THE CONCEPT OF CONTRADICTION IN
THE STUDY OF COGNITIVE DEVELOPMENT

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PART 1

THE RESOLUTION OF CONTRADICTION
AS A POSSIBLE CAUSAL AGENT
IN COGNITIVE DEVELOPMENT
CHAPTER 1
LITERATURE RELATING TO THE
ROLE OF THE RESOLUTION OF
CONTRADICTION DURING COGNITIVE DEVELOPMENT

In 1969 Inhelder and Sinclair described for the first time work they had undertaken aimed at accelerating cognitive development by producing the conditions of natural development as described by Piaget's theory of equilibration.\(^1\) This work was reported for a second time by Inhelder in 1972. It was finally integrated with a theoretical framework and other experiments and presented again by Inhelder, Sinclair and Bovet in 1974.

The 1969 study encouraged work by Strauss and his collaborators which consisted of a replication of the paradigm with different measures (Strauss & Rimalt, 1974; Strauss & Ilan, 1975). It also prompted work by Lefebvre and Pinard who used an alternate paradigm (Lefebvre & Pinard, 1972, 1974). These studies were conducted principally to show that Piaget's theory of equilibration was supported by empirical data, but their results could also be interpreted to show that resolving a contradiction is a motivating force or causal agent in cognitive development.

In the Inhelder, Sinclair and Bovet (1974) study, 16 children between the ages of five and seven years inclusive who understood conservation of number,\(^2\) but who had not achieved an understanding of conservation of

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\(^1\) "Equilibration" is the self regulating aspect of development. The self regulating mechanism involves a feedback loop which restores the cognitive system, following a perturbation, to its previous state, or, in some cases (called an increasing equilibration) to a higher level of understanding. Fuller details of Piaget's theory of equilibration can be found in Appendix 1b.

\(^2\) The concept of conservation is the concept that "quantity", of all sorts, remains the same regardless of its spatial arrangement. An explanation of these terms may be found in Appendix 1a.
length, were asked to judge if "roads" built with different numbers of matches were of the same length. The children had two different strategies available to them to solve this problem. They could either align the boundary lengths of the two "roads" vertically (see B'in Figure 1.1), a strategy which employed their (imperfect) understanding of the concept of length, or they could count the matches in both "roads" (see B" in Figure 1.1), a strategy which employed their understanding of the concept of number.

However, by counting the number of matches the children obtained a different answer from that obtained by judging the perceived boundary lengths of the "roads". That is, the children who had attained conservation of number, but not conservation of length, claimed that if the "road" had the correct number of matches it was "too long" (according to a judgement by aligned boundaries (see B")). If the road was the "correct" length by aligned boundaries, it contained too few matches (see B').

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Figure 1.1: Two "roads" (B' and B") that could be deduced to be of the same length as "road" A.
In the type of situation represented in Figure 1.1, the children's answers obtained by counting the matches contradicted the answers obtained by aligning the boundary points. Thus a contradiction existed in the children's reasoning.

In the 1974 study, the children were required to do a series of exercises in which they had to judge whether "roads" built with the same or different numbers of matches were of the same or different lengths. They were also asked to build "roads" of the same length as a model "road" using matches the same size as those in the model and also using matches smaller than those in the model. These exercises were repeated over three or four sessions.

Prior to commencing these exercises all the children were conservers of number, but 75% (i.e. 12) of the children did not conserve length and 25% (i.e. 4) were classified as "transitional" on conservation of length (as measured in the pretest). After the conflict-inducing exercises only 12.5% (i.e. 2) of the children remained non-conservers of length (second post-test).

Two main conclusions were drawn from the results of this study. The first conclusion was that the action of putting the two concepts (or in Piaget's terminology, "schemes") into conflict caused the children to advance in their cognitive development.

The second conclusion drawn by Inhelder et al. was that four stages in the children's comprehension of the conflict could be distinguished. These were:

Stage 1. The children kept the two modes of reasoning (i.e. that based on numerical correspondence and that based on

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3 The terms "cognitive conflict" and "contradiction" have been used synonymously by these writers. In the present chapter the terms will also be used synonymously. They will be defined in Chapter 2.
spatial alignment) apart. The children did not hesitate to say either that there were equal numbers of matches but that the roads were of unequal length, or, alternately, that the roads were of equal length but that there were unequal numbers of matches. The children sensed no inconsistency between these conclusions.

Stage 2. The children were moved by an apparent urge to understand the discrepancy between the solutions obtained by counting the number of matches and by aligning the boundary points of the "roads". The children became perplexed and some said it was simply not possible to build a "road" of equal length to the experimenter's "road".

Stage 3. Some children developed compromise solutions, where they found ways of retaining both the spatial and the numerical correspondence of the two "roads". These included breaking a match in two, or placing a match perpendicular to the "road" being built.

Stage 4. The children resolved the contradiction between their responses by correctly understanding that equal length did not imply spatial correspondence in the alignment of the boundaries of the two "roads".

Inhelder, Sinclair and Bovet (1974) called these stages in the comprehension of the conflict "switching", "juxtaposition", "compromise" and "resolution" respectively.
Following this experimental paradigm of Inhelder et al. in which two concepts or "schemes" were put into conflict, Strauss and Rimalt (1974) conducted a study using 35 children who understood conservation of number but did not understand conservation of area. In this experiment "barns" were placed in two "fields" and the children were asked if the area remaining in the "fields" was the same for both. By counting the "barns" the children obtained a different answer to that arrived at by perceptually estimating if the areas were the same or different.

Strauss and Rimalt found that during the experiment 54% of the children developed in their understanding of the concept of conservation of area, and 94% of these acquired conservation of area. In a control group (N = 27), who performed no training exercises, only 26% of the children progressed in their comprehension of the concept of area. The four stages of comprehension of conflict: switching, juxtaposition, compromise and resolution, were also distinguished in this study.

In 1975 Strauss and Ilan conducted a similar study using the concept of conservation of length and the concept of speed. In this study the children were asked to judge if two roads were of the same length when one was bent and the other was straight, but when their boundaries corresponded (see A in Figure 1.2). As the children could conserve length they judged that one of the roads was longer. The children were then asked if two cars starting and stopping at the ends of the roads simultaneously had travelled at the same or different speeds. As the children did not understand the concept of speed they decided that, as the cars started and stopped simultaneously, they had both travelled at the same speed. Finally the road was straightened (see B in Figure 1.2) and the same question about speed was asked. As the cars no longer stopped at the same place the children's answers to this question contradicted their answers to the previous question.
In this study it was found that 35% of the children (N = 20) who had previously not understood the concept of speed gained the concept (second post-test). No child in a control group (without the contradictory experience) gained the concept of speed. Again, the four stages of comprehension of conflict (switching, juxtaposition, compromise and resolution) were reported. These four stages distinguished by Inhelder, Sinclair and Bovet (1974) were therefore said to have been confirmed.

From their experiments, Strauss and his collaborators have developed a theory of cognitive development. This theory (which will be described as the "structural-mix" theory) asserts that no one can be said to be
uniquely at one developmental stage at any given time. Thus, for example, no one reasons only at the pre-operation level, or only at the concrete operational level. Rather different concepts are concurrently at different levels of development. That is to say a person operates at several structural levels at any one time. The structural-mix theory provides a clear mechanism for transition from one developmental stage to the next. The mechanism involves encountering cognitive conflicts or contradictions. It functions as follows. Different concepts may be at different developmental stages. There may come a time when two such concepts are used to interpret the one situation and so, because contradictory answers are obtained to the one problem, they come into conflict. The resolution of these two contradictory answers is then attempted and can be described by the stages of comprehension of contradiction distinguished by Inhelder, Sinclair and Bovet. The resolution of the contradiction is finally achieved. However, this may set up a situation where a contradiction can arise between the concept achieved by the resolution of the previous concepts and other less developed concepts. The process of cognitive development consists, then, of the continual resolution of contradictory solutions which have been obtained by using concepts which are at different levels of development (Langer, 1969; Lerner, 1976; Strauss & Langer, 1970).

The developmental stages referred to are those of Piaget's theory of cognitive development. They are (1) the sensory motor stage (0 to approximately 2 years), (2) the pre-operational stage (2 to 6 or 7 years), (3) the concrete operational stage (6 or 7 years to 11 or 12 years), and (4) the formal operational stage (12 years and older). Appendix Ia provides details of the characteristics of each stage.

It may be noted that Piaget (1972b) has said that adults do not operate at the formal operational level of reasoning at all times. However, he in no way considered that this could mean that a "structural mix" position was an accurate description of his theory.
It can be seen, then, that the Strauss et al. extensions to the original Inhelder, Sinclair and Bovet experiments clearly implicate the encountering and resolving of contradictions as a causal agent in cognitive development.

Other studies in reaction to the original Inhelder, Sinclair and Bovet experiment have also been carried out.

Lefebvre and Pinard (1972, 1974) felt that the problem with using cognitive conflicts to accelerate development was that during normal cognitive development children were unaware of the potential conflicts between different approaches to thinking about the concept until they were ready to acquire the concept being taught. In order to show whether cognitive conflict could be effective for training cognitive development, they used a preparatory stage in their experiment. In this preparatory stage they made the child aware of the inadequacy of his or her rules regarding conservation of quantity before presenting the "conflict situation". In doing this, they assumed that in the conservation of liquid quantity most children at the pre-operational stage used the rule "higher equals more". By putting small amounts of liquid into a tall glass and large amounts into a short but very wide glass, they attempted to teach the rule "bigger (i.e. wider) equals more". Once the child appreciated this new rule, the Experimenters used various "conflict situations". In one of these, they put liquid into two containers, one small and the other large. The amount of liquid in each container was such that the level to which the liquid rose in each container was the same. (See A in Figure 1.3). In such a situation a rule for judging equality of amount such as "equal levels means equal quantities" conflicted with a rule such as "bigger equals more". In another situation they put liquid which rose to a high point in a small container and asked the child to compare it with liquid which rose to a lesser height
in a large container (see B in Figure 1.3). In this case the rule for judgement of quantity "higher equals more" conflicted with "bigger equals more".

Figure 1.3: "Conflict situations" in the experiment of Lefebvre and Pinard (1972).

It was found that almost 100% (N = 15) of the children in the training group acquired conservation of liquid quantity, whereas only one of the children in a control group (N = 10) did. Lefebvre and Pinard concluded that, if a child can be prompted to become dissatisfied with his or her decision rules in a conservation situation, then cognitive conflict is effective in the acceleration of development.
These experiments prompted Lefebvre-Pinard (1976) to suggest that certain preconditions must be met before the child's cognitive development can be accelerated by cognitive conflict or contradiction. These conditions are (a) that the child must possess sufficiently well articulated schemes at the pre-operational level to allow that child to establish clear relationships between events, (b) that the child must be consistent in the use of the concepts so that a unique meaning is attributed to them and so that no contradiction results from each successive use of the concepts, and (c) that the child must have the capacity to accept the sanction of empirical facts and to perceive events without interpreting them in a distorted manner.

It is possible to interpret the findings of the Lefebvre and Pinard (1972, 1974) experiments as a disconfirmation of the theory of "equilibration", as the child must be "well prepared" before recognising a contradiction, and this is unlikely to occur in normal development. However, Lefebvre and Pinard (1974, 1976) in fact saw their experiment as support for the equilibration model and for the findings and theoretical framework of Inhelder and Sinclair (1969).

There is one major difference between the studies performed by Strauss and his collaborators (and their subsequent theoretical theoretical elaboration) and that of Lefebvre and Pinard (and its subsequent elaboration). This difference is that whereas Lefebvre and Pinard appear only to be referring to the transition from pre-operational thought to concrete operational thought, Strauss et al. appear to be referring to all transitions between all the developmental stages.

This interpretation of their work is confirmed by some other studies which are used as evidence by Strauss and his collaborators in their theoretical model (e.g. Strauss, 1972). These studies were of a
type where the conflicting solutions to the problem were generated by having the child watch, without comment, an adult modelling a different solution to the problem. In the studies the children were exposed to a model behaving at a level one stage above their present developmental level (+1) or two stages above their present developmental level (+2) or one stage below their developmental level (-1). Basing her work on Turiel's (1966) study with moral reasoning, Kuhn (1972, 1974) presented children at different stages of development (as measured by a pretest for level of classification behaviour) with models performing classification tasks in the manner of children one stage above, two stages above or one stage below the subject's current stage of classification behaviour. On a post-test for classification behaviour, Kuhn found that 19% of the children had changed to a higher level of performance. Most of these children had been submitted to the +1 condition. No child regressed on the post-test, even those that had been submitted to the modelled -1 behaviour. Similar findings have been reported by Turiel (1965, 1969) and Turiel and Rothman (1972) using moral reasoning modelled at different levels.

Although the studies reported have used mainly pre-operational children the generality of their technique to include all stages of development seems to suggest that they do not see this stage as particularly special in any way. It therefore seems that Strauss and his collaborators envisage that the role of contradiction as a causal agent in cognitive development applies to transitions between all stages of
development.\footnote{As an aside, it may be noted that these studies of modelled behaviour have been extended to studies in which the conflict is generated by two-person interactions. In these latter experiments pairs of children one of whom has attained conservation of certain concepts and one of whom has not attained conservation of those concepts are asked to jointly determine the correct answer to the conservation problems. It has been found in this type of study that children who have attained conservation often dominated the encounter (Silverman & Stone, 1972; Silverman & Geiringer, 1973) although they did not do so when discussing control problems (e.g. what is the best TV show?) (Miller & Brownell, 1975). Further, even in cases where children who have not attained conservation dominated the encounter, these non-conserving children subsequently gave conservation answers on a post-test (Murray, 1972; Murray, Ames & Botern, 1977; Miller & Brownell, 1975; Silverman & Geiringer, 1973).}

By contrast, Lefebvre and Pinard do not seem to accept that contradiction plays a causal role in all stage transitions as they assert that a certain level of pre-operational competence is a precondition for the recognition of contradictions. They therefore exclude the transition from sensory-motor reasoning to pre-operational reasoning from their discussion of the role of contradiction in development.

While the different groups of researchers disagree about whether the resolution of contradiction constitutes a causal agent at all stages of cognitive development, or only for the transitions from pre-operational to higher levels of thought, they all make one basic assumption. This assumption is that children will endeavour to resolve a contradiction if they recognise it. This assumption is vital to their position that the resolution of contradiction plays a causal role in cognitive development. The assumption has been noted explicitly by Inhelder, Sinclair and Bovet who say that "once the children become aware of the discrepancy in solutions resulting from two different strategies they begin to try to reconcile them" (Inhelder, Sinclair and Bovet, 1974, p.260).
It is this assumption that is the crux of the theoretical position of these researchers. If the child does not attempt to resolve his or her conflicting reasoning, then the resolution of conflict cannot be a mechanism of the process of cognitive development. This assumption will be considered again in Chapter 2 as it constitutes a major point in several of the experiments performed in this thesis.

