver from B to F in ship 1. They are now discussing where to leave the crown.

Analysis

This is an example of a task focus difference. Y proposes they leave the crown at F. X challenges this by proposing they leave it at C because that is where they left it last time. X's challenge brings into Y's task focus what they did last time, and because she agrees with what they did last time, she quickly accepts.



Example 2.4 : Task Focus difference

Context

The children have made their second move which was to transport the guard, the pilot and the driver on ship 1 to F from B. They have just decided to leave the crown in C (see previous example). They are now trying to work out how to get the crown there.

Analysis

This is a very interesting example of a task focus difference. Y proposes a plan. X challenges this plan in line 053 by saying that the pirates will get them. This challenge brings into Y's task focus the problem of the pirates and because of this she accepts X's challenge. She then goes onto to propose a solution in liner 058.

Take Crown to C

Take Crown by Ship

050 Y* : shall we go down there [points to H]
051 : by sea and by sea
052 X : OK
[went to card key]
053 : No
054 : but the pirates can get us
055 Y*: Yeah well
056 : If we ...
057 X : Right I know

Take Crown by Plane

058 Y*: we take the guard and the pilot by plane with
: the crown Yes?
059 X : Yeah

Example 2.5 : Not Interpretable

Context

All the characters and ship are at F with the crown. The children have decided to fly the crown across the sea (i.e. to C).

Analysis

This conflict is very difficult to analyse because I just do not understand this exchange.

061 Y*: Do we take the crown to there aswell

062 X : Yeah

063 : and leave the crown [points to c]

064 : and drive up there [c to a]

065 Y*: fly there [?] without the crown

066 X : uh

067 Y*: Fly there [?] without the crown

068 X : yeah

Example 2.6 : Hypothesis testing : Information seeking

Context

The children have made their third move which was to transport the captain, the driver, the guard and the pilot on ship 1 from F to H. This was so they could use the plane, which is at F, to fly the crown to C.

Analysis

This is a good example of an intersection difference resolved through active information seeking. The disagreement is over where they are at the moment. L proposes they are at H. X claims they are at F. They resolve it by looking at what is at H.

We're at Hushley

091 Y^2 : we're at H . Yes?

092 X : yeah

093 Y^2 : so if we take the plane route

095 : No

096 : we're at F

097 Y^2 : take

[mouse swap]

098 : No

099 : we're at H

100 X^2 : go see

[went to H]

101 Y : Hushley

102 : we're at H

103 X^2 : yes

Example 2.7 : Not Interpretable

Context

The captain, the driver, the guard and the pilot are all on the ship which is at H. The children are now deciding who to take off the ship.

Analysis

This is quite a difficult example to analyse. It appears that when X attempts to take off the guard by selecting him. Y challenges this move and then changes her mind. It is not clear why she did this. It could be just compliance.

get driver off

[selects driver]

110 Y : Not the driver

111 ; Oh Get him of it

Example 2.8 : Task Focus Difference

Context

The children have just unloaded ship 1 but they are still in ship 1 actions. They want to now load the plane but in order to so this they need to go to plane actions.

Analysis

This is an example of a task focus difference. the children have decide to take the pilot and the guard and fly them back to F. As the first step in this plan X proposes they go to actions. Y challenges this by saying that they are already in actions. But X' proposal makes Y change her task focus and she realises that they need to be in plane actions to load the pilot and the guard on the plane and at the moment they are in ship actions.

Flyback with pilot and guard (117–125)

Ship actions (120–125)

116	Y	: We're at H at the moment
117		: So we have to flyback
118	X*	: Yeah flyback
119	Y	: with the pilot and the guard
120	X*	: So actions
121	Y	: we are in actions
122		: get
123		: no
124		: they're off aren't they
125	X*	: Yeah

Example 2.9 : Task Focus Difference

Context

The children have just made their forth move which was to fly to F from H with the pilot and the guard. they are now trying to load the crown onto the plane.

