Children's Learning from Contrast Modelling

K.J. Pine*, D.J. Messer^, & K. St. John*

*University of Hertfordshire,

Psychology Dept.,

College Lane,

Hatfield,

Herts.

AL10 9AB

Tel: 01707 284000

Fax: 01707 285073

E-mail: K.J.Pine@herts.ac.uk

^Psychology Division,

South Bank University,

103 Borough Rd.,

London SE1 0AA

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Abstract

This study investigates the effectiveness of immediately modelling the correct solution to a task on which children were making errors. The technique is based on proposals by Saxton (1997) who, in his Contrast theory of negative input, claims that corrective speech input is particularly effective when it immediately follows a child’s error, such as an overgeneralisation of a verb ending. Our study concerns a very different domain, that of children learning to balance beams on a fulcrum, but one in which children also tend to overgeneralise a particular strategy. On a pre-test on the balance beam task, we identified a number of children (N = 79, mean age = 74.82 months) who were making errors. These children were randomly assigned to two groups and either (a) watched the correct solution being modelled by an adult or (b) saw the correct solution being modelled by an adult immediately after their own error. The latter, Contrast Modelling, condition produced a significantly higher number of children who had improved at the task at post-test. The implications of these findings for general models of development are discussed.

Introduction

It is generally assumed that the use of both feedback and correct exemplars will assist children's learning. These assumptions underlie much classroom activity which is mediated both by teachers and by computers. Research into the effectiveness of feedback has generally indicated that it can assist children's progress (e.g. Tait, Hartley & Anderson, 1973; Schimmel, 1983), although in certain circumstances feedback may be ineffective (Cromer, 1987; Messer, Norgate, Joiner, Littleton & Light, 1996; Messer, Mohamedali & Fletcher, 1996). The benefits of correct exemplars and modelling have been highlighted by the work of Bandura (1973) and have been the subject of intense research for nearly three decades.

It is apparent that feedback and modelling can be organised in a variety of ways. In this study we investigate the benefits of providing children with the correct model after they have made an error. Our interest in this issue arose from work by Saxton (1997) which suggests that children's language acquisition can be assisted by the provision of a correct utterance immediately after children have made a grammatical error. The effect of this type of response often has been overlooked in studies of children's speech because of the emphasis given to the many model utterances that are present in the language environment of children. Saxton found that organising the presentation of information in this way was more effective than providing a similar number of non-contingent examples of model utterances. Saxton proposes what he refers to as Contrast theory to account for these effects and stresses that the potency of this process is due to the immediate contingency of the correct adult utterance upon the child's error.

Saxton situates his research in relation to current discussions about language acquisition and a longstanding argument about the significance of negative input and feedback. The findings of Brown and Hanlon (1970) indicated that parents do not explicitly correct their children's grammatical errors. However, subsequent investigations revealed that adults often follow a child's error with a grammatically correct expansion of the utterance (e.g. Hirsh-Pasek, Treiman & Schneiderman, 1984; Demetras, Post & Snow, 1986; Bohannon & Stanowicz, 1988). The ensuing debate about these findings concerned whether expansions assist language acquisition by providing children with indirect feedback about which of their utterances are correct and which are incorrect (Pinker, 1988; Jackendoff, 1993). Saxton argues that such discussions have ignored the potential benefits of children being immediately provided with a correct model utterance. He believes that expansions provide more than indirect feedback about whether or not an utterance is grammatically correct. He claims that the contrast between a child's error and the parent's model utterance provides a much more powerful learning experience, and he has experimental evidence to support his claim.

The research conducted by Saxton was concerned with children making overgeneralisation errors; that is they apply a grammatical rule to an inappropriate word. Well-known examples of this phenomenon are children saying “sheeps” or “goed” (Saxton, 1997, p.155). Children's overgeneralisation errors are similar in form to one of the levels of cognitive development identified in our previous research. This research has developed out of Karmiloff-Smith's (1992) model of Representational Redescription, and she discusses the way that overgeneralisation errors correspond to one of the levels of knowledge she identifies. Our own research, using a balancing task, has confirmed Karmiloff-Smith's predictions that children show evidence of "overgeneralisation" by inappropriately applying a "rule" to certain problems. The work also indicates that these children are less likely than children at other representational levels to benefit from interventions designed to assist their learning. This makes it especially interesting to determine whether contingent modelling can be utilised by children who show evidence of overgeneralisation, but who are involved in a very different task.