While all the researchers in this field have accepted this latter assumption, it has been called into question by Flavell (1977) who argues that three 'preconditions' must exist before contradiction can play a causal role in cognitive development. These are: (a) the child must have the ability or predisposition to attend to, or notice, both of the apparently conflicting elements in the situation, (b) the child must have the ability or predisposition to interpret and appreciate them as conflicting, and therefore problematic and (c) the child must respond to the sensed conflict by progressing rather than regressing, for example, by trying to explain it rather than clinging defensively to his or her initial belief or refusing to have anything more to do with the problem.

Flavell finds it difficult to accept that these preconditions can exist and rejects the idea that contradiction\footnote{He calls this "disequilibrium".} is a causal agent in cognitive development (Flavell, 1977).

However, if contradiction is not a causal agent in cognitive development how can we explain the responses to contradiction documented in the studies previously described?
This question has been partially answered by Piaget. For Piaget, the problems of when children are able to recognise a contradiction, of how they react to contradictions, and of the effect encountering contradictions has on cognitive development, have been troubling ones since he first discussed them in 1928. At that time Piaget had been observing the judgements and explanations of children and had distinguished two types of contradiction in the thought of young children. The first he called "contradiction by amnesia". This involved the child having two opinions between which (s)he hesitated, for example that the moon was alive and that it was not. The child had good reasons for both beliefs and affirmed each in turn. After each affirmation (s)he forgot his or her last belief and it was this forgetting or 'amnesia' that caused the child to make contradictory statements. The second type of contradiction was called "contradiction by condensation". The cause of this type of contradiction was said to be that children's concepts were 'overdetermined'. That is, a large number of heterogeneous factors were considered relevant to the definition of the concept and there was an inability to constrain the concept. Thus, for example the sun might be alive because it gave light, or not alive because it had no blood. The child made contradictory statements because (s)he used all possible determining factors in his or her explanation. Piaget (1928) gave the following example of an interview with a 7½ year old child to illustrate contradiction by condensation.

To (7½) thinks that boats float because they are wood. - Why does wood stay on the water? - Because it is light and the little boats have sails (over-determination). - And those that have no sails, why do they not sink? - Because it is light ... - And how about big boats? - Because they are heavy ... - Then heavy things stay on top of the water? - No. - Does a big stone? - No, it sinks. - And big boats? - They stay because they are heavy. - Is that the only reason? - No. - What else? - Because they have big sails. - And when they
are taken away? - Then they are less heavy. - And if the sails are put on again? - The same thing happens, they stay (on the water) because they are heavy.
(Piaget, 1928, p. 169).

Piaget concluded at this time that a child was insensitive to contradiction, by either amnesia or condensation, until (s)he reached the stage of concrete operational thought. Once having reached that stage the child avoided making contradictory statements and recognised contradictions in argumentation.

While this conclusion was consistent with his empirical observations, Piaget was troubled by the question of why, precisely, thought ought to be non-contradictory. Following his classification of contradictions Piaget asked:

What is contradiction between two judgements or within one and the same concept? From the point of view of logic it is an ultimate and indefinable notion which can only be described by showing the mental impossibility of affirming contradictory propositions simultaneously. But from a psychological point of view we have here a problem because we cannot see how it comes about that the mind wishes to avoid contradiction nor what are the conditions of non-contradiction. We cannot say straight away of the psychological (as opposed to the logical) structure of thought any more than of the structure of any other natural phenomenon that it is non-contradictory (...)

How then are we to characterise from the psychological point of view behaviour or mental states which are concomitants of logical non-contradiction in distinction to those other forms of behaviour which, if translated into fully explicit judgments would be contradictory?
(Piaget, 1928, p. 170).

Piaget concluded at the time that:

non-contradiction is a state of equilibrium in contrast to the state of permanent disequilibrium which is the normal life of the mind.
(Piaget, 1928, p. 170).
This "state of equilibrium", he added, could be reached only when a reversible operation was achieved. Reversible operations could only be present if the stage of concrete operational thought had been achieved.

Piaget later conducted comprehensive research into the problem of the effect of contradiction on development (Piaget, 1974) and found, as did Inhelder, Sinclair and Bovet, that a stage of non-recognition of contradiction was followed by puzzlement, and, ultimately, resolution of the contradiction. However, despite this work, in 1975 Piaget returned to his original concerns about the problems of contradiction. In 1975 he said: 6

We may ask if (disequilibrium) is inherent in the subject's very actions or merely due to contingent historical situations. A question arises therefore of establishing whether the cases of (disequilibrium), in other words the contradictions, are inherent in the constitution of the objects on the one hand, or in the subject's actions on the other. (Piaget, 1977, p. 12).

In this statement Piaget is making two points. First, he is suggesting that contradictions are "due to contingent historical situations", that is, due to the cognitive system that is developing over time as the child grows. Second, he is asking whether it is possible that "contradictions" are part of the nature of the world, of objects and of actions, or whether they are by-products of the "historical situations". In the next paragraph he elaborates his first point.

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6 The following quotations are taken from the 1977 translation of Piaget's 1975 book. In this translation the french word "déséquilibre" has been translated as "non-balance". For most readers of Piaget, however, the term "disequilibrium" is more familiar. The word "disequilibrium" will therefore be inserted in parentheses in the quotations each time the word "non-balance" has been used in the text.
We may ask, furthermore, if they result merely from momentary conflicts which we may assume occur in any historical development. In this case they would simply be due to systems and subsystems of observation and coordination because none of the systems can be completed immediately (causal systems are never finished) and they develop at different speeds. In short, no form of thought, at any level, is capable of becoming instantaneously a coherent, total reality. (Piaget, 1977, p. 12).

Here Piaget is suggesting that other developing systems could cause apparent contradictions to occur and hence that these contradictions are due to "historical development".

In a later paragraph, Piaget discusses the second point of the initial paragraph, that is, whether contradictions are part of the nature of the world:

The full significance of progressive equilibration as a process of development should not be underestimated in favour of that of (disequilibrium). The "dialectics of nature" has attempted with some exaggeration to find "contradictions" in the very heart of operations at play in the physical world, for example, in situations of actions and reactions; these causal models are in fact exempt of any logical or normative contradiction. (Piaget, 1977, p. 12).

In this paragraph, Piaget claims that "contradictions" can be found in the nature of the world only "with some exaggeration". He therefore dismisses the idea that all nature contains "contradictions", as is asserted, for example, by the so-called "dialectical psychologist", Riegel (1978). It may be recalled that in 1928 Piaget also suggested that contradiction was "the normal life of the mind" (1928, p.170), so it was no doubt after considerable reflection that he reached the conclusion that contradictions are inherent neither in objects nor in the subject's actions or reactions.
Piaget summarises his viewpoint by stating that the idea that contradiction is inherent in the characteristics of thought, is difficult to support. Instead, he sees contradiction as a by-product of an historical, psychogenetic or sociogenetic development. The summary is expressed as follows:

In describing cognitive development, the proposition that (disequilibrium) or contradictions are inherent in the very characteristics of thought seems difficult to support, at least in the present state of our knowledge. We have not succeeded in supplying a formal elaboration of a "logic" dialectic; "contradiction", consequently, appears as a notion whose significance is psychogenetic, sociogenetic, or historical, and not inherent in the operational structures which lead to a state of closure. (Piaget, 1977 pp. 12 - 13).

Piaget is therefore asserting that, in any developing system, conflicts between different aspects of the system must arise. However, we may assume that these do not cause, or even contribute to, the continuing development of the system but, rather, the conflicts become resolved when the system has developed to the point where the various aspects are no longer in conflict.

Nevertheless, Piaget does not dismiss the study of contradiction out of hand. He agrees that it is useful since in the early stages of cognitive development the child encounters so many contradictions. He claims, however, that the young children's resolutions of these contradictions "depends on the subject's reasoning methods". This is stated in the following passage:

The historical or psychogenetic occasions of conflict are far more frequent at the initial stages and (disequilibrium) is far more difficult to overcome. There must be a reason for this, and it cannot depend on the nature of the problems encountered, since elementary and simple questions should correspond to conflicts which are also simple. The explanation must have general application and depend on the subject's reasoning methods (or "strategies" - if we choose to use a more fashionable term) rather than on the contents of the reasoning. (Piaget, 1977, p. 14).
Piaget therefore agrees that contradictions arise and need to be resolved, but in no way sees the resolution of such contradictions as a causal agent in cognitive development. Rather, he is asserting that in order to resolve contradictions the child must have developed to a sufficiently high cognitive level. When (s)he has developed to this point then (s)he resolves the contradictions. The encountering or resolving of contradictions, however, is not involved in the cognitive development.

In reviewing the literature on the role of the resolution of contradiction in cognitive development, then, we find that two general viewpoints exist. One, exemplified by the work of Inhelder, Sinclair and Bovet; Strauss and his collaborators; and Lefebvre and Pinard (whom we shall call "the Training Theorists") suggests that the resolution of contradiction plays a causal role in cognitive development. The second, exemplified by the work of Piaget, suggests that contradictions are resolved once the child has developed in his or her cognitive capacities to a level where (s)he is able to resolve the contradictions.

There are three main points of conflict between the Training Theorist position and Piaget's position. The three relevant viewpoints of the Training Theorist position are as follows:

1. The resolution of contradiction is a causal agent in cognitive development.
2. Since the resolution of contradiction is implicated in all transitions in cognitive development following the pre-operational stage, children of the final three stages of cognitive development (the pre-operational stage, the concrete
operational stage and the formal operational stage) are capable of recognising a contradiction.

3. Once a contradiction is recognised an attempt will be made to resolve it.

The contrasting viewpoints expressed by Piaget are:

1. Concrete operational thought is acquired by processes other than the resolution of contradictions.
2. Prior to the acquisition of concrete operational thought children do not have the competence to recognise contradictions. They therefore make contradictory statements and do not react to contradiction.
3. Contradiction poses no problem for the child either before or after the child has acquired concrete operational thought. Prior to the acquisition of concrete operational thought contradictions are not recognised. After the acquisition of concrete operational thought they are competently handled. That is, they are either eliminated or, if the child is at a point in his or her development where (s)he is able to resolve them then they are resolved.

In the discussion of the literature in this chapter it should be noted that the key terms used have not been defined and appear to have been used informally. Definitions for some of the terms appear, however, to be essential. For example, it would appear necessary to provide consistent definitions for at least the terms "contradiction", "cognitive conflict", "to recognise a contradiction" and "to resolve a contradiction". In the following chapter the problem of the definition of the term "contradiction" will be discussed and definitions of the relevant terms will be presented.
CHAPTER 2
A DEFINITION OF THE CONCEPT OF CONTRADICTION

As mentioned in the previous chapter, few of the researchers and theoreticians currently considering the resolution of contradiction as a possible cause of cognitive development have clearly defined the terms they are using. In this chapter a very brief review of some of the definitions used in the literature will be presented and this will be followed by the definitions that will be used in this thesis. Interestingly, once these definitions have been given, a model of the range of possible reactions to contradiction emerges. This model will be outlined later in the chapter. Following the model, a discussion of the experimental methodology used in this thesis will be presented.

2.1 THE DEFINITION OF 'CONTRADICTION' AND ASSOCIATED CONCEPTS IN THE LITERATURE

In the psychological literature relating to contradiction, two different concepts have been discussed. The first has been called contradiction. This was discussed by Piaget. It was also carefully considered by Riegel, who proposed that contradiction is central to cognitive development. The second was called cognitive conflict. This concept has been used by Inhelder, Sinclair and Bovet (1974), Strauss and his collaborators and Lefebvre and Pinard (1972, 1974).

Piaget says that contradiction results from an incomplete compensation between affirmations and negations (1974, pp. 9 - 11). This makes little sense until we note that Riegel (1973) has said, when defining contradiction:

The positive and negative instances of an attribute are mutually dependent. Red determines as much what is not red as not red determines red. (Riegel, 1973, p. 354).
It appears that Piaget is saying much the same thing. That is, since a correct classification includes both positive and negative instances, a contradictory classification consists of an incomplete exclusion of these instances. For example, in a correct classification, the category "dead" determines, by exclusion, the category "not-dead". However in a contradictory classification the category "dead" does not also determine the category "not-dead".

A contradiction of this type was used by Stoppard (1967) in his play "Rosencrantz and Guildenstern are Dead". In the play Guildenstern kills the player, asking him how it feels to really die, rather than to act dying as in previous plays. However since this is also a play, the "dead" player rises to his feet, not dead. The following passage illustrates Stoppard's use of this device:

**GUIL** (fear, vengeance, scorn): Your experience! - Atores! (He snatches a dagger from the PLAYER's belt and holds the point at the PLAYER's throat: The PLAYER backs and GUIL advances, speaking more quietly) I'm talking about death - and you've never experienced that. And you cannot act it. You die a thousand casual deaths - with none of that intensity which squeezes out life ... and no blood runs cold anywhere. Because even as you die you know that you will come back in a different hat. But no one gets up after death - there is no applause - there is only silence and some second-hand clothes, and that's - death - (And he pushes the blade in up to the hilt. The PLAYER stands with huge, terrible eyes, clutches at the wounds as the blade withdraws: he makes small weeping sounds and falls to his knees, and then right down:). (While he is dying, GUIL, nervous, high, almost hysterical, wheels on the TRAGEDIANS -) if we have a destiny, then so had he - and if this is sure, then that was his - and if there are no explanations for us, then let there be none for him - (The TRAGEDIANS watch the PLAYER die: they watch with some interest. The PLAYER finally lies still. A short moment of silence. Then the TRAGEDIANS start to applaud with genuine admiration. The PLAYER stands up, brushing himself down.)

**PLAYER** (modestly): Oh, come, come gentlemen - no flattery - it was merely competent - (Stoppard, 1967, p. 89).
This passage demonstrates the effect of a classification in which the category "x" contains instances which are also contained in the category "not-x". That is, there is an "incomplete compensation" between the positive and negative aspects of the category. It is this type of phenomenon that both Riegel and Piaget have referred to as a "contradiction".

To give a clear definition, then, we may say that for Piaget, a contradiction is a classification error caused by incomplete comprehension of the negative aspects of a concept. While this definition of contradiction is interesting it is difficult to see how the definition could apply to the studies of other researchers in this field, and, at times, even to Piaget's own studies.