Analysis

In order to get the crown onto the plane the children need to go to plane actions. They are now at F and can go directly to plane actions from there. But X goes to plane actions via the card actions. Y challenges this by saying Y should have gone down there (i.e. press plane actions). This challenge makes X change her task focus and see her mistake.

Load Crown on plane

Go to plane actions

133 Y : actions now

[went to card actions]

134 : Oh should have gone down there

135 X^2: sorry

Example 2.10 : Task Focus Difference

Context

The children have just made their fifth move which was to fly the guard and the pilot with the crown from F to C. The driver and captain are at H with ship 1. They are now trying to work out how to get the driver and the captain back.

Analysis

This is a good example of a task focus difference. Y makes a proposal to go to B in the plane. X challenges this proposal. Y's explanation in lines 151 to 154 changes X's task focus and she accepts the rationale behind the plan.

get all passengers

144	X	: We have to get all the passengers
145	Y*	: passengers
146		: yeah

We're at C

147		: we're at C
148	X	: yes

Flyback round

149	Y*	: **We'll have to flyback round [C to H to F to B]**
150	X	: **No**
151	Y*	: **without the crown**
152		: **leave the crown there [C]**
153		: **flyback there [b] to get the car**
154		: **to drive there [B to A to C]**
155	X	: **yes**

Example 2.11 : Task Focus Difference

Context

The children have sailed the ship from H to F and then to B with the captain and the driver on board. They are now going to load the passengers onto the car.

Analysis

This is a good example of a task focus difference. The children have to get the passengers into the car. X proposes they go to car actions to load the passengers on. Y challenges this by saying they need to get the passengers off. this challenge changes X's task focus. She then realises that they first need to unload them from the ship before they can load them onto the car.

Load passengers on car

Load car

196 X : get the car

197 : car actions

198 Y : no we have to take them off

199 X : oh yeah

Unload Ship

[went to card ship1 actions B]

[unloads captain and driver from ship1]

Pair 3 Kelly and Marie-Anne (Unsuccessful)

Example 3.1 Intra-individual Conflict

Context

The children have just started the game and have made no moves yet. They have decided to take the car to B and now discussing who to take on the car.

Analysis

In this example, X is have a discussing with herself whether to take the guard and the driver.

007 X[a] : We want a driver and a guard

[select driver]

008 :no

:but there isn't any bandits

009 : oh yes there is

010 :but they won't get us

011 : right so we want the driver

Example 3.2 Intra-individual Conflict

Context

The children have just taken the pilot, the guard, the driver and the captain on the car to B.

Analysis

X is discussing with herself whether to go to boat actions first or car actions first.

025 X*: right we want to go to Brockley

[went to Brockley]

026 : right we want boat actions don't we

027 Y : yeah

[went to card ship1 actions B]

028 X*: No

029 : we've got to get the things of the car

030 Y : the things

031 X : the people

Example 3.3 Intra-individual Conflict

Context

the children have just made their first move and have unloaded everybody from the car. they are now discussing who to take on the ship.

Analysis

Again X is trying to decide who to take on the ship with hardly any contribution from Y.

038 X*: we'll come back on the boat

039 : but we won't have

040 : or should we take the captain with us

041 : we'll take them all with us

042 Y : yeah yeah

Example 3.4 Task Focus Difference

Context

The children have just completed their first move and have unloaded everybody from the car.

Analysis

The children have decided to use the ship. The task focus difference occur when X suggests they go to A, which would mean they would have to use the car. Y challenges this in line 047 which brings into X's task focus their decision to use the ship and so she quickly realises her mistake and accepts Y's challenge.

use Ship

Unload Everybody

041 X* :We'll take them all with us

042 Y :yeah yeah

[unload guard, captain, pilot and driver from car]

043 X* :Just to be safe

044 Y :Yeah just to be safe

Go to A

045 X* :the car is now at B

046 :we want to go to A

047 Y :no we don't

048 :we want actions for the boat yeah

[went to card actions]

049 X* :for the boat yeah

Example 3.5 Task Focus Difference

Context

The children have driven everybody to B in the car. Ship 1 is also at B and they have decided to use it.