The task chosen to test this hypothesis in our investigation is a balance beam task (see Karmiloff-Smith and Inhelder, 1974) in which a child has to balance some wooden beams upon a simple fulcrum. The beams basically fall into two categories, symmetrical and asymmetrical. The symmetrical ones are either a flat piece of wood, or one with a small block attached to each end. The asymmetrical ones have one or two blocks, only at one end. When placed upon a fulcrum the symmetrical beams balance at their geometric centre whereas the asymmetrical beams have to be positioned off-centre. In our previous studies we have replicated Karmiloff-Smith and Inhelder's finding that many children are only able to balance symmetrical beams. This is because they place every beam, whatever its type, onto the fulcrum at its geometric centre. Yet when the asymmetrical beams fall these children replace them at the centre, often many times, before dismissing them as being impossible to balance. This somewhat surprising finding is remarkably robust. For example, in a cross sectional study of 168 children aged 4 to 9 years, we found 80 children who could not balance asymmetrical beams (Pine and Messer, 1999). These children seem to operate according to the maxim that ‘all things must balance in the middle’ and ignore the proprioceptive feedback from their own hands which intuitively one would expect to guide them to balance the beams off-centre.

Although these language and cognitive domains present very different problems to children, involving learning irregular past tense verbs or balancing asymmetrical beams, in both cases children are seen to overgeneralise a rule. In Saxton’s study of language, children were overgeneralising the -ed ending of the past tense to irregular verbs (e.g. <u>I feeled it</u> instead of <u>I felt it,</u> 1997, p. 315). In the balancing studies, the children were overgeneralising a strategy for symmetrical beams to asymmetrical beams. Because of these commonalities, we thought it would be of considerable interest to ascertain whether these processes reflect general cognitive principles underlying the linguistic and cognitive domains. However, it is worth noting that the information provided by Contrast modelling could form the basis of slightly different learning processes in these examples of language and balancing. It is possible that language development involves learning irregular past-tense verbs on a case-by-case basis, as has been proposed in the dual mechanism model (Pinker, 1991), and here children would have to learn exceptions to a rule. This claim is disputed by connectionist theorists who argue that irregular and regular verbs are acquired by the same associative cognitive mechanism (e.g. Plunkett, 1995). On the other hand, Karmiloff-Smith (1992) has suggested that the development of higher levels of representation does not necessarily involve the elimination of earlier representations, and these earlier representations may continue to be applied in some circumstances to problems (Murphy, Pine & Schelletter, 2002). Thus, children might continue to apply their ‘centre’ strategy to symmetrical beams, but formulate a new rule to cope with exceptions. It should be apparent that these approaches to acquisition identify different mechanisms, and there is uncertainty about the precise learning mechanisms in both language and other domains. However, all these proposals are compatible with a learning process that involves contrast modelling.

Karmiloff-Smith (1992), in her Representational Redescription model, offers a plausible explanation for why these overgeneralisations occur in many domains of learning. In her model, knowledge which is acquired about the physical world is initially encoded in an implicit format. This means that children can interact with, and often gain mastery over, their spatial environment without having any knowledge of the physical laws which govern their world. Thus, a child as young as 4 or 5 years may be able to balance both symmetrical and asymmetrical beams on a fulcrum, but shows little evidence of higher order abstraction of principles and cannot explain their own success. However, Karmiloff-Smith believes that the cognitive system does not simply guide action but is driven to gain control and understanding of the actions. Therefore an abstract system is built, founded upon the implicit knowledge. In order to achieve this, following a period of success, the implicit representation undergoes redescription to the next level in the RR model called Level E1. This involves abstracting the central feature from the wide range of experiences the child has had within the domain and forming a coherent rule or ‘theory’. Such ‘theories’ constitute a more abstract type of knowledge and in the case of the balancing domain involves the assumption that ‘all things balance in the centre’. This generalisation means that accuracy suffers, errors are made and evidence which disconfirms the theory is ignored. The advantage is that the child now has a useful heuristic and can build further abstract - or metacognitive - knowledge. A number of other investigators have commented on cognitive development in relation to implicit and explicit examples of children’s knowledge (Alibali & Goldin-Meadow, 1993; Clements & Perner, 1994; Kuhn, Amsel & O’Loughlin, 1988).