The other concept that we noted in the psychological literature relating to contradiction was "cognitive conflict". A theoretical definition of cognitive conflict was attempted by Mischel (1971). He said that whatever resists assimilation to the child's schemas generates cognitive conflict. In an experimental setting however, a situation of cognitive conflict is said to occur when the subject has arrived at two different answers to one problem. These answers need not be contradictory. For example, if a question is posed: give an antonym for the word "slow"; two answers may be obtained, such as, "fast" and "rapid". Although these two answers are different, they are not contradictory. If they are not contradictory, of course, the conflict may be resolved when it is realised that the two answers are compatible. However, it is possible that a conflict nevertheless was experienced by the subject when the two different answers were obtained. In the situations used by the Training Theorists it is assumed that the two different answers will be mutually exclusive and hence "contradictory" and the

9 "schemas" here means "schemes" as it has been used in this paper.
contradiction will therefore need to be resolved. It is interesting to
note that Piaget, Inhelder et al, Strauss and his collaborators, and
Lefebvre and Pinard all use the expression "cognitive conflict or contra-
diction" as if the concepts were synonymous. As has just been shown how-
ever, "contradiction" is a subclass of "cognitive conflict".

Since the field is in such disarray regarding the definition of
terms, it seems important in this paper to define each term used very
carefully. An attempt will be made to define each term in such a way
that it is relevant to the two reasons for studying the effect of
encountering contradictions which were outlined in the Introduction.

The usefulness of these definitions as guides for thinking about
contradiction will be evaluated at the conclusion of the thesis.

2.2 DEFINITIONS

Before beginning to give precise definitions we must decide which
terms need to be defined. In the previous chapter not only have we
spoken of "contradiction" and "cognitive conflict", we have also referred
to "recognising a contradiction", "resolving a contradiction", "avoiding
a contradiction" and "eliminating a contradiction". All these terms
need to be defined clearly. Additionally, indices for their measurement
must be determined.

In the definitions of these terms the phrase "symbolic representa-
tion" will be used. The meaning of the phrase "symbolic representation"
will include knowledge represented in a non-linguistic manner. It has
been agreed generally in modern cognitive psychology that knowledge can
be represented in the form of images or "thoughts", without these images
or thoughts being necessarily translated into linguistic forms. A
"symbolic representation" will therefore refer to knowledge represented
either in non-linguistic thoughts or linguistically.
The first definition proposed is that of the word "contradiction". It will be referred to as DF1:

DF1: A "contradiction" is a relationship of incompatibility between two symbolic representations.

The important aspect of this definition is that a contradiction refers to a relationship, and that the relationship is one of incompatibility between the two elements. The word "incompatible" has been chosen to include the logical meanings of "contradiction" and "contrary" as well as the psychological meanings of "in opposition to", "in conflict with" and "inconsistent with". It indicates a paradoxical relationship or, in other words, that the relationship is incompatible in that both symbolic representations have been assumed to be true, whereas if the one is true (in its present form) then the other must be false (in its present form).

Three types of situation which exemplify a relationship of incompatibility between two symbolic relationships can be distinguished. These are:

1. A situation where the relationship of incompatibility is between two internally represented beliefs;

10 In logic, a contradiction is a relationship of opposition between a universal affirmation (all x's are y's) and a particular negation (some x's are not-y's) or between a universal negation (no x's are y's) and a particular affirmation (some x's are y's). In logic a contrary is a relationship of opposition between a universal affirmation (all x's are y's) and a universal negation (no x's are y's). (Edwards, 1967).

11 In a psychological article, Luchins and Luchins (1965) said "we shall say that a subject referred to contradictions if he mentioned that the statements contradicted, were inconsistent with, contrary to, in conflict with, opposed to, disagreed with or were cancelled out by other statements." (1965, p. 52).
2. A situation where the relationship is between an internally represented belief and an externally presented source of information (the external source of information may be linguistic or perceptual);¹² and

3. A situation where the relationship of incompatibility is between two externally presented sources of information.

An example of the first type of situation is found in the work of Inhelder, Sinclair and Bovet where the child has beliefs about the equality and inequality of number and the equality and inequality of length and these two sets of beliefs relate in an incompatible way.

¹² Inhelder, Sinclair and Bovet (1974) have made a distinction between the first two types of situation described here. They have called them two different "types of conflict" and say:

> two different types of conflict can be observed. First, different subschemes, each developing at its own developmental rate can create a conflictual situation since one system may have reached a more advanced state than the other. Second the child's reasoning may be at a level where he becomes aware that experimental reality does not conform to his deductions or inferences." (lnhelder et al. 1974, p. 242).

While this distinction has been made in the literature there appears to be some doubt about whether it is a valid distinction. For example, Piaget (1974) notes that since the recording of an external event (or external source of information) involves interpretation on the part of the child, and since the interpretation is mediated by the child's internal representations then even in the case of a conflict between "deductions" and "an external source of information" the conflict is actually between two sets of subschemes, one deductive and the other interpretative. Strauss (1972) also noted that as a child often misinterprets or distorts data so as to be consistent with his or her predictions, the conflict is again between two subschemes rather than between an internally represented belief and an external source of information. In this thesis, however, the distinction between the situation type 1 of DF1 and the situation type 2 of DF1 will be retained, and will be discussed further in the following chapters.
The second type of situation occurs when a child makes a prediction about the action of an object (e.g. this thing will sink). The child makes this prediction on the basis of his or her beliefs about the object, then an external source of information contradicts the prediction (e.g. the object can be seen to float).

The third type of situation occurs when the child is given some information (e.g. the new dress is blue) and is then given information contradicting this (e.g. the new dress is red).

As an important aside, it may be noted that no definition has been proposed for the term "cognitive conflict". Rather, those situations that have been described in the literature on contradiction by the term "cognitive conflict" are now incorporated in situation type 1 of DF1. These sorts of conflicts are a subset of "cognitive conflicts" in general. The term "cognitive conflict" will therefore not be used further in this paper.

It was said earlier that DF1 applies to all uses made of the term "contradiction" in psychological research. It may be noted, however, that the research addressing the question of whether the encountering of contradiction is a causal agent in development uses situations type 1 and type 2 of DF1, whereas the research addressing the question of the development of contradiction as a logical concept uses situation type 3 of DF1.

Having defined the word "contradiction", we may now move onto the other expressions that have been used in the literature. These include such phrases as "recognising a contradiction", "avoiding a contradiction" etc. Examining these expressions it seems that the first distinction that needs to be made is between recognition and non-recognition of
contradiction. Phrases such as "eliminating", "avoiding" and "resolving" contradiction all refer to the child's reaction to contradiction once it has been recognised. In the definitions that follow the word "label" will be used. This word is used in the same way as "symbolic representation", that is, it refers to pre-conscious and pre-linguistic activities as well as to linguistic activities of which the child is aware. The following definitions are proposed:

1. DF2: The "recognition of contradiction" involves the labelling of the contradictory relationship as one which needs to be changed in some way so that it becomes non-contradictory.

   It may be recalled from the explanation of DF1 that the reason the relationship is said to be one of incompatibility is that both symbolic representations are assumed to be true, and in their form at that time, if one is true then the other must be false. This causes the incompatibility of the representations.

   Several ways are available for changing the contradictory relationship into a noncontradictory relationship. These changes all assume that the contradiction has been recognised. The different changes are defined below.

2. DF3: The "elimination" of a contradiction. This occurs when one symbolic representation is labelled as true and the other as false.

3. DF4: The "rejection" of the contradiction. This occurs when the entire argument which contains the two contradictory representations is labelled as false.
4. **DF5**: The "avoidance" of the contradiction. This occurs in cases where, if the subject continued to argue using the premises (s)he had been using, then a contradictory statement would result. However, the subject changes his or her premises of reasoning so that no contradictory statement results as if recognising that to continue using the previous premises would have resulted in a contradictory statement.

5. **DF6**: The "resolution" of the contradiction. This occurs when both representations are still labelled as true, but the representations are integrated into a more comprehensive framework so that although the representations are still both true they are no longer incompatible.

6. **DF7**: An "attempt to resolve" the contradiction. This occurs when the subject attempts to integrate the two representations into a more comprehensive framework but fails. The two representations however are still labelled as true, and since the attempt at integration was unsuccessful the subject is still left with the original contradictory relationship.

As mentioned previously, the responses outlined in **DF3** to **DF7** all describe different reactions to the "recognition" of contradiction. Finally, we can define "non-recognition of contradiction".

7. **DF8**: The "non-recognition of contradiction" involves the subject not labelling the relationship as one which needs to be changed.
This can be inferred from the subject's lack of reaction by any of the ways defined in DF3 to DF7 in the face of a contradictory relationship.

Each of these definitions is easier to understand in the context of an example. An example of each reaction to contradiction will therefore be given:

1. Example of elimination of contradiction (DF3). Elimination of contradiction occurs mainly in the situation type 2 of DF1, that is, where there is a contradiction between an internal representation and an external source of information.

Two things are necessary for the reaction to be described as an "elimination of contradiction". First, the subject must recognise the conflict between the internal representation and the external communication.

(e.g. Experimenter (E): Will this stone sink or float? Subject (S): It'll float. (Observation).
E: What did it do?
S: It sank.
E: Is that what you said?
S: No.) (As opposed to S: Yes, that's what I said it would do; which would constitute a non-recognition of the conflict).

Second, the subject must make a subsequent prediction or statement to show that either the internal representation only or the external communication only is correct (e.g. internal representation correct:
E: What about this stone?
S: It'll float 'cause it's small.
E: What about the other stone - it sank.
S: It was too small. This one is bigger; or external source of information correct:
E: What about this stone?
S: It'll sink.
E: How do you know?
S: 'Cause the other stone sank too).

In the case of eliminating the contradiction the subject has not understood the phenomenon any better after the contradiction has been eliminated, but the reasoning at that time has been made non-contradictory.

2. Example of rejection of contradiction (DF4).
Rejection of a contradiction occurs mainly in the situation type 3 of DF1, that is, in a contradiction between two external sources of information. In this case the argument that was being presented is rejected as a whole.

(e.g. E: Pick me out the shape that is long and short.
S: That's silly; or
E: Is this statement true or false about this button:
   'The button is blue and it is not blue'.
S: That doesn't make sense.

Rejection of contradiction can also occur in the other two types of situation mentioned.
(e.g. E: Build me a "road" that is straight and is just as long as my "road".
S: I can't.)
In the case of rejection of contradiction the subject has again not understood the phenomenon any better but has simply rejected the task. Thus his or her reasoning is non-contradictory again. In logic the only possible reaction to contradiction is rejection of the argument.

3. Example of avoidance of contradiction (DF5). Avoidance of contradiction occurs in situations where the subject changes his or her reasoning before encountering the contradiction as if recognising that to continue reasoning in the previous manner would result in a contradictory statement. It occurs mainly in situations type 1 and type 2 of DF1.

(e.g. E: Will this wooden block float or sink?
S: It'll float because it's small.
E: How about this plastic disc?
S: It's small too. It'll float.
E: And this tiny screw?
S: (knowing from previous experience that metal sinks) It'll sink. It's too small.)

To classify the child's response as 'avoidance' of contradiction is a difficult matter as one must assume that the child has anticipated that if (s)he had continued in his or her present line of reasoning then a contradictory statement would have resulted. As will be discussed in Section 2.3 this inference may not always be valid.

4. Example of resolution of contradiction (DF6). Resolution of contradiction can occur in all three types of situations distinguished in DF1. It involves the labelling of the incompatible relationship as an "apparent contradiction", and by
integration into a more comprehensive framework, shows that the relationship is not "really" contradictory.

(e.g. E: Build me a road that is straight the same length as mine.
S: (Builds) E's road

S's road

E: Is that the same length as mine?
S: No.
E: Can you build a road the same length as mine?
S: (Builds) E's road

S's road

E: Are the two roads the same length now?
S: Yes.
E: But look how long yours is!
S: But it's got the same number of matches.
E: But it goes way past mine.
S: But if you straighten the other one then they'll both be just the same.
E: And how about now. Are they the same length?
S: Yes, they're the same.

or e.g. E: Pick me a shape that is long and short.
S: I can't. I can pick two though.
E: Show me.
S: (Picks). E: Why are they long and short?
S: This one is long and this one is short.
E: Can you pick just one?
S: No.)
When the children resolve a contradiction they integrate the two concepts. At times, such as in the first example presented here, this integration may appear to be an "elimination of contradiction". This is because, as in this example, the child is apparently labelling the conservation of number solution as "true" and the incorrect "conservation" of length solution as "false". This complies with the definition of "elimination of contradiction" (DF3). However, in fact a simple labelling process is not occurring. Rather, the child is, in the process of integrating the two concepts, understanding the concept of length fully and recognising that, in the case where the continuous length of the "road" is being discussed then the number of units is the most appropriate. Such a child would, however, also be able to explain that if the end points of the roads were being considered then a judgement by boundary points would be most appropriate.

In all cases of situation type 1 of DF1, where a less developed concept is contradicted by a better developed concept, the child's resolution of this contradiction is defined as a "resolution of contradiction" (DF6), and not as an "elimination of contradiction" (DF3). As was previously mentioned, in the case of "elimination of contradiction" the child does not understand the phenomenon any better. In the case of the resolution of contradiction (s)he does.

It is, in fact, this integration of the concepts that prompts certain researchers to posit the resolution of contradiction as a causal agent in development, since the contradiction
appears to have prompted the children to understand both concepts and to have coordinated them at a higher level of conception. The children therefore begin to move to a higher stage of development.

5. Example of attempt to resolve contradiction (DF7).
Attempts to resolve contradiction also occur in all three types of situations of DF1. In this case the child attempts the same reasoning as described in DF6 but fails.

\[\text{E: Build me a straight road the same length as mine.} \]
\[\text{S: (Builds)} \]
\[\text{E: Are they the same length?} \]
\[\text{S: No. Mine is shorter.} \]
\[\text{E: Build me one the same.} \]
\[\text{S: (Builds)} \]
\[\text{E: Are they the same length?} \]
\[\text{S: No. Mine is too long.} \]
\[\text{E: Can you build me one the same length as mine?} \]
\[\text{S: (long hesitation. Builds)} \]
\[\text{E: Are they the same length now?} \]
\[\text{S: No. Mine is too long ... I don't know.} \]

Attempts to resolve a contradiction are marked by hesitation, puzzlement, confusion, stopping during the response and compromise solutions. In a compromise solution the child
attempts to fulfil all the perceived conditions of the task including the erroneous conditions which they bring with their internal representations. For example, two compromise solutions for the previous problem are the use of very small matches e.g. \[ -o \]
and the use of a vertical match e.g.
\[ \sim \]
In these cases the child wants to use four matches in each road (correct solution) but (s)he also wants to keep the roads as near as possible within the boundaries of the model road (erroneous condition brought to the situation by the internal representation).