Analysis

The children have decided to use ship 1 (which is at B). the task focus difference occurs because X goes to use Ship 2 (which is at C). Y realises the mistake and so challenges X. This challenge makes X also see her mistake and she goes onto use ship 1.

Use Ship			
Ship 2			[went to press Ship2 actions]
Ship 1	050	L	: no actions there
	051	Y*	: right
			[went to card ship1 actions B]

Example 3.6 Task Focus Difference

Context

The children have made their third move which was to take everybody on ship 1 to F. Next they tried to take the crown back on the boat only to find it will be stolen by the pirates. They have now decided to use the plane and have found it is at H and are trying to get there.

Analysis

This is a good example of a task focus difference. X proposes they go to H on the boat. Y challenges this proposal by saying the pirates will get them. This challenge brings into X's task focus the problem of the pirates and therefore accepts it. Y then constructs a plan which overcomes the problem of the pirates.

Go to H in Ship	102	X*	: We've got to go to H by boat
	103	Y	: Yeah but the bandits will get us
	104		: pirates
	105	X*	: oh yeah
Leave Crown and go to H	106	Y	: If we leave the crown here [F]
	107		: go on the boat there [H]
	108		: and they can't get us
	109		: and come back with the palne
	110	X	: yeah

Example 3.7 Not Interpretable

Context

The children have just decided to go and get the plane, which is at H, in ship 1. They are now deciding who to put on the boat.

Analysis

This is a complicated disagreement to understand ands does not fit easily within the framework of the model. It appears that they have decided use Ship 1 and they have gone to Ship 1 actions. R by mistake tries to unload some people. Y spots this mistake and challenges her in line 120. X still does not see her mistake and counters by saying she is trying to put them back on. X only accepts the challenge when Y explains the error in line 124.

Go in Ship 1 to plane at H

Go to Ship Actions

118 X^2 : we want ship actions

[went to ship actions]

load passengers

119 : we want the captain and the driver

[went to press get off]

120 Y : no

121 : they're allready off aren't they

122 X^2: yeah

123 : but we want them all back on the ship don't we

124 Y : well thats get on

125 X^2 : oh yeah

[loads guard captain pilot driver from ship1]

Example 3.8 Task Focus Difference

Context

The children have made their fourth move which was to sail in ship 1 from F to H with the captain, the driver, the pilot and the guard. They are now trying to load the everybody on the plane.

Analysis

This is a good example of a task focus difference. The children realise they can only take the pilot and one other person on the plane. X proposes they take the captain. Y challenges this by saying they need to take the driver. This challenge brings into X's task focus the need to take the pilot and because of this she accepts. Y then comes up with a solution to the problem.

take everyone on plane to F

Load Everyone

[attempts to load captain guard driver and pilot on plane]

[BEEP BEEP plane over loaded]

Take captain

145	R[a]	: take one passenger
146	Y	: pilot
147	X[a]	: passenger
148		: we want the captain though with the boat
149	Y	: we need the driver an all
150	X[a]	: oh no