Karmiloff-Smith supposes that when acquiring language, children gradually recognise patterns in their linguistic environment and construct ‘theories-in-language’ as revealed by overgeneralisation errors such as foots instead of feet, or goed instead of went (Karmiloff-Smith & Inhelder, 1974). Karmiloff-Smith suggests that this phenomenon in language demonstrates that children are building a meta-linguistic system and that providing frequent counter-examples will not induce them to drop their theory. She points out that children continue for some time to produce these overgeneralisations until they are ready spontaneously to recognise that exceptions to the rule exist.

The top-down nature of the knowledge involving overgeneralisations raises concerns about how children can be helped to move beyond this stage. Karmiloff-Smith argues that the process is largely endogenous and that redescription to more explicit formats usually will be internally provoked. Consistent with this view are findings that children at this level of knowledge do not benefit from observational learning, where the model is not contingent on the child’s error (Pine and Messer, 2000), and that children do not benefit from computer-based feedback (Messer et al., 1996). However, this viewpoint may need to re-evaluated because there is evidence that peer interaction can assist representational redescription at some levels (Messer et al., 1993) and that asking children to produce explanations of another's correct performance aids progress (Pine & Messer, 2000). It should also be apparent that Saxton's theory claims children becomes aware of exceptions to the rule via the immediate juxtaposition of incorrect and correct speech forms, whereas the RR model supposes that at certain phases children will have difficulty making use of external information

Drawing on Karmiloff-Smith's, Saxton's and our own work, we pose a question about whether Contrast Modelling is an effective intervention technique, particularly in relation to children who "overgeneralise". In this study, children who are making errors on a balance beam task are provided with models of the correct solution in an intervention that follows the pre-test. Children are randomly allocated to one of two conditions. In one condition the modelling immediately follows the child's error, this is referred to as the Contrast modelling condition (analogous to Saxton's Contrast theory of corrective input). In the second, Non-Contingent modeling, condition the child sees an adult model the correct solution but this does not immediately follow the child's own error. If it is the contingency of the correction upon the child's error that is the potent variable, as Saxton claims to be the case in language learning, we expect the Contrast condition to produce greater improvement. Such a finding would suggest that there could be a general learning mechanism underlying similar forms of both linguistic and other cognitive behaviour.

Method

A pre-test, treatment phase and post-test design was employed. The treatment phase had two between subjects conditions: Contrast modelling and Non-Contingent modelling. The dependent variables were (i) the within subjects pre- to post-test change in number of asymmetrical beams balanced (ii) the within subjects pre- to post-test change in representational level.

Participants.

One hundred and twenty six children from four Hertfordshire lower schools took part in the pre-test. The children were all in Year 1 or Year 2 and ranged in age from 5 to 7 years. Forty-seven of the children were able to balance all the beams at pre-test and did not take part in the rest of the study. Seventy-nine children, mean age 74.82 months, took part in the treatment phase and post-test phase of the experiment. These included 42 boys and 37 girls.

Materials.

For the pre- and post-test eight wooden beams were used:

4 symmetrical beams, two without blocks (30 cm. long), one with a block either end (30 cm. long) and one ‘double’ beam (45 cm. long). All of these balanced at their geometric centre.

4 asymmetrical beams, one with one block at one end, three with two blocks at each end, 30 cms in length. All of these balanced off-centre. For examples of the beams used see

Figure 1. The fulcrum was constructed by having a plastic block, 1cm square x 30cms long glued along the centre of a wooden base, 20cms wide x 30cms long. The sessions were recorded using a Panasonic VHS video camera.

Insert Fig 1 about here

Procedure.

The children were seen individually in a quiet area of the school. The child was seated at a table alongside the experimenter and, after introductions, the experimenter explained that they were to do some balancing. Each child was shown the materials and told, “I would like you to see if you can make any of these wooden beams balance on the bar here *(indicates fulcrum).*” After checking that the child understood what was required, answering any questions asked and ensuring that she or he wished to continue, the experimenter invited the child to choose a beam with which to begin.