The occurrence of attempts to resolve contradictions reinforce the view of those researchers who believe that contradiction is a causal agent in development as the occurrence of such attempts confirms that the child can recognise the contradiction and also creates the behavioural climate in which the child might ultimately resolve the contradiction and hence move to a higher stage of development.

6. Example of recognition of contradiction (DF2). A contradiction is said to be recognised when the child responds in any of the ways listed in DF3 to DF7. There are also some occasions on which children respond in a different way to contradiction and control items, but not necessarily in any of the ways DF3 to DF7. (e.g. E: Tell me if this statement is true or false: 'this button is blue and it is not blue'.}
S: It's true and false. On the control items which contained no contradiction, the same subject responded either "true" or "false" in each case.) In cases such as this where the subject distinguishes between control and contradiction items, the subject is said to have recognised (DF2) the contradiction. This will be discussed further in Section 2.3.

7. Example of non-recognition of contradiction (DF8). A contradiction is said not to have been recognised either when the subject does not respond in one of the ways listed in DF2 to DF7, (for example, when (s)he chose an object specified by a contradiction without comment, obeys an instruction containing a contradiction without comment, does not comment that a solution cannot be correct (i.e. that the two answers are incompatible), or when the subject makes contradictory statements without reacting to these.

2.3 A MODEL OF POSSIBLE REACTIONS TO CONTRADICTIONS

It has been noted, in the examples of "recognition of contradiction", that certain reactions to contradictions occur which have not been classified under the definitions DF3 to DF7. There are several examples of this. These include:

1. a child may deny perceptual data (e.g. a stone predicted to float may sink. E: did it sink or float?

   S: It's floating - see it's not quite on the bottom there.)
This child could be said either to be avoiding the contradiction (as (s)he is modifying his or her argument) or to be eliminating the contradiction (as (s)he is ignoring the external source of information). It seems then that avoiding and eliminating contradictions have certain responses in common.

2. Similarly, the data may be distorted (e.g.,

```
   o---o
   |   |
   o---o
```

E's road

```
   o---o---o
   |   |   |
   o---o---o
```

S's road (made of three matches)

E: Are the roads the same length?
S: Yes.
E: Do they have the same number of matches in each of them?
S: Yes.
E: Can you count them?
S: 1, 2, 3, 4, and 1 (then on the same match)
   (2, 3), 4.
E: Count them again.
S: 1, 2, 3, 4; 1, (2,3), 4.
E: They've got the same number then?
S: Yes, four in both.)

This response could be classified as avoiding the contradiction (as the argument is modified) or an attempt to resolve the contradiction (as a "compromise" solution has been invented). It seems here that avoiding the contradiction and attempting to resolve the contradiction have responses in common.
3. Again, in the case of the situation type 1 of DF1, where the child has two internal representations that are appropriate, the child may use only one representation and hence only one strategy of reasoning. In this case, it could be that the child has recognised the contradiction and is avoiding it by using only one strategy of reasoning; alternately, (s)he may not have recognised a possible contradiction at all because (s)he is using only one strategy. This latter possibility has been that which is accepted by the literature.

4. It was noted in the example of recognition of contradiction (DF2) that there are some occasions on which the child simply reacts differently to contradiction and control items, but this reaction cannot be classified according to the definitions DF3 to DF7. Here it seems that recognition of contradiction and non-recognition of contradiction also have some responses in common as the child does not react to the contradiction, (s)he merely distinguishes it from a control item.

We have noted here four examples of responses, that could be given by children when encountering a contradiction, which are not included in the definitions. In fact, all of them could, according to the definitions, be assigned to either of two categories. This seems to suggest that the reactions of children to contradiction should be represented by a continuum rather than classified discretely. Adopting this position, we may represent schematically a continuum of the responses that are possible when the child encounters a contradiction. The Model is shown in Figure 2.1.
Figure 2.1 does not represent any particular child's reaction to contradiction. Rather, it shows the interrelationship of all the possible reactions to contradiction which have been defined in the previous section. For example, the most basic example of "recognition of contradiction" (DF2) that has been defined is the "avoidance of contradiction" (DF5). It is the most basic example because some responses which could be classified as "non-recognition of contradiction" (DF8) may also be classified as "avoidance of contradiction" (DF5) (as has been exemplified above in the third and fourth examples) and hence as "recognition of contradiction" (DF2). However, the response "avoidance of contradiction" (DF5) also has instances in common with the two responses "denial of data" and "distortion of data" (as in the first and second examples). While these two responses both have elements in common with the response "avoidance of contradiction" (DF5) they have no elements in common with each other, and can therefore be seen as leading in opposite directions. These directions become more polarised when the response "denial of data" has elements in common with the response "elimination of contradiction" (DF3), and the response "distortion of data" has elements in common with "attempts to resolve contradiction" (DF7) (from the first and second examples again). From the original definitions it can be seen that the responses "elimination of contradiction" (DF3) and "attempt to resolve contradiction" (DF7) are quite different as the former involves the labelling of one representation as true and the other as false, whereas the latter involves the labelling of both representations as true.
Figure 2.1: A schematic representation of the continuum of possible responses by children encountering a contradiction.
This is as far as the examples cited previously take us. However, if we continue to examine the definitions we find that the response of "elimination of contradiction" (DF3) can be seen to have elements in common with "rejection of contradiction" (DF4). Additionally, if the subject continues to "attempt to resolve" (DF7) the contradiction and continues to fail to resolve it (s)he may ultimately "accept the contradiction" as an unresolvable contradiction. For example both a wave theory and a particle theory of light transmission exist in physics and are considered to be contradictory theories that cannot be resolved. We can propose then that the "attempt to resolve" (DF7) contradiction has elements in common with an "acceptance of contradiction" (undefined). The two responses "rejection of contradiction" (DF4) and "acceptance of contradiction" (undefined) are at opposite ends of the continuum of possible responses to contradiction. However, another response to the contradiction is possible. This is the "resolution of contradiction" (DF6). This response may derive both from the "attempt to resolve" (DF7) the contradiction, and, once the subject has developed sufficiently in his or her cognitive capacities, from the "elimination of contradiction" (DF3). While the response of "resolution of contradiction" is the same in both cases the response has been separated in the Figure since its different origins have theoretical importance.

The Figure is therefore neither temporal nor developmental. Rather it represents the relationships between the terms which have been defined in this chapter. However, while it derives from the definitions of terms, it also seems to have developmental implications. This will be discussed further. The figure is of particular interest because the schematic representation leads us to four different possible endpoints of the process of reaction to an encountered contradiction. These
Endpoints have been shown by the numbers (1), (2), (3), and (4) on the Figure. The four endpoints can be seen to correspond to a description of four theoretical positions in the psychological literature. These endpoints and their equivalent theoretical positions are:

(a) Endpoint Number (1): This corresponds to the position of logic (which has been described by Piaget). In logic, a statement containing a contradiction (e.g. $p \land \neg p$) is an invalid statement, and is false by definition. An argument containing a contradiction or resulting in a contradiction (e.g. in proofs by reductio ad absurdum) is invalid and the argument, and premises on which it is based must be rejected.

(b) Endpoint Number (2): This corresponds to the position adopted by Piaget in his later work. Piaget says that contradictory statements are eliminated once the concrete operational stage of development has been reached. The contradictions continue to be eliminated until the child has developed in his or her reasoning to a point at which the contradiction can be resolved. It is then resolved.

(c) Endpoint Number (3): This corresponds to the position adopted by the "Training Theorists". They suggest that once a contradiction is recognised an attempt is made to resolve the contradiction. This attempt is continued until ultimately the contradiction is resolved. It is this position which suggests that the encountering of contradiction is a causal agent in cognitive development, because the recognition of the contradiction prompts attempts at its resolution, and, attempts at resolution of contradiction prompt ultimately,
the resolution of the contradiction and hence an advance in cognitive development.

(d) Endpoint Number (4): This corresponds to the position of the theoretician Riegel. Riegel, because of his dialectical position, suggests that the encountering of contradiction is essential in cognitive development. Following the Hegelian viewpoint he suggests that every thesis (which, in the language of this paper is a symbolic representation) contains the seeds of its own antithesis (i.e. an incompatible symbolic representation) and that these are resolved to form a synthesis (i.e. a resolution). However this synthesis, being a thesis, contains the seeds of its own antithesis and a new synthesis emerges, etc. However, Riegel suggests that there are some contradictions that cannot be resolved. He gives the example of the wave and particle theories of light, and suggests that in this case the truly developed mind accepts this contradiction. He goes further to say that even in the case where a synthesis is achieved the contradictory elements of the thesis and the antithesis still remain and this underlying contradiction between thesis and antithesis must be accepted by a mature mind. (Riegel, 1973, 1975, 1978).

2.4 THE RELATIONSHIP OF THE MODEL TO COGNITIVE DEVELOPMENT

It was said in the previous section that the Model represents the relationships between the different terms defined in this chapter. However, the endpoints which were reached in the Model have been shown to have equivalents in psychological theory. The Model may therefore be seen as having developmental significance for the study of children's actual reactions to contradiction.
As was mentioned earlier, the Endpoint Number (2) and Endpoint Number (3) on the Model can be seen to represent the theoretical position of Piaget and of the Training Theorists respectively. Regarding the Model as a representation of actual reactions of children it is possible to ask the question: once children have recognised a contradiction, which path on the Model most accurately describes their responses? That is, do most children deny the data and eliminate the contradiction (DF3), leading to the endpoint equivalent to Piaget's position, or do they distort the data and attempt to resolve the contradiction (DF7), leading to the endpoint equivalent to the Training Theorists' position?

If a path on the Model which most accurately describes the children's reactions could be found, this has significance for the major question of Part 1 of the present study. This was: is the resolution of contradiction a causal agent in cognitive development? It was noted in Chapter 1 that in order for the resolution of contradiction to be a causal agent in cognitive development then the responses of "attempt at resolution" (DF7), or similar responses, such as "distortion of data", must be observed.

In other words, in order to claim that the resolution of contradiction plays a causal role in cognitive development the path on the Model which most accurately describes the children's responses must be the path which leads to Endpoint Number (3). Should the majority of responses found be those which lead to the Endpoint Number (2), such as "denial of data" or "elimination of contradiction" (DF3), it would be difficult to support the proposition that resolution of contradiction is a causal agent in cognitive development.
Chapters 3, 4 and 5 will describe three experiments which examine the relationship between the Model and cognitive development. Before presenting these, a brief mention will be made of the methodological approach used in those experiments.

2.5 THE CLINICAL METHOD

The clinical method is the method of experimentation traditionally associated with the work of Piaget and his collaborators. The first description of the clinical method can be found in Piaget (1926) where he described the flexible interviewing technique he used to probe the thoughts of children.

The clinical method is a very useful experimental methodology for exploratory research. Ginsburg and Opper (1969), in commending the method, say:

Piaget felt that the early portion of his research was essentially exploratory. His goal was to open up new areas for investigation and to propose preliminary hypotheses for further examination. The early work was not intended to prove a theory or present definitive views on intelligence, and Piaget felt that methods should be as flexible as possible in the preliminary stage of research. (Ginsburg & Opper, 1969, p. 98).

Inhelder, Sinclair and Bovet (1974) also noted the usefulness of the method when they said:

Each time research was started in a new area, it was necessary to proceed by trial and error, aided somewhat by intuition. Rather than programming our research in detail beforehand, we always allowed ourselves a more or less lengthy period of exploration during which it was essentially the responses of the children that guided us. (Inhelder, Sinclair & Bovet, 1974, p. 22).
The research presented in this thesis is exploratory. Very little experimental work has been done on the role of the resolution of contradiction during cognitive development. The definitions which have been proposed are new and exploratory work is necessary to verify their usefulness. The verification must be obtained from measures of the responses of the children upon encountering a contradiction. To obtain such measures a subtle and flexible method of experimentation is required.

The clinical method, with its history of use by the Piagetian school, is the most appropriate experimental method that can be used in the research that is described presently. The aim of the clinical method is to follow the child's thought, without influencing it by suggestion or by imposing an adult's view on the child. To meet this aim the experimenter, when questioning the child, must constantly be forming hypotheses about the child's thought, and testing these hypotheses by changing the experimental situation, the action required of the child, or by posing a different question. The experimenter must also challenge the child (that is, give a countersuggestion), to find whether the child holds firmly and consistently to his or her beliefs (Inhelder, Sinclair & Bovet, 1974).

While the use of the clinical method is open to certain criticisms regarding the reliability of the data obtained (for example, Ginsburg & Opper, 1949; Osherson, 1974) the advantages it gives in exploring the child's thought and reactions to contradiction outweigh such criticism. As proof of the reliability of the clinical method it may be recalled that it was through using the clinical method that Piaget first found non-conservation behaviour in young children, one of the most repeatable findings of developmental psychology (Cowan, 1978).
The clinical method will be used extensively in this thesis.

In the following chapter the first experiment is presented. This experiment repeated several of the studies described in the literature on the role of the resolution of contradiction during cognitive development. The terms defined in the present chapter will be used in the analysis of the experiment to find whether the definitions are appropriate to the children's performances. An examination of the children's behaviour in relation to the Model described in Section 2.3 will also be undertaken to determine its adequacy as a developmental model.
CHAPTER 3
EXPERIMENT 1: A STUDY OF CHILDREN'S
REACTIONS TO CONTRADICTIONS IN TWO
DIFFERENT TYPES OF SITUATION

3.1 INTRODUCTION

Experiment 1 had four aims. The first was to determine the age and stage of development at which children recognise a contradiction. As this may be dependent upon the particular type of contradiction with which the children are confronted, this experiment included four different "contradiction" tasks. These, as will be explained below, exemplified two general types of "contradiction" situation.

The second aim was to establish the degree of generality which is exhibited in children's responses to contradiction once the contradictions have been recognised. In the present experiment thirteen separate "patterns" of reaction are possible. First, children may react similarly across the different types of situations outlined in DFI. A second possibility is that children's reactions to contradiction differ across different types of "contradiction" situation. Finally, children's reactions to contradiction may be highly task specific.