go back and get others

151	Y	: Ah yes well err
152		: we'll have to go back every now and then

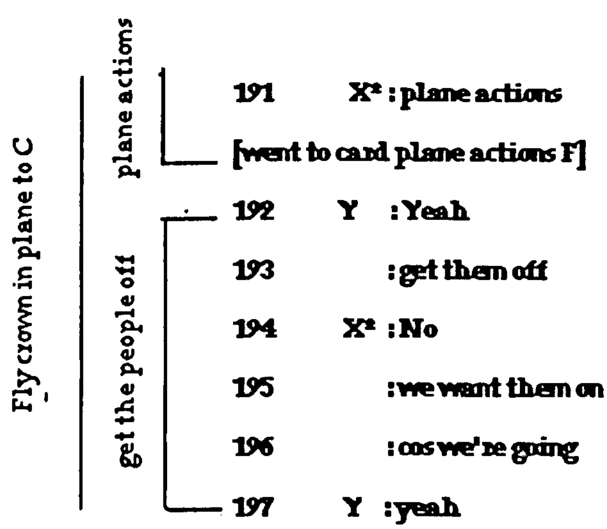
Example 3.9 Task Focus Difference

Context

The children have just ferried the captain and the driver in the plane to F from H leaving the guard at H. They now want to pick up the crown and take it back to C.

Analysis

This is another example of a task focus difference. Y proposes they take everybody off. This is a mistake because they have decided to use the plane to go to C. X spots the mistake and challenges Y. This challenge brings into Y's task focus the fact they are going to use the plane so the people need to stay on the plane. Y therefore accepts X's challenge.



Appendix B : Coding Scheme for Jugs

Instructions

Your task is to classify the utterances in the extracts. Each line in an extract is taken to be an utterance. Use the context table to tell you what categories a particular utterance can be. For example if an extract has a fourth utterance then it can only be classified as an accept. Then use the category examples to assist you in classifying the utterance .

Context Table

Participant	A		B		A		B
Utterance	0		1		2		4
	Proposal	->	Accept				
	Proposal	->	Hesitation	->	Ignore		
					Support	->	Accept
	Proposal	->	Exclamation	->	Ignore		
					Support	->	Accept
	Proposal	->	Question	->	Ignore		
					Support	->	Accept
	Proposal	->	Challenge	->	Ignore		
					Accept		
					Support	->	Accept

Category Examples

1) Hesitation

Eg "wait", "hold on"

2) Question

Eg "why", "huh", 120?

3) Exclamation

Eg "120!", "Wow", "Bloody Hell"

4) Challenge

with no explanation

Eg "no" , "don't do that"

with explanation

Eg "no thats too much"

"Now what can we do"

"38 is not going to fit into the others"

with Alternative

Eg "How about 30 + 9"

"No lets put two 20's and a 9"

5) Support

eg "Yes I know but you can take some out"

"Yes but we can subtract"

"If you do that then you can empty some out"

6) Accept

explicit

eg "yes" "ok" "alright"

or repeat the proposal]

eg " Fill jug B up", "60", "jug B"

Implicit

If one subject A makes a proposal and the subject B does not respond this is taken to be acceptance by subject B

It is marked in the transcripts by "[ ]"

eg A Lets fill jug B

[fills Jug B]

PROPOSAL 1

B []

1.1 Acceptance

7) Ignore

Propose next step in proposal with no reference to previous utterance

eg	A	Fill Jug B up
		PROPOSAL 1
	B	Hey wait
		HESITATION
	A	Empty that [B} into there [C]

Examples

1)

	KM	Lets Fill Jug B
		PROPOSAL 1
	JD	OK
		1.1 Accept

2)	KM	Lets fill Jug B
		[Fills Jug B]
		PROPOSAL 1
		Now empty that [B] into there [C]
	JD	[]
		1.1 Accept

3)	KM	Lets fill jug B
		[Fills jug B]
		PROPOSAL 1
	JD	Yeah Ok
		1.1a Accept
		No that's far too much
		1.1b Challenge
	KM	No its alright we can take some out
		1.2 Support

4)	KM	Fill jug B up
		PROPOSAL 1
	JD	No Fill up Jug C and pour it into B
		1.1 Challenge
		PROPOSAL 2
	KM	No fill up jug B
		2.1 Challenge
		PROPOSAL 3
	JD	But its well over 84
		3.1 Challenge
	KM	Yes I Know but we can take some out
		3.2 Support
	JD	OK
		3.3 Accept

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