Pre-test: The child attempted the beams one at a time and the experimenter encouraged the child to give explanations about how each beam balanced or, if it would not, the reason why he or she thought it would not. This was done by asking the children after they were successful, “How did you get that one to balance?” or “How is that one balancing?” Similarly, if a child failed to balance a beam the experimenter asked questions like, “Why won’t it balance?”, “What did you do to try and get it to balance?” or “Do you think it can be balanced?” Any children who successfully balanced all the beams were praised, thanked and returned to their classroom.

Treatment Phase: After the pre-test the children who had not balanced all the beams were randomly assigned to one of two conditions. Thirty-eight children went on to experience the Contrast modelling condition, 41 went on to the Non-Contingent modelling condition.

Contrast modelling condition: In this condition the experimenter selected the beams that the child had failed to balance at pre-test and told the child, “ I would like you to have another try at balancing these beams”. The child attempted the beams one at a time and, as soon as he or she failed to balance one, the experimenter said, “Shall I have a try at that one?” and balanced the beam on the fulcrum. This was repeated for each of the beams that the child failed to balance, each time the child’s unsuccessful attempt was immediately followed by the experimenter modelling how the beam balanced.

Non-Contingent modelling condition: In this condition the experimenter selected the beams that the child had failed to balance at pre-test and asked the child to have another attempt. Then the experimenter said to the child, “ I have had a bit more practice than you at balancing. Would you like to see how I make these beams balance?” The experimenter then balanced each of the beams in turn upon the fulcrum.

Post-test: The child was then told, “Now I would like you to have another go at balancing all the beams” and the post-test was conducted in the same way as the pre-test, with the child attempting all 8 beams and the experimenter asking questions to probe their knowledge.

There was then a short debriefing session when the experimenter answered any questions the children had, praised and thanked them. The child’s performance during the session was recorded on a data sheet by the experimenter and by the video recording. As well as recording the number of beams balanced by each child, a classification system was used to code each child at pre- and post-test according to a level of representation. This ensured that not only behavioural measures were obtained but also a measure of the explicitness of the children's knowledge about balancing, based on the type of explanations they were able to offer. Our previous work (see Pine and Messer, 1998, 1999) has identified a developmental sequence of levels which accounts for children's representations of the balance task and these were used to classify the children in this study:

Implicit: the child is able to balance at least three of each type of beam (out of 4 symmetrical and 4 asymmetrical beams), but has no consistent strategy for balancing or for initially placing a beam on the fulcrum. In addition the child is unable to offer an explanation for their success (e.g., says "Don't know" or "I just did it"), or explanations fail to include a mention of both the relevant variables, weight and distance.

Implicit Transition: the child is able to balance no more than one of each type of beam, but places all beams onto the fulcrum at around their mid-point. Explanations are similar to those at the Implicit level (see above).

Abstraction Non-Verbal: the child is able to balance at least three symmetrical beams but fails on all, or all but one, of the asymmetrical beams. There is clear evidence of a centre strategy, with all beams being placed onto the fulcrum at their mid-point. The child may state that asymmetrical beams cannot be balanced but does not explain their centre theory.

Abstraction Verbal: performance is equivalent to Abstraction Non-Verbal level (see above) but explanations include reference to the centre strategy (e.g., says, "You have to put it in the middle.").

Explicit Transition: the child is able to balance at least three of each type of beam and is able to explain their strategy for balancing both types (e.g., says, "You have to put this in the middle," for a symmetrical beam, or, "You have to put this one a bit more over to the side," for an asymmetrical beam). However, there is no explanation of the function of the two relevant variables, weight and distance.

Explicit E3: the child is able to balance at least two, and usually all, of each type of beam and explanations include reference to the compensatory function of the two variables, weight and distance (e.g., says, "This side's got more weight on so I make this side longer so that it has the same weight").

A small number of children could not balance any beams at pre-test, showed no use of any strategy and could not explain the task; they were classified as Pre-Implicit.

Children were classified according to the criteria outlined above. For the present study inter-rater reliability was assessed by having two raters independently classify 12 of the children's videotaped performances at pre-test. This produced 83% inter-rater agreement. Discrepancies were resolved by discussion and thereafter one experimenter classified the children.

Results

The number of children classified at each representational level.