The experiment was based on several studies in the psychological literature which have examined the effect of contradiction on cognitive development. In order to examine the effect of contradiction on

13 In Chapter 2 it was noted that the study of contradiction as a causal agent in cognitive development involved principally the presentation of the situations 1 and 2 of DFI. These were, respectively, the incompatibility between two internally represented beliefs and an incompatibility between an internally represented belief and an external source of information. Only these two situations will be used in Part 1 of this paper.
reasoning, and to study the children's reactions to contradictions, it is necessary to have some system for classifying the responses. The definitions introduced in Chapter 2 constitute such a system. Thus, they were used to categorise the children's reactions to the tasks in Experiment 1. The third aim of the experiment, then, was to establish the usefulness or otherwise of the definitions for classifying the actual behaviour of children when confronted with contradictions.

The final aim of the experiment was to determine which path on the Model proposed in Chapter 2 best described the children's reaction to contradiction. In doing this it was hoped that the question of whether or not contradiction is a causal agent in cognitive development might be partially answered. In terms of the Model this question becomes: will the child react to the contradiction in ways which lead to Endpoint Number 2 on the Model or to Endpoint Number 3. The Training Theorists, adopting the position that contradiction plays a causal role in cognitive development would hypothesise that reactions on the path to Endpoint Number 3 (e.g. distortion of data, attempt at resolution) will occur most frequently.

As was noted previously, the tasks exemplified two types of "contradiction" situation. These were the situation type 1 of DF1 and the situation type 2 of DF1. Tasks 1 and 2 exemplified the situation 1 of DF1. That is, they involved a contradiction between two internally represented beliefs. Tasks 3 and 4 exemplified the situation 2 of DF1. That is, they involved a contradiction between an internally represented belief and an external source of information.

In general terms the tasks were:
1. A task which evoked both the concept of number and the concept of length (the task was taken from Inhelder, Sinclair and Bovet, 1974).\footnote{It is important to note that both the Inhelder, Sinclair and Bovet (1974) experiment and the subsequent experiments of Strauss and Rimalt (1974) and of Strauss and Ilan (1975) were all training studies. In this paper it is not the success of cognitive conflict or contradiction as a training device that is being investigated but the child's reaction when faced with a contradiction. Hence, although the study is referred to as a "training study" at times, there is no training involved and the child is not expected to learn. It is the child's reaction to the contradiction that is of interest.} In the literature it is assumed that this task poses a contradiction for those children who have acquired conservation of number but not conservation of length (the former precedes the latter in development by approximately two years). The contradiction is assumed to occur because the application of an adequate concept or "scheme" for number to the problem results in a conclusion which is incompatible with the conclusion which is reached by the application of an inadequate concept or "scheme" for length. In this view then, children who conserve neither number nor length, and children who conserve both should experience no contradiction when presented with this task. The reaction of the children who conserve number but do not conserve length inform us about their recognition of and reaction to contradiction.

2. A task in which children were presented with a physical occurrence in which two events occurred in a particular temporal order. The children were asked to produce a sentence in which the temporal order of the events corresponded with their order of mention in the sentence (e.g.
"the baby rings the bell and then the boy brings him the cup"). In the critical part of this task children were required to reverse the order of mention of the events in the sentence, while maintaining their original order of occurrence (e.g. "the boy brings the baby the cup after the baby rings (has rung) the bell"). This task was taken from Ferreiro and Sinclair (1971). In this task the children's concepts for the production of a sentence involving a temporal sequence (which involves the correspondence of the temporal order of the sentence and the events) contradict the children's concepts for the comprehension of a sentence involving a temporal sequence. That is, once the children have produced the sentence, which is likely to be incorrect since the children temporally order the sentence from "first event" to "last event", they will understand that this sentence does not describe the situation they have been asked to describe. The children's reaction to this contradiction informs us about their ability to recognise and react to a contradiction.

3. A task in which children were asked to make predictions about the physical actions of an object (specifically, will it float or sink). This prediction may then be contradicted by the actual action of the object. (The task was taken from Inhelder and Piaget, 1958). In this task the children's predictions which are based on internally represented beliefs may be contradicted by an external source of information which is the action of the object itself.
4. A task in which the child predicts the action of an object (specifically will it make the water go higher than before) and the action of the object may contradict this prediction. This task involved the conservation of volume task (Piaget & Inhelder, 1941). Conservation of volume does not normally involve a contradiction, since the child is not normally shown the results of the actions about which (s)he is asked to make a prediction. If however the task is modified so that the child is shown the result of the action, it is possible to present the child with a contradiction (of the situation type 2 of DF1) if his or her prediction happens to be incorrect.

This last task is particularly interesting as the early training literature (e.g. Greco, 1959a, 1959b; Smedslund, 1961a; Wohlwill, 1959) showed that observing the results of the actions being performed in a conservation test is not sufficient to induce non-conserving children to change their answer. This is largely because the children in this situation distort the perceptual data to conform to their predictions. This distortion of data response, if it is found in the present experiment, would support the Training Theorists' position regarding the children's reaction to contradiction.

3.2 METHOD

3.2.1 Description of the Tasks

The tasks were the following:

(a) Task 1: Conservation of length using conservation of number. (Adapted from Inhelder, Sinclair & Bovet, 1974).
Materials: Twenty standard length matches.
          Twenty matches half the length of standard matches.

Procedure: The procedure comprised three phases. These were:

Phase 1: Conservation. Two "roads" were made of six standard length matches each (see A in Figure 3.1). The matches were placed end to end, creating continuous roads. It was established that the child knew that there were the same number of matches in each road and that the roads were the same length. One match was removed from the end of one road and placed at the other end (see B in Figure 3.1) and the child was asked if there were still the same number of matches in each road and if the roads were still the same length. Explanations of the child's response were sought.

![A](image1) ![B](image2)

Figure 3.1: Conservation phase of Task 1.

The roads were returned to their original configuration (A in Figure 3.1) and the equality of number and of length was re-established.
A second transformation was performed (see Figure 3.2) and the equality of the number of matches and the length of the roads was again questioned.

![Diagram of transformation](image)

**Figure 3.2:** Second transformation in the conservation phase of Task 1.

Phase 2: Judgement. The child was asked to judge if two roads were the same length, after they had been constructed. The constructions, some of which included small matches, are shown in Figure 3.3.

![Diagram of constructions](image)

**Figure 3.3:** The constructions made in the judgement phase of Task 1.

The four sets of roads A, B, C, D in Figure 3.3 were presented sequentially. In each case the child was asked if the numbers of matches in the two roads were the same and if the lengths of the two roads were the same. When using the small matches the experimenter pointed out that the matches were small, but not that they were half the length of the standard matches.
Phase 3: Construction. The experimenter constructed a road and asked the child to make a straight road of the same length as the experimenter's road, starting at the point the experimenter indicated. Figure 3.4 shows the experimenter's roads and the starting point indicated for the child. The child was provided with the standard length matches for this task. The experimenter's roads were built of standard length matches.

Figure 3.4: The experimenter's roads for which the child was asked to build straight roads of the same length.

Next, the child was asked to build straight roads the same length as the experimenter's but on this occasion was given the small matches, whereas the experimenter had used standard length matches. Figure 3.5 shows the experimenter's roads.

Figure 3.5: The experimenter's roads for which the child had to build straight roads the same length, with the small matches only.
The child was asked after every construction in this phase whether his or her road was the same length as the experimenter's road, and if the child said it was not, (s)he was asked to build a road of the same length as the experimenter's road.

(b) Task 2: Construction of temporal clauses, reversing the order of mention. (Adapted from Ferreiro & Sinclair, 1971).

Materials: a "boy" doll, a "baby" doll, four wooden blocks, a toy bell, a toy cup, a toy chair, a toy rattle, a cloth, a square plastic container, a small wooden block.

Procedure: The task had three phases. Phases 1 and 2 were practice phases. Phase 3 constituted the critical phase.

The three phases were:

Phase 1: Presentation. All the objects were placed on the table and the child was asked to name them. Discrete labels for each object were required (e.g. "boy" and "baby" or "boy doll" and "baby doll" rather than "dolls").

Phase 2: Introduction. The experimenter told the child a "story" which was a sentence involving a temporal sequence, for example, "the baby tips the blocks out of the cup and then the boy puts them back in again". The experimenter then acted out the story with the materials and asked the child to tell the story that (s)he had just seen. This was repeated several times with the experimenter acting out the sequence with the materials, and the child
telling the story. A second story was then acted out by the experimenter (with no verbal introduction) and the child was asked to tell the story that had been represented. The child was then asked to answer questions about when each part of the story action had occurred (e.g. with the story "the baby drinks from the cup, and then the boy gives it a rattle": when did the boy give the baby the rattle? When did the baby drink from the cup?).

Phase 3: Test. The experimenter acted out another story with the materials and asked the child to tell the story. The experimenter then asked the child to tell the same story, but to begin by talking about the second part first. For example, in the first test story "the baby rings the bell and the boy brings him the cup" - the child was asked to tell the same story but to start talking about the boy first. After the production had been attempted the child was asked if his or her story accurately described what the experimenter had acted out with the dolls. If the child denied his or her story was an accurate description, (s)he was asked again to try to tell the story the experimenter had acted out with the dolls but to start the story by talking about "the boy" first. Three test sentences were used:
1. The baby rings the bell and then the boy brings him the cup.

2. The baby builds a tower with some blocks and then the boy knocks it over.

3. The baby sits on the chair then the boy washes the baby.

All sentences were in the present tense.

(c) Task 3: The Concept of Floating and Sinking. (Adapted from Inhelder & Piaget, 1958).

Materials: A bucket one third full of water. A large piece of wood, a small piece of wood, a wooden "paddle-pop" stick (a smooth stick 10 cms long, 0.75 cms wide and 0.1 cms thick), a wooden bead, a wooden block, a plastic spoon, a metal spoon, a piece of wire, a nail, a metal weight, a pebble, a stone, a plastic token, a piece of alfoil in the shape of a dish, a candle, a key, a match, a cork, a two cent piece, a piece of paper, a plastic lid with raised sides, a ball of plasticine, a plastic toy house.

Procedure:

The child was initially asked to describe what happens when an object floats and when it sinks. The child was then given an object and asked to predict whether it would float or sink. After the prediction was made the child was invited to place the object in the bucket of water and observe the outcome. Once the child had become familiar with the task the experimenter deliberately
chose a sequence of items and the child was asked to make a prediction. The items were chosen so that the child was likely to contradict him or herself, for example, if the child said the small wooden block "floats because it is small" then the next item would be the pebble. If the child said the pebble "sinks because it is round" the next item would be the wooden bead etc.

(d) Task 4: Conservation of Volume. (Adapted from Piaget & Inhelder, 1941).

Materials: Two identical narrow beakers, half full of water.
Two elastic bands.
Two balls of plasticine of equal shape, mass, weight and volume.

Procedure: The procedure had three phases:

Phase 1: Introduction. The child was shown the two beakers, both containing water, with elastic bands placed around the beakers to mark the level of the water. Modifications were made to the amount of water in each beaker until the child agreed that there was the same amount of water in both beakers, and that the elastic bands were at the same place on each beaker.

A ball of plasticine was placed in one beaker, and the child observed that the water level rose. The child then placed the other, identical ball in the other beaker and was asked if the water had risen
by the same amount. If the child did not agree that it had, modifications were made to the ball of plasticine (by adding or taking away plasticine) until the child agreed that both balls caused the water to rise by an equal amount in each beaker.

Phase 2: Conservation Test. The child was asked to remove the ball from one beaker and roll it into a "sausage". (S)he was then asked to judge whether, when the "sausage" was placed into the beaker (and completely submerged), the water would rise to the same level as the beaker with the ball in it, or higher or lower. (S)he was not shown the result of this action. If the child asserted that the water would rise to the same level with both shapes, and gave conservation of volume as the reason, a second transformation was performed (the "sausage" was returned to a ball, then the ball was broken into pieces). If, again a conservation of volume response was obtained the test was finished. If however the child suggested that the water would rise to a higher or lower point after either the first or second transformation, the the outcome test was given.

Phase 3: Outcome Test. The experimenter placed the "sausage" in the beaker and asked the child to observe the water level and judge whether it was the same, higher or lower than the water level in the beaker with the ball in it. The "sausage" was then changed
into a ball and the child shown that the levels were the same in both beakers. Next, the ball was broken into pieces and the child asked to predict where the water level would rise to. (S)he was shown the result, and asked whether his or her prediction had been correct. Finally, after the plasticine was again converted to a ball and the child had agreed to the equality of water levels with the balls, the ball was changed into a "ring" and the same prediction and observation procedure repeated.

(e) Task 5: Conservation of number.

Materials: Fifteen red plastic discs.
Six blue plastic discs.

Procedure: A standard conservation of number test was given.
(See Appendix 2a or Inhelder, Sinclair and Bovet, 1974, p. 275)

(f) Task 6: Conservation of continuous unequal length.

Materials: Two flexible wires of different lengths (15 cms and 10 cms).

Procedure: A standard test for conservation of continuous length was given. (See Appendix 2a or Inhelder, Sinclair and Bovet, 1974, p. 287)

3.2.2 Subjects

A total of 63 children aged between 5 and 11 years from a suburban Canberra Primary School were used as subjects. Table 3.1 shows the number of children in each age group attempting each task. Ideally each
child performed each task. (See below for further details). The child's age was taken as his or her age last birthday. Approximately equal numbers of male and female children were used.

Table 3.1: Number of children of each age presented with each task in Experiment 1

<table>
<thead>
<tr>
<th>Age in years</th>
<th>Task 1 (n=9)</th>
<th>Task 2 (n=13)</th>
<th>Task 3 (n=10)</th>
<th>Task 4 (n=6)</th>
<th>Task 5 (n=15)</th>
<th>Task 6 (n=3)</th>
<th>Total (n=63)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>5</td>
<td>7</td>
<td>6</td>
<td>3</td>
<td>8</td>
<td>9</td>
<td>35</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>11</td>
<td>6</td>
<td>4</td>
<td>13</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>14</td>
<td>10</td>
<td>49</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>3</td>
<td>6</td>
<td>11</td>
<td>2</td>
<td>6</td>
<td>35</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>6</td>
<td>10</td>
<td>6</td>
<td>15</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td>7</td>
<td>7</td>
<td>63</td>
</tr>
</tbody>
</table>

3.2.3 Selection of Subjects

The children were selected by the teacher of the class from which they were being drawn.

Different methods of selection of children result in different biases in the sample used. In these experiments the aim is to find the range of behaviours that the children are capable of producing, rather than show that any given child is capable of a certain type of performance. Because this aim is a general one the bias introduced by the different methods of selecting children need not be carefully considered. However, biases occur, and hence the method of selection of the children will be noted. The methods of selection and the biases they introduce are the following: (a) Requesting the teacher to choose the children normally results in the very bright children, or less often, the "class nuisances" being selected. (b) Testing all the children in a given class (as was done in Experiments 2, 4 and 5) obviates this bias, but normally results in an interaction between age and grade (e.g. the 6 year olds drawn from 2nd grade are more advanced than the 6 year olds drawn from 1st grade). (c) Randomly selecting equal numbers of children from each age group is the ideal solution (e.g. Experiment 3) but few schools are able to give experimenters the freedom to use this method of selection. The age/grade interaction can still occur in this case.
3.2.4 Order of Presentation of Tasks

The tasks were presented in three sessions. Each session was separated by one week. The typical order of presentation was: Session 1: Task 5; Task 3. Session 2: Task 6; Task 2. Session 3: Task 1; Task 4. Not all children completed all tasks, some being unavailable in particular sessions or because time ran out in some sessions.

3.2.5 Materials

Tape recorder and cassette tape for each subject.
Record sheets for each task.

3.2.6 Procedure

Each child was interviewed individually by the Experimenter. The testing place was an empty classroom in the school. The child accompanied the Experimenter from the classroom to the testing room and was seated beside the Experimenter at the testing table. The Experimenter then turned on the tape recorder, and, guided by the previous tests given to that subject and the guidelines for order of presentation of the tasks, commenced the first task. The child was tested in three sessions, with one session per week. Each session lasted less than 20 minutes.

The testing place will be described in each experiment as it often controlled the degree of interruption experienced by the experimenter and the child. An empty classroom constituted an ideal testing place but few of the schools had sufficient space to allow this. Consequently testing was occasionally carried out in a corridor. This led to interruptions from classmates sent out of the classroom for misbehaviour, or on errands. As with the selection bias these interruptions are not important for research exploring the range of children's answers, but may be relevant to experiments dealing with a given child's capacity to reason in a certain way (e.g. Experiment 5).
3.2.7 Scoring

During the interview with each child the Experimenter recorded the visible manipulations of the test materials made by the child such as the 'roads' made in the training of length task, and the objects chosen to float or sink, and also recorded the child's affective responses (e.g. surprise, puzzlement) to the contradictions. After testing, the tape recording for each child was transcribed (a verbatim record was not obtained). This allowed a "protocol" to be made for each subject which included the Experimenter's questions, the child's actions and the child's verbalisations. (Examples of protocols may be found in Appendix 21). The scoring of each task was complex, and will be described below. Briefly, an inventory of general categories of the children's responses was developed from the protocol. The inventory was then formed into an ordered set of categories with each general response category that had been listed in the inventory scoring an arbitrary, ordered number. Each category was then classified as representing "non-recognition of contradiction", "recognition of contradiction" or "resolution of contradiction".

3.3 RESULTS
3.3.1 The Scoring Procedure Used on the Protocols

As was mentioned earlier, a protocol was obtained for each task performed by each subject. Then, for each task all the protocols from all the subjects were grouped together. The scoring procedure then contained the following phases:

Phase 1: A list was made of the "general categories of response" that were given. For example, in Task 1, if one child built a road with a vertical match (i.e. \[ \text{\includegraphics[width=0.1\textwidth]{vertical_match.png}} \]) and another used a small match
(i.e.  ) both these responses were categorised as "compromise responses".

Phase II: The general categories were ordered into a set of scored categories with the developmentally earliest response category given the lowest score and the developmentally most advanced response category the highest score. The individual protocols were then scored by allocating the score which corresponded to the general response category into which the particular response fell to the protocol.

Phase III: From these ordered categories an internal grouping of response categories was made which indicated non-recognition of contradiction, recognition of contradiction and resolution of contradiction. Returning to the individual protocols, these were rescored into that one of the internal groupings into which the scored response category fell.

The following comments need to be made regarding each Phase:

Phase I: It was not difficult to make an inventory of all the general response categories produced by the children. The literature existing on each of the tasks already lists certain response categories and new response categories that were noted could be added to these.

Phase II: Ranking of the response categories into a set of ordered categories was more difficult. However, the literature already lists the general response categories ordinally (e.g. Stage IA, IB, IIA, IIB, III etc) and new response categories could be inserted into these existing ordinal categories. The assumptions used in inserting these response categories were:
1. The developmentally early responses will be simple (e.g. refusal, description of the event) and the later responses will be complex (e.g. attempts at causal explanation, multivariate explanations).

2. In developmentally early responses the children will ignore or not notice contradiction, and in the later responses they will eliminate or resolve the contradiction.

Phase III: The ordered categories were grouped as representing "non-recognition of contradiction", "recognition of contradiction" or "resolution of contradiction" according to the definitions proposed in Chapter 2. That is, responses equivalent to DF8 were grouped as "non-recognition of contradiction", responses equivalent to DF2, DF3, DF4, DF5 and DF7 were classified as "recognition of contradiction", and responses equivalent to DF6 were grouped as "resolution of contradiction". Prior to testing it was not known in which ways the child's "recognition of contradiction" responses would be manifested in each task (e.g. elimination (DF3), attempt at resolution (DF7) etc.) The way in which the "recognition of contradiction" could be identified in each task is an interesting finding as it clarifies the relationship between the Model and cognitive development. Details regarding the scoring of the protocols may be found in Appendix 2.

3.3.2 The child's reaction to contradiction in each task

In this section each task will be evaluated individually to find at what age the children recognise contradiction and how they react to contradiction.
Task 1

On Task 1, only the construction phase was used in analysis (see Appendix 2c for scoring method and scores on the other phases). After ranking the responses given (see Appendix 2c for the ranked responses and for the number of children behaving in each way), they were categorised as "refusal", "non-recognition of contradiction", "recognition of contradiction" and "resolution of contradiction".

"Refusal" included responses that made no reference to the number of matches or length of the roads, for example, the child built a "boat" with the matches or lined them up across the table.

"Non-recognition of contradiction" included responses where the child used only one strategy (either number or length), or where the child used one strategy in one situation (e.g. number) and the other in another situation (e.g. length) without relating either the two strategies or the two answers they received to the same problem.

"Recognition of contradiction" was observed in "attempts to resolve" (DF7) the contradiction. The responses included puzzlement, denial of the equality of length of the roads at any time, claiming the task was not possible and compromise solutions.

"Resolution of contradiction" was scored when the child correctly built all the roads requested with matches of any length.

The number of children of each age responding in each way can be seen in Table 3.2.
Table 3.2: Number of children at each age group reacting in each way in Task 1

<table>
<thead>
<tr>
<th>Reaction to contradiction</th>
<th>5 &amp; 6</th>
<th>7 &amp; 8</th>
<th>9</th>
<th>10 &amp; 11 a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refusal</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Non-recognition of contradiction</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Recognition of contradiction</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Resolution of contradiction</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>

(a) Ages were grouped to provide greater numbers at each age group

Virtually all the children recognised a contradiction (although it is presumably significant that the only "non-recognition of contradiction" responses occurred in the youngest age group). It is evident that a development towards "resolution of contradiction" (DF6) occurs in this task with age (although this is not significant ($\chi^2 = 1.6, df = 1$)). Recognition of contradiction versus resolution of contradiction by less than or equal to 8 years versus 9 years and older). This resolution of contradiction is preceded by "recognition of contradiction" manifested solely by "attempts at resolution" (DF7). In this task, therefore, the child's behaviour is described by the path to Endpoint Number 3 on the Model.

Task 2

In this task the responses were ranked (see Appendix 2d) and split into the four categories previously used. "Refusal" was characterised by the child's refusal to attempt to begin a sentence with the second actor. "Non-recognition of contradiction" included all responses where
the child simply reversed either the order of the actors, or the actions, or both, and when asked if they had accurately described what had happened with the dolls in the "play", they replied that they had done so. The "recognition of contradiction" responses were mainly "attempts at resolution" (DF7). They included hesitation and puzzlement and a variety of compromise solutions where an extra activity was introduced to help the response. For example, the sentence acted was "the baby performed action A and then the boy performed action B". The correct response would have been: "the boy performed action B after the baby performed action A". However, the compromise solutions included: "the boy performed action B and then the baby performed action C"; and "the boy performed action C and then the baby performed action A and then the boy performed action B".

Finally the "resolution of contradiction" responses included the use of the words "after" or "and before that" to indicate the temporal sequence.

The number of children responding in each way in each age group is shown in Table 3.3.

Table 3.3: The number of children in each age group responding in each way on Task 2.

<table>
<thead>
<tr>
<th>Reaction to contradiction</th>
<th>Age Groups in Years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 &amp; 6</td>
</tr>
<tr>
<td>Refusal</td>
<td>2</td>
</tr>
<tr>
<td>Non-recognition of contradiction</td>
<td>8</td>
</tr>
<tr>
<td>Recognition of contradiction</td>
<td>8</td>
</tr>
<tr>
<td>Resolution of contradiction</td>
<td>0</td>
</tr>
</tbody>
</table>
The responses in this task were different from the previous task. Here many children did not recognise a contradiction. With age there appeared to be an increase in the proportion of children recognising a contradiction. However this was not significant ($\chi^2 = 1.4$, $df = 1$) (Non-recognition of contradiction versus recognition of and resolution of contradiction by less than and equal to 8 years versus 9 years and older). Very few children resolved the contradiction in this task. The problem here seems to be that the task was too difficult. The question of when children can understand and produce phrases with temporal connectives has been examined by researchers in the field of psycholinguistics (Amidon, 1976; Amidon & Carey, 1972; Clark, 1971, 1973; Johnson 1975). While a specific age for competence with temporal phrases is difficult to specify because of differences between comprehension, production and transformation performances it would seem that this Task 2 should have been performed successfully between 8 and 10 years of age. In the present study however the task proved to be so difficult that only four of the sample of 50 children resolved it. Nevertheless a trend across age was found, and it seems that the "resolution of contradiction" as described by Inhelder et al. (1974) and by Strauss et al. (1974, 1975) has occurred. Hence the "resolution of contradiction" (DF6) has again been shown to occur after "attempts at resolution" (DF7).

In this task again, therefore, the path of the Model leading to Endpoint Number 3 seems to most accurately describe the children's behaviour.

Task 3

In this task recognition of contradiction was manifested by "avoidance of contradiction" (DF5) as opposed to "attempts at resolution" (DF7) as was found in the previous two tasks. This is of interest as Task 1
and Task 2 involved the situation type 1 of DF1 whereas Task 3 (and Task 4) involved the situation type 2 of DF1.

As in the previous tasks, the responses of the children after being listed ordinally, were sorted into four categories (see Appendix 2e). The first of these was "refusal" to respond in the situation. "Non-recognition of contradiction" was exemplified by the child predicting that an object would float or sink on the basis of its being "light" or "heavy". This attribution was however without reference to the real weight of the object. Additionally when the prediction was not confirmed the opposite property (light as opposed to heavy or vice versa) was then attributed to the object (e.g. the plastic disc "will float because it's light"; it sinks; "it sank because it was heavy").

"Recognition of contradiction" was identified by the careful avoidance of contradiction, for example, the child would say that the object was "too light" or "too heavy" rather than reverse the property, or the child would distinguish unique properties of each object on which to base a prediction (e.g. it is wood, it is steel, it is round, it has a hole, it is plastic etc).

"Resolution of contradiction" was scored when the child discussed the concepts of relative weight or "air" in the object. The number of children at each age behaving in each way is shown in Table 3.4.
Table 3.4: The number of children in each age group behaving in each way on Task 3.

<table>
<thead>
<tr>
<th>Reaction to Contradiction</th>
<th>Age Group in Years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 &amp; 6</td>
</tr>
<tr>
<td>Refusal</td>
<td>1</td>
</tr>
<tr>
<td>Non-recognition of contradiction</td>
<td>5</td>
</tr>
<tr>
<td>Recognition of contradiction</td>
<td>6</td>
</tr>
<tr>
<td>Resolution of contradiction</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 3.4 shows that by 7 years of age all the children are thinking in a non-contradictory manner and that the transition from contradictory to non-contradictory reasoning appears to occur between 5 and 6 years of age. This indirectly confirms Piaget's hypothesis that children think in a non-contradictory manner only after they have acquired concrete operations. A direct test of this hypothesis will be presented in Section 3.3.3. The one 11 year old shown in Table 3.4 as refusing to attempt the task appears to disconfirm the strong hypothesis that all children reason in a non-contradictory manner after the age of 7 years. However, it is more likely that this child's response reflects the child's transition from concrete operational thinking to formal operational thinking. At this transition children have been found to apparently "regress" in their reasoning as they try to apply their new formal operational capacities to the material and treat the task as more difficult than it is (Elkind, 1967).

In this task, then, the "resolution of contradiction" (DF6) was finally achieved by way of "avoidance of contradiction" (DF5) and "elimination of contradiction" (DF4). That is, the child's behaviour...
on the task can best be described by Endpoint 2 on the Model. This finding is interesting as the only apparent difference between this task and the previous two tasks (where "resolution of contradiction" (DF6) was achieved through "attempts at resolution" (DF7) that is, Endpoint Number 3 on the Model) is the type of situation used to present the contradiction. The next task to be analysed is again a situation 2 task (i.e. the same as Task 3) so that the same comparison can be made.

**Task 4**

In this task two parts of the task were scored. These were the conservation test and the "Outcome test". The conservation test was scored:

1. non-conservation response
2. intermediate response
3. conservation response.

To be scored as giving a conservation response the subject was required to give a conservation answer after the transformation of the plasticine, to support this with a verbal explanation of reversibility, compensation or identity, and to resist a counter-suggestion. An intermediate response was scored if the child showed uncertainty of his or her answer on the first transformation, or if, after giving a conservation response for the first transformation, (s)he then gave a non-conservation answer on the second transformation. A non-conservation response was scored if the child asserted that the volume of the plasticine would not remain the same after the transformation that is, that the water would rise to a higher or lower point than previously.

Only those children who gave non-conservation or an intermediate response were given the "outcome test", that is, they were shown the "sausage" placed in the water, and were asked to comment on whether the
water rose higher or lower or to the same point as the beaker of water with the ball in it, before being asked to predict where the water would rise for a second and third transformation of the plasticine ball.

The children who correctly predicted the behaviour of the ball on the first instance (i.e. those who scored a "conservation response") were scored as having "solved the problem on the first presentation".