The 47 children who balanced all of the beams at the pre-test are not included in any of the analyses. Those who failed to balance at least one beam took part in the rest of the study (N = 79). The number of children at each level of representation at pre-test is shown in Table 1.

Insert Table 1 about here

The effect of the conditions on ability to balance symmetrical and asymmetrical beams.

For the majority of children the symmetrical beams were far easier to balance than the asymmetrical beams. At pre-test the mean number of symmetrical beams balanced, out of a maximum of 4, was 2.89 (sd = 1.19), this improved to 3.63 (sd = .83) at post-test. The mean number of asymmetrical beams balanced at pre-test, again out of a maximum of 4, was just 1.24 (sd = 1.18), rising at post test to 2.79 (sd = 1.49). As there was more scope for pre- to post-test improvement in the ability to balance asymmetrical beams (and it is with these beams that errors arise from overgeneralisation) the following analyses concerns these beams.

The mean number of asymmetrical beams balanced at pre-test by children who were subsequently randomly allocated to the Contrast modelling group was 1.05 (sd = 1.04). The mean number balanced by children who were subsequently randomly allocated to the Non-Contingent modelling group was 1.43 (sd = 1.32). To test that the two groups did not differ significantly at pre-test these scores were entered into a one factor Analysis of Variance (ANOVA) with Condition (2 levels, Contrast modelling and Non-Contingent modelling) as the between subjects factor. No significant difference was found, F (1,77) = 2.94 p > .05.

The number of asymmetrical beams balanced at pre-test and at post-test were entered into a mixed ANOVA with Condition as the between subjects factor (2 levels, Contrast modelling and Non-Contingent modelling) and the pre- and post-test scores as the repeated measures dependent variable. There was a main effect of number of beams balanced pre- to post- test, F (1, 77) = 83.04, $p < .01$. Therefore, overall the children were able to balance significantly more asymmetrical beams at post-test than at pre-test. There was also an interaction of the number of beams with condition, F (1,77) = 5.57, $p < .05$. The Contrast modelling condition produced a significantly greater improvement in the number of asymmetrical beams balanced pre- to post-test than the Non-Contingent modelling condition (see Figure 2).

Insert Figure 2 about here

The effect of the conditions on representational level.

As well as performance measures we were also interested in whether the children's representation of balancing had been changed. By classifying the children according to one of the levels of representation at pre-test it was possible to record whether or not a child had reached a higher level of representation in the post-test. As Table 1 shows, of the 38 children in the Contrast modelling condition, 23 (61%) moved to a higher level at post-test. In the Non-Contingent modelling condition, only 9 children out of 40 (23%)

improved. A chi-square analysis of these frequencies revealed a highly significant association between condition experienced and improvement, X^2 (1, N = 78) = 11.65 p < .01.

Contrast Modelling and Children's Level of Representation

It was thought worthwhile to examine the effect of the conditions on children at different levels of representation. However, the limited number of children at some levels means that one must be cautious when interpreting these data.

Implicit Levels: There were only 9 children at the Implicit level, and none of these increased their performance from pre-test to post-test. Of the 14 children at the Implicit Transition level, in the Contrast Modelling condition 4 out of 6 improved, and in the Non-Contingent modelling condition 3 out of 8 improved. Due to the small numbers in these groups it was not possible to test these associations statistically.

Abstraction Levels: Did contrast modelling assist the progress of children who were using a centre strategy with asymmetrical beams and failing to balance them? These children were classified as being either at the Abstraction Non-Verbal or the Abstraction Verbal levels.

The Abstraction Non-Verbal group (n = 21) included children who tried to balance beams at their geometric centre but could not verbalise their centre strategy. Of the 10 children at this level in the Contrast modelling condition, 7 improved (70%) whereas of the 11 children at this level in the Non-Contingent modelling condition, only 3 improved (37%). A Chi-square analysis revealed that the association between condition and improvement just reached significance, X^2 (1, N = 21) = 3.83, p = .05. Thus for children at the

Abstraction Non-Verbal level, improvement was more likely if they had been in the Contrast modelling condition.