The responses of the children given the "outcome test" were listed (see Appendix 2f) and the same four categories as used in the previous tasks were again scored. In this task they were:
1. refusal to predict
2. "non-recognition of contradiction". The response that would have been scored as "non-recognition of contradiction" was one in which the child did not notice that the water rose to the same level in both beakers after the transformed objects were placed in the beaker. For example, if the child had predicted that the water would rise to a higher or lower level after a transformation, and then (incorrectly) "observed" the water to rise to a higher or lower level respectively. This behaviour in fact did not occur with any subjects.
3. "recognition of contradiction" included predicting that the water would rise to a higher or lower level than in the beaker containing the ball and then observing that it rose to the same level in both beakers. The prediction was sometimes corrected on the final transformation after feedback had been received.
4. "resolution of the contradiction". That is, (s)he predicted that the water would rise to the same level as the beaker containing the ball on both transformations and observed this to be so.

Table 3.5 shows the number of children of each age responding in these ways.
Table 3.5: The number of children in each age group reacting in each way in Task 4

<table>
<thead>
<tr>
<th>Reaction to Contradiction</th>
<th>Age Group in Years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 &amp; 6</td>
</tr>
<tr>
<td>Refusal</td>
<td>1</td>
</tr>
<tr>
<td>Non-recognition of contradiction</td>
<td>0</td>
</tr>
<tr>
<td>Recognition of contradiction</td>
<td>3</td>
</tr>
<tr>
<td>Resolution of contradiction</td>
<td>4</td>
</tr>
<tr>
<td>Solution on the first presentation</td>
<td>1</td>
</tr>
</tbody>
</table>

In this task then even the youngest children recognised the contradiction and half the youngest children resolved the contradiction during the task presentation.

It has thus been found in this task, using a situation type 2, that the resolution of contradiction (DF6) was achieved through the "elimination of contradiction" (DF3). In this task, however, no age related development can be noted.

These findings confirm that the Endpoint Number 2 of the Model described the child's behaviour in the situation type 2 of DF1. The implications of the findings concerning which Endpoint of the Model describes the children's behaviour will be discussed in Section 3.4.

The Task 2 and Task 4 were included in this experiment to determine the generality of the children's reactions to contradiction. From the individual analysis of the tasks it appears that Task 2 conforms to the findings in the literature regarding the children's responses to contradiction. Task 4, however, is unusual in that no period of "non-recognition of contradiction" has been found. To further examine the
question of the generality of the child's response to contradiction the
scores of the children who each did several tasks may be examined.

Patterns of performance across several tasks

Since each child was given more than one task, it is possible to
see if the children behaved in the same way on all tasks. (The score of
each subject on each task is presented in Appendix 2g). The four scor-
ing categories of "reaction to contradiction" were reduced to two, which
were "non-recognition of contradiction" (previously categories "1" and
"2") and "recognition of contradiction" (previously categories "3" and
"4"). Using only those children who had been given three or four tasks
(excluding Tasks 5 and 6 which were given to all the children) it was
possible to determine whether the children were consistent in their
reaction to contradiction (see Appendix 2h). It was found that 20 of the
children responded to all contradictions in the same manner and 16 in an
inconsistent manner. The number responding in an inconsistent manner
was, therefore, high, especially since the categories of response were
so large (i.e. "non-recognition of contradiction" as opposed to "recog-
nition of contradiction"). In analysing these consistencies and inco-
sistencies in terms of age it was found that the younger children tended
to be inconsistent more often, but that some of the older children were
also responding in an inconsistent way (see Table 3.6).

Table 3.6: The number of children in each age group responding
consistently to the contradiction in three or four tasks.

<table>
<thead>
<tr>
<th>Consistency of response</th>
<th>5 &amp; 6</th>
<th>7 &amp; 8</th>
<th>9</th>
<th>10 &amp; 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inconsistent</td>
<td>7</td>
<td>3</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Consistent</td>
<td>1</td>
<td>6</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>
These data are puzzling. At all ages some children responded in different ways to contradictions in different task situations. This may mean that it is not a general response to contradiction that is being determined in the children's behaviours but rather some reaction specific to each task. It may also mean that the tasks are of different levels of difficulty and, hence, the children recognise contradictions in difficult situations later than they recognise contradictions in easy situations.

The Differential Difficulty of the Tasks

The tasks could be difficult in two different ways. Either the concept involved in the task may be a difficult one, or the recognition of contradiction in the particular context of the task may be difficult. To determine which of the concepts is most difficult we may refer to the literature to find at what ages the concepts in each task are acquired. If this is done the following ranking in order of difficulty is obtained: Task 1 (conservation of length acquired at 7 or 8 years of age), Task 2 (use of temporal connectives acquired at 8 to 9 years of age), Task 4 (conservation of volume acquired at 10 to 11 years of age), and Task 3 (concept of relative density acquired at 11 to 12 years of age).

If the children's responses on the four tasks are evaluated with this ranking of difficulty in mind then many of the children still behave in an inconsistent manner in their reaction to the contradiction on the four tasks. The tasks may also be ranked in terms of the difficulty the children had in recognising the contradiction (i.e. the higher the proportion of children who "recognise the contradiction" the easier the task). Using this criterion (and the data in Tables 3.2 to 3.5) the following order of difficulty is obtained: Task 4 (all the children recognised the contradiction), Task 1 and Task 3 (these two tasks
appeared to be of equal difficulty: children recognised the contradiction after 6 years of age, and Task 2 (many children did not recognise the contradiction). If the difficulty of recognising the contradiction of the tasks is systematically affecting the children's reaction to contradiction then it should be possible to form a Guttman Scale showing that a contradiction in the easiest tasks will be recognised before a contradiction in the later tasks. A Guttman Scale was constructed manually (see Appendix 2h) and it was found that five sets of responses did not conform to the difficulty pattern suggested above but 31 sets did so.

This finding strongly supports the suggestion that the tasks are of varying difficulty in terms of when a contradiction will be recognised. In the easiest task the contradiction was recognised before 5 years of age, in the most difficult it was not recognised until 9 years of age. This finding tends to support the account of the "Training Theorists" who suggest that contradiction, the resolution of which plays a causal role in cognitive development, can be recognised at all stages of cognitive development. However, the complexity of the contradiction, or the context in which it is placed may influence when the contradiction is recognised.

The preceding analysis examined the children's reactions to contradiction, basically, in relation to the children's ages. However, within the age range studied there is only a loose relationship between age and developmental stage. In the next section the relationship between the children's performance and their developmental stage will be examined.
3.3.3 Developmental Stage and Recognition of Contradiction

The child's developmental stage has been measured by the conservation tasks, which were called Task 5 and Task 6. The results of these tests will be given, and these will be followed by a discussion of the relation between developmental stage and reaction to contradiction.

In the conservation tasks, for the child to be scored as 'conserving' number or length the child was required to give a conservation answer on two transformations of the material, and to support this with a verbal explanation of identity, compensation or reversibility,\(^\text{17}\) and to resist a countersuggestion.

On Tasks 5 and 6 the expected (Inhelder, Sinclair & Bovet, 1974) two year lag of conservation of length over conservation of number was found. That is, the age at which 75% of the children showed conservation behaviour on Task 5 (the conservation of number task) was 6 years. The age at which 75% of the children showed conservation behaviour on Task 6 (the conservation of length task) was 8 years.\(^\text{18}\) (See Appendix 2b for the actual figures). This finding replicates the finding of the Inhelder, Sinclair and Bovet (1974) study, that is, that conservation of number is acquired at an earlier age than conservation of length.

The theories discussed in Chapter 1 proposed a stage related development in the child's reaction to contradiction. Piaget (1928) had

\(^{17}\) In some of the Genevan studies all three explanations were required. Following the more recent literature only one was required in this study.

\(^{18}\) According to accepted practice (see Laurendeau & Pinard, 1962, p. 94) the age at which 75% or more of the children are classified as conservers is the age of acquisition of the concept. Kamura and Easley (1977) use a 50% success rate in the task to determine the age of acquisition of the conservation. The more conservative 75% success rate was chosen in this study in line with Piaget's and Inhelder's (1941) practice. However, Kamura and Easley refer to Piaget and Inhelder's (1969) study where a 50% cut off level was used.
suggested that only after the acquisition of concrete operations would the child recognise contradictions. Strauss et al., on the other hand, suggested that children could recognise contradiction at all stages of their development, (e.g. Strauss, 1972) although undoubtedly the complexity of the contradiction that they could resolve would increase as the children's cognitive capacities increased with development. The second part of this latter proposition has been supported by the analysis of the children's behaviour in several tasks. Evaluating the findings of each task in terms of the age at which the child acquires concrete operations (which occurs between 5 and 7 years of age), we find that the results of Task 1 and Task 3 may support Piaget's hypothesis that contradictions are only recognised after the acquisition of concrete operations. However, in Task 2 we find that well after the children would have acquired concrete operations, they are still unaware of this contradiction and that in Task 4 children of all ages recognised the contradiction. While these conclusions do not bode well for Piaget's views on the recognition of contradiction, a stronger test of this hypothesis is available by comparing the children's conservation of number and conservation of length test scores with their reaction to the contradictions.

Two conservation tests, the conservation of number test and the conservation of length test were given to each subject. These tests were scored as 1 - non-conservation response; 2 - intermediate response and 3 - conservation response. Each child who scored either 1 on the conservation of number task and 1 on the conservation of length task or 2 on the conservation of number task and 1 on the conservation of length task was classified as "Not Yet Concrete Operational". All other children (i.e. those who scored 2 & 2 or 3 & 1 or 3 & 2 or 3 & 3 on the
conservation of number task and conservation of length task respectively were classified as "Concrete Operational".

The child's behaviour on the contradiction tasks was scored as "non-recognition of contradiction" (Non-Rec) or "recognition of contradiction" (Rec).

Table 3.7 shows the cross-tabulation of these two classifications for each task.

Table 3.7: The number of children, on each task, classified by developmental stage and reaction to contradiction.

<table>
<thead>
<tr>
<th>Developmental Stage</th>
<th>Task 1</th>
<th>Task 2</th>
<th>Task 3</th>
<th>Task 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-Rec</td>
<td>Rec</td>
<td>Non-Rec</td>
<td>Rec</td>
</tr>
<tr>
<td>Not Yet Concrete Operational</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Concrete Operational</td>
<td>2</td>
<td>27</td>
<td>14</td>
<td>26</td>
</tr>
</tbody>
</table>

From Table 3.7 it can be concluded that there is no relationship between the level of cognitive development and the child's recognition of contradiction. The number of children who can be classified as "not yet concrete operational" is small. However, it is quite clear that a strong hypothesis suggesting that children are able to recognise contradictions only after they have attained concrete operational reasoning must be rejected in all tasks. The Piagetian position regarding when the child is able to recognise contradiction is not verified for any of the tasks.
3.4 DISCUSSION

In terms of the model proposed in Chapter 2 of possible reactions to contradiction, it appears that the path followed by the children's reactions (towards Endpoint Number 2 or Endpoint Number 3) in this experiment was task dependent. In the two tasks which exemplify situation 1 of DF1, recognition of contradiction was indexed by "attempts at resolution" (DF7). The children exhibited both the puzzlement and the compromise solutions which had been found in the Inhelder, Sinclair and Bovet experiments (1974) and in the other experiments which followed from their study. In the two tasks exemplifying situation 2 of DF1, on the other hand, recognition of contradiction was manifested by "avoidance of contradiction" (DF5) and "elimination of contradiction" (DF3). The direction, in terms of the Model, that the children's reactions took therefore seemed to depend on whether a situation 1 task or a situation 2 task was used.

While the Model referred only to the children's reactions to contradiction, the theories outlined in Chapter 1 also made predictions about the age at which the child could recognise a contradiction. The results of the present experiment support the account offered by the "Training Theorists" as children at all ages and developmental stages were able to recognise a contradiction.

Overall then, while the experiment is somewhat inconclusive, because of the task dependent reactions, it seems reasonable to suggest that the theory of the "Training Theorists" has been provided with more support than has Piaget's theory, and hence it is still possible to entertain the notion that contradiction is a causal agent in cognitive development.
However, one odd result causes us to pause. This result derives from Task 1, which was adopted by the "Training Theorist" school as the prototype for their subsequent experiments. It may be recalled that for Task 6 (conservation of length) most subjects had acquired conservation of length by 8 years of age. However, Table 3.2 shows that 50% of the 9 year old children had not "resolved the contradiction" but had "recognised the contradiction". That is, they had presented a response of puzzlement or compromise that was classified as an "attempt at resolution" (DF7).

If these children understood both concepts why should they have been puzzled or have needed to develop compromise solutions? If we examine the behaviour of the individual subjects, we find that all of these 'puzzled' 9 year old children scored as conservers of both number and length on the conservation phase (phase 1) of the conservation of length by using conservation of number task itself and only one child scored at an intermediate level rather than as a conserver on the conservation of length pre-test given in a previous session. Given these estimates of the children's original understanding of the concepts, only one 9 year old could possibly have been in a position to deduce contradictory answers to the problem. Why four of the children should then be puzzled or produce compromise solutions is difficult to understand.

Two possible reasons can be suggested. The first is that the 9 year old children understand both concepts very well, and the task is too easy. They are looking for a 'trick' and consequently make errors. While there is little documented material on this (but see, for example, Hall and Kingsley, 1968) it is often assumed that giving basic conservation tests to older children and adults can lead to these subjects making elementary errors as they are looking for something harder in the task or
a trick of some sort.

Therefore, considering only the 5, 6 and 7 year old children (ages which were used in the original Inhelder, Sinclair and Bovet task) and tabulating pre-test scores (represented as conservation of number then conservation of length; thus 1,1 is a nonconserver on both concepts, 3,1 is a conserver on number but not on length) against the response type the Table 3.8 is obtained.

Table 3.8: The number of children in each pre-test category reacting to the contradiction in each way

<table>
<thead>
<tr>
<th>Reaction to Contradiction</th>
<th>Pre-Test Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,1</td>
</tr>
<tr>
<td>Refusal</td>
<td>1</td>
</tr>
<tr>
<td>Nonrecognition of contradiction</td>
<td>1</td>
</tr>
<tr>
<td>Recognition of contradiction</td>
<td>4</td>
</tr>
<tr>
<td>Resolution of contradiction</td>
<td>0</td>
</tr>
</tbody>
</table>

Even with these more appropriately aged children, three subjects who scored as conservers on both concepts (3,3) did not resolve the contradiction in the task. Additionally, four children who should have encountered no contradiction (being non-conservers on both concepts (1,1)) "attempted to resolve" (DF7) the "contradiction"!