The Abstraction Verbal group (n = 20) included children who tried to balance beams at their geometric centre but these children, unlike those at the Abstraction Non-Verbal level, could also verbalise their strategy. Unfortunately, the allocation of these children to the two conditions was less balanced than the group above (with more of them experiencing the Contrast modelling condition) but nonetheless a similar pattern emerged. Of the 13 children at this level in the Contrast modelling condition, 10 improved (77%) whereas, of the 7 children at this level in the Non-Contingent condition, only 2 improved (35%). A Chi-square test of these frequencies found that there was a significant association between condition and improvement, X^2 (1, N = 20) = 4.43, $p < .05$. Thus, for children at the Abstraction Verbal level, it appears that improvement was more likely if they had been in the Contrast modelling although this analysis has to treated with caution as some expected frequencies were low.

Therefore, it appears that children at the Implicit levels did not gain any particularly powerful assistance from Contrast modelling or Non-Contingent modelling. In contrast, children with a centre theory of balancing, whether verbalisable or not, were helped more by the Contrast modelling condition than by the Non-Contingent modelling condition, a pattern which reflects the more general finding of the study.

Discussion

This study set out to investigate whether modelling the correct solution to a child on the balance beam task would be more effective when the modelling was contingent upon the child's own error. This was done either by showing children the correct solution immediately after their own error (Contrast modelling), or by simply showing children correct solutions to their previous errors (Non-Contingent modelling). Our hypothesis, that the Contrast modelling condition would produce more children who improved than the Non-Contingent modelling condition, is supported by the data reported here. As well as significantly improving the children's ability to balance asymmetrical beams, this condition was also effective in bringing about improvement in the children's representations of balancing. There are also indications that Contrast modelling was especially effective with children at the Abstraction levels, i.e., those who were failing to balance asymmetrical beams due to overgeneralisation of a centre strategy. The choice of control groups followed the design employed in the research by Saxton (1997). It should be acknowledged that the employment of additional control groups would further increase confidence in these conclusions, for example by having a group who attempted the task but did not receive any feedback, and by having a group who did not engage in the task at all.

Although the Contrast theory of corrective input has been advanced as an explanation for improvement in children's language (Saxton, 1997), this is the first attempt (as far as we are aware) to apply the theory to a different cognitive domain. In our study the participants were not children who were making linguistic errors, but children who were balancing wooden beams on a fulcrum. It is therefore interesting to discover that a similar principle, which operates in language learning, can also help children in other domains. Given that it is difficult to assist the cognitive development of children who attempt to balance beams at their geometric centre (Messer et al., 1996; Pine & Messer, 1998, 2000), it is especially interesting that these children made significant gains in the Contrast modelling condition.

The question that our data does not answer is exactly why the contingency of the modelling appears to be so crucial to assisting cognitive development. We can only speculate as to why this may be the case. Saxton claims that contrast modelling is effective because it reveals to the child a contrast, or conflict, between their own error and the correct form. This, he says, provides a basis for rejecting the incorrect form. Can this explain why non-contingent modelling is less effective in the present study? Here, the children who made errors at pre-test went on to retry them in the Non-Contingent modelling condition and to see an adult modelling the correct solution just a minute or two later. In the Contrast modelling condition, the child had another attempt with each beam they had failed to balance and this was followed immediately by the adult modelling the correct solution. It may seem surprising to some that this subtle contingency manipulation was responsible for producing such a large effect. One might expect that children in the Non-Contingent modelling condition, having had the solution shown to them, would also go on to adopt a better strategy at post-test. Yet two-thirds of them failed to do so and continued to make errors. The difference in conditions, with one having the child see the correct solution modelled after making the error, produced a dramatically different picture with almost two-thirds of the children from the Contrast Modelling condition performing better at post-test.

In our work we have always found it informative to measure not only what children are able to do (e.g., how many beams they can balance) but also what children actually know and the different ways of knowing (see Pine & Messer, 2000). This is because children can sometimes balance all the beams with little or no ability to explain their own success. Or, alternatively, they can fail with asymmetrical beams and yet show signs of beginning to develop some abstract knowledge about balancing, which involves balancing the beams at their centre. Therefore, children's balancing performance can be accompanied by knowledge at varying levels of explicitness (see Karmiloff-Smith, 1992) and this is borne out by the six levels of representation used to classify children in this study. We propose that the effects identified in this study can be best explained by supposing that children's cognitive development is facilitated by their having to access their representations at the same time that information that challenges their representations is presented. Children at the Implicit level did not improve, and this may have been due to the fact that they cannot access their representations. During Contrast modelling, the child is presented with the correct solution whilst their own representation of the task is still active i.e., immediately after their own attempt. In the Non-Contingent modelling condition, the children saw the correct solution but their own representation may no longer have been active, with the result that it was less likely to be challenged. Support for this interpretation comes from other findings which indicate that when children at the

Abstraction level are asked to explain another's correct non-contingent performance their own performance improves, whereas children who see the model but do not have to explain what is happening do not improve (Pine & Messer, 2000). Thus, we hypothesise, that when the correct model is presented in a non-contingent manner *and* children are asked to access their own representations then cognitive progress is more likely to occur. Thus, we are not disagreeing with Saxton's ideas about Contrast modelling, but suggesting that they may be extended to a greater range of circumstances.

Assessing changes in the children's representations of the task, as well as their performance, also gives more insight into whether children are merely mimicking the correct solution they saw modelled or whether they have made cognitive progress in their understanding of the task. The representational improvement, as well as procedural change, found in many children this study is more likely to be indicative of lasting cognitive change (as found in Messer et al., 1996; Pine et al., 1999) although future studies could employ delayed post-tests to verify this. Saxton et al. (1998) has carried out a study into the longer-term effects of this type of corrective modelling and found that improvements in children's linguistic output were sustained five weeks later.

In this study we selected children aged from 5 to 7 years, since children older than this are more likely to be able to balance all the beams. Saxton, too, concentrated on 5 year-olds, an age when children are still making linguistic errors. It is therefore possible that this learning mechanism is only appropriate within a certain age group. However, Karmiloff-Smith (1992) has pointed out that representational levels are not restricted to certain ages or stages and it is likely that older children or adult learners could also benefit from contrast modelling in other domains. Thus, whilst this work clearly raises many questions about the domain generality of language learning mechanisms, we believe further work in this area might illuminate the potential of this method for those involved in teaching or training. It suggests that, because of its non-contingency, demonstrating a new skill to others might not be the best approach for a teacher to adopt. These data suggest that allowing the learner to attempt the task first and then providing the correct model immediately after an error has occurred might be a more effective way of facilitating change.

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Table 1: The number of children who were at each level at pre- and post-test, allocation to conditions and number who improved.

REPRESENT-ATIONAL LEVEL	NUMBER OF CHILDREN AT LEVEL		CONTRAST MODELLING		NON-CONTINGENT MODELLING	
	Pre-test	Post-test	n	n improved*	n	n improved*
Pre-Implicit	5	3	3	2	2	0
Implicit	9	9	3	0	6	0
Implicit Transition	14	9	6	4	8	3
Abstraction Non-Verbal	21	12	10	7	11	3
Abstraction Verbal	20	16	13	10	7	2
Explicit Transition	9	19	3	0	6	1
E3	0	10	n/a		n/a	
	79		38	23	40	9

1 subject missing data
* improvement defined as being at a higher level at post-test than pre-test.

<u>Figure 1:</u> Examples of (a) symmetrical beams and (b) asymmetrical beams used in the balance beam task.

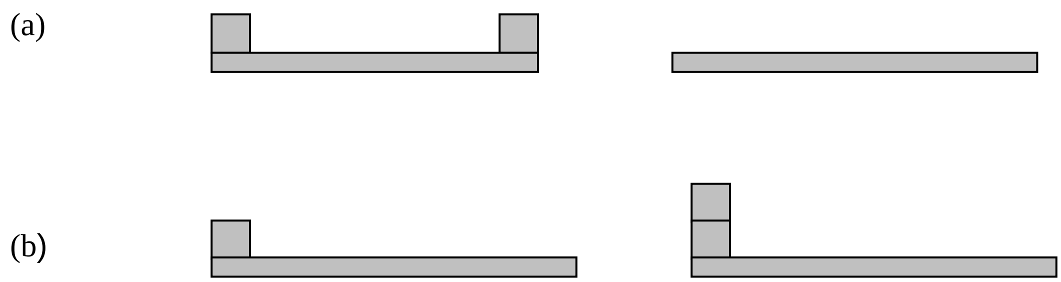

Figure 2: The mean number of asymmetrical beams balanced at pre- and post-test by children in each of the conditions.