This raises the second possible reason for the unusual result. That is, that, in their reaction to this task, the children are reacting to something other than a contradiction between two internal representations.
The experiment described in Chapter 4 investigates this possibility, with appropriately aged children of 5 and 6 years only.
CHAPTER 4

EXPERIMENT 2: A STUDY OF THE "SITUATION 1 OF DFI"
METHOD OF PRESENTING CONTRADICTIONS TO CHILDREN

In the previous chapter a preliminary experiment showed some support for the position taken by the "Training Theorists" in that children at all ages and stages of development were able to recognise and resolve contradictions.

It was also found that children reacted to a contradiction either by attempting to resolve the contradiction or by eliminating it, depending on the type of task used. The Endpoints Number 2 and 3 of the model described in Chapter 2 therefore appear to describe children's reactions to contradictions encountered in different types of tasks.

One finding of Task 1 of the first experiment has, however, brought into question the issue of what precisely the child finds contradictory in the task. This is the finding that in a task involving the situation 1 of DFI (a contradiction between two internal representations) children who should have resolved the contradiction (i.e. conservers on number and on length) were exhibiting behaviour that indicated that they were "attempting to resolve" it. Similarly, children who should have been aware of no contradiction (i.e. non-conservers on number and length) were exhibiting behaviour that indicated that they were "attempting to resolve" a contradiction! In this chapter these findings will be carefully explored.

4.1 WHAT IS CONTRADICTORY IN THE INHEDER, SINCLAIR AND BOVET (1974) EXPERIMENT?

Inhelder, Sinclair and Bovet (1974) have specified precisely why a child should encounter a contradiction in the training of conservation of length using conservation of number task. They say that it is because
this "numerical equivalence" scheme derived from the one-to-one procedure comes into conflict with the previously established scheme of "going beyond", which leads the child to judge, e.g., that the collection extending further contains the greater number of units. Inversely, a judgement of numerical inequality based on nonadherence to the one-to-one procedure may enter into conflict with one of equality based on frontier effects of the configuration of the elements. (Inhelder, Sinclair & Bovet, 1974, p. 248).

They suggest that the child is placed in a situation of conflict because (s)he has two contradictory solutions to a problem. Briefly, the argument is as follows: The child has acquired conservation of number. Thus (s)he knows that four matches remains four matches regardless of their spatial configuration. (S)he is also, in this situation, persuaded to apply this conservation of number to a length situation. So (s)he infers that a road four matches long is the same length as a road four matches long. However, (s)he has not yet acquired conservation of length. So (s)he knows that equal boundaries mean equal lengths or boundaries that do not coincide mean that the two roads are not of equal lengths.

In a situation where the two roads are straight all these inferences are compatible. (See Figure 4.1)

![Figure 4.1: A situation of two straight roads.](image-url)
In the situation represented in Figure 4.1 the child knows:

1. four matches = four matches
2. a road four matches long = a road four matches long
3. the boundaries coincide, thus the lengths are equal.

However, if the situation occurs where one road is bent, then the inferences are not compatible (see Figure 4.2).

![Figure 4.2: A situation in which one road is bent.](image)

In the situation represented in Figure 4.2, the child knows that:

1. four matches = four matches
2. a road four matches long = a road four matches long
3. the boundaries do not coincide, thus the roads are not the same length.

Thus, the child infers from 1. the two roads contain the same number of matches

- from 2. the two roads are the same length, and
- from 3. the two roads are not the same length.

In this situation the child arrives at a contradiction which is: the roads are the same length and they are not the same length.

However, this analysis contains some assumptions. The first is that the child can be persuaded to apply conservation of number reasoning to a length situation. The second will be explained in some detail. If the
child is given the situation shown in Figure 4.3, (s)he knows, that even with equal numbers of matches the roads are not of equal lengths because the units are not of equal lengths.

![Figure 4.3: A situation of two roads with equal numbers of matches.](image)

Thus no contradiction exists in this situation. However, if we recall the original conservation of length experiment of Piaget, Inhelder and Szeminska (1960), the same situation could be occurring in the "contradiction" task. The original conservation of length task involved an initial configuration with two sticks as is shown in Figure 4.4.

![Figure 4.4: The initial configuration of the sticks in the original conservation of length task.](image)

After the child had agreed that the two sticks were of equal length one of the sticks was moved along as is shown in Figure 4.5.
The non-conserving child would then assert that the sticks were of different lengths as the boundaries no longer coincided. After re-establishing the equality of length of the two sticks a second transformation was performed (as is shown in Figure 4.6) and the non-conserving child would assert that the sticks were of different lengths.

If matches are substituted for sticks, and the training of conservation of length using conservation of number task re-examined, the situation that is presented to the child is shown in A of Figure 4.7. However if the child does not conserve length (as the children in the study did not) then (s)he would perceive the situation as two long matches and two short ones (as is shown in B in Figure 4.7).
Thus even though there are the same number of matches, the roads are not the same length as one contains two short matches, and no contradiction exists. For a child to understand that a contradiction exists (s)he must be aware that turning one match on its side does not make it shorter.

Thus the full initial situation that the child must understand to arrive at contradictory solutions in the training task is shown in Figure 4.8.

1. a conserver of number thus reason: 4 matches remain 4 matches
2. a conserver of length thus reason: a tilted match is the same length as a straight match
3. persuaded to make an inference thus reason: a road 4 matches long is the same length as a road 4 matches long
4. a non-conserver of length \(^{16a}\) thus reason: boundaries that do not coincide are not of equal length.

Figure 4.8: The "initial situation" for a child to arrive at contradictory solutions in the training of conservation of length task.

\(^{16a}\) It should be noted that this is conservation of unequal length. This ability is not necessarily implied by the standard conservation test.
This figure includes the two behaviours which we have noted that Inhelder et al. (1974) have assumed in their analysis of the conflict situation. These are the points 2 and 3 in the Figure. Although these are behaviours of the child and not assumptions that the child makes, they will be called "assumptions" in this paper to remind us of their origins.

Comparing points 2 and 4 from Figure 4.8 we arrive at the curious conclusion that a child must be a conserver of length (at least to some degree) to be trained in conservation of length. Despite the oddness of this theoretical statement the demonstration by Inhelder et al. (1974) seems convincing, and can be replicated (see Experiment 1).

However, the "assumptions" behaviour (i.e. the points 2 and 3 in Figure 4.8) as well as the conservation behaviour of the children can be verified empirically for each subject, and Experiment 2 was performed to do just that.

Experiment 2 was designed to discover whether a child who "attempted to resolve" (DF7) a contradiction in the critical "conservation of length using conservation of number" task (called "the critical task") had made contradictory judgements in answer to that task.

This was done by ascertaining whether the "initial situation" for the subject was that shown in Figure 4.8, which would lead him or her to make contradictory judgements in the critical task, or whether the "initial situation" for the subject varied in any way from Figure 4.8, which would lead him or her to make non-contradictory judgements in the critical task. This was then compared with his or her performance on the critical task. It was hoped to show that children whose "initial situation" would lead to contradictory answers (i.e. children who had shown the pattern of behaviour in Figure 4.8) would be puzzled by the
critical task and would "attempt to resolve" the contradiction but that children whose "initial situation" would not lead to contradictory answers (i.e. children whose pattern of behaviour was different in any way from that shown in Figure 4.8) would not be puzzled by the critical task and would show "non-recognition of the contradiction" (DF8), since they had experienced no contradiction.

4.2 METHOD

4.2.1 Experimental Design

The children were given three sets of tasks. These were:

1. The conservation tasks. Two conservation tests were given.
2. The assumptions tasks. Two assumptions tests were given.

These four tests measured the "Initial condition" of the subject's reasoning.

3. The situation involving a possible contradiction.

Children of two different ages were tested. The Design is shown in Figure 4.9.

<table>
<thead>
<tr>
<th>Age</th>
<th>Conservation Tests</th>
<th>Assumptions Tests</th>
<th>Contradiction Situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 years</td>
<td>Task 1  Task 2</td>
<td>Task 3  Task 4</td>
<td>Task 5</td>
</tr>
<tr>
<td>6 years</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.9: Representation of the "Age by three types of tasks" design of Experiment 2.
4.2.2 Description of Tasks

The tasks were the following:

   (a) Task 1: Conservation of Number.
      Materials: Thirteen red plastic discs. Six yellow plastic discs.
      Procedure: The standard conservation of number test was given (see Appendix 2a, or Inhelder, Sinclair and Bovet, 1974, p. 275).
   (b) Task 2: Conservation of Length.
      Materials: Two pieces of flexible wire of different lengths (15 cms and 10 cms).
      Procedure: The standard test of conservation of unequal continuous length was given (see Appendix 2a or Inhelder, Sinclair and Bovet, 1974, p. 287).

   (a) Task 3: One Match Assumption.
      Materials: Two standard size matches.
      Procedure: The child agreed that two single matches placed one beneath the other with aligned boundaries (see Figure 4.10) were of equal length.

---

19 Although the test used in this experiment appeared in the Appendix of the Inhelder, Sinclair and Bovet (1974) book, in the original Inhelder, Sinclair and Bovet (1974) experiment a different conservation of number test was used.

20 In the original Inhelder, Sinclair and Bovet experiment the children were given two conservation tests as "pre-tests" for the experiment. Only those children who scored as conservers on the conservation of number pre-test and non-conservers on the conservation of length pre-test continued to be given the next parts of the experiment. In this study however, all the children were given all the tests, regardless of their performance on the conservation tests.
Three transformations were then performed, in random order for each child. These are shown in Figure 4.11. After each transformation, the child was asked if the matches were the same length. Between transformations the two matches were returned to the original configuration (Figure 4.10) and the equality of length of the two matches re-established. The child was asked to explain his or her responses.

(b) Task 4: Several Match Assumption.

Materials: Eight standard size matches.

Procedure: The child agreed that a road of four matches placed end to end was equal to another road of the same type (see Figure 4.12).
Three transformations were then performed in random order for each child (see Figure 4.13) and the child was asked if the two roads remained the same length after each transformation.

The matches were returned to the "equality" position (Figure 4.12) between each transformation, and reasons were requested for the child's answers.

3. The Situation Involving a Possible Contradiction.

Task 5: Conservation of length using conservation of number.

This task is almost identical with Task 1 of Experiment 1. However, two sizes of small matches were used in this task. The task will be briefly described.
Materials: Twenty standard length matches.
Ten matches half the length of a standard match.
Ten matches one third the length of a standard match.

Procedure: There were three phases:
Phase 1: Conservation. The child was asked to make conservation judgements about both the number and the length of two roads made of matches. The original configuration and first transformation is shown in Figure 4.14.

![Figure 4.14](image_url)

Figure 4.14: The original configuration (A) and first transformation (B) in Phase 1 of Task 5.

The second transformation is shown in Figure 4.15.

![Figure 4.15](image_url)

Figure 4.15: The second transformation in Phase 1 of Task 5.
Phase 2: Judgement. The child was asked to judge if two roads were the same length. In the first example presented there was an equal number of matches in each road (see Figure 4.16).

![Figure 4.16: First construction in Phase 2 of Task 5.](image)

In the second construction the road with the smaller boundary distances contained the most matches (see Figure 4.17).

![Figure 4.17: Second construction of Phase 2 of Task 5.](image)

The children were also asked whether one road contained more matches.

Phase 3: Construction. The child was asked to construct a straight road which was the same length as the experimenter's road. In the first two constructions (shown in Figure 4.18 and 4.19)
the child was given the same length matches as those in the experimenter's road.

In the final two constructions (shown in Figure 4.20 and 4.21) the child was given a box of small matches some one half the length and some one third the length of the matches in the experimenter's roads. The small matches were not commented upon by the experimenter. In each case the child's construction was to start on the left hand boundary of the experimenter's road.
4.2.3 Subjects

Nine 5 year olds and ten 6 year olds from a Canberra Infants School were used as subjects. The child's age was taken as his or her age last birthday. There were nine females and ten males.

4.2.4 Selection of Subjects

All the children from a combined kindergarten and first grade class at a Canberra Infants School were tested.

4.2.5 Order of Presentation of Tasks

Task 1 and Task 2 (conservation of number and conservation of length) were presented first, in that order, to all children.

This was followed, for half of the children by Task 5 (possible contradiction situation) and then Tasks 3 and 4 (assumptions tasks). The other half of the children received Task 3 and Task 4, followed by Task 5. Task 3 and Task 4 were always presented in that order. While such close presentation of fairly similar tasks is not desirable it was unavoidable on this occasion as each child could be seen for one session only. The variation in the order of presentation of the Tasks should have been partially controlled for practice effects.

4.2.6 Materials

Tape recorder and cassette tape for each subject.

Record sheets for each Task.

4.2.7 Procedure

The children were tested individually. The testing place was a corner of the corridor outside the children's classroom. The child was sent out of the classroom to the experimenter by the returning subject.
The subject was requested to sit at the table alongside the experimenter, his or her name and age requested, and rapport established. The tape recorder was switched on and the tasks given. All visible manipulations were recorded by the experimenter on the record sheets. All the tasks were presented in one session. Task administration took 15 to 25 minutes.

4.2.8 Scoring

The tape recording for each child was transcribed approximately by the experimenter onto the child's record form. Appendix 3c contains examples of the protocols. The protocols obtained were scored as follows:

Tasks 1 and 2

For the tests of conservation of number and conservation of length the children were classified as giving a conservation response, or a non-conservation response. A conservation response (C) required a correct judgement, an appropriate supportive explanation (see p. 83) and a resistance to a counter suggestion. All responses not fitting these criteria were scored as non-conservation responses (NC). Four patterns of response are possible, as shown in Table 4.1.

Table 4.1: Possible response patterns to Tasks 1 and 2.

<table>
<thead>
<tr>
<th>Possible Patterns of Response</th>
<th>Conservation Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cons. of Number</td>
</tr>
<tr>
<td></td>
<td>Task 1</td>
</tr>
<tr>
<td>1</td>
<td>NC</td>
</tr>
<tr>
<td>2</td>
<td>C</td>
</tr>
<tr>
<td>3</td>
<td>NC</td>
</tr>
<tr>
<td>4</td>
<td>C</td>
</tr>
</tbody>
</table>
According to Piaget's theoretical argument (Piaget, Inhelder & Szeminska 1960) the third pattern (NC (number), C (length)) should not occur. The children who could encounter a contradiction in Task 5 are those showing the pattern 2 in Table 4.1; or 3 if it was to occur.

Tasks 3 and 4

In the two assumptions tests, the child was scored as giving a conservation of length (C) response, or a non-conservation of length response (NC). The three criteria of correct judgement, appropriate explanation and resistance to countersuggestion were required for the child to be classified as giving a conservation response. Four patterns of responses again exist which are shown in Table 4.2.

Table 4.2: Possible response patterns on the Tasks 3 and 4.

<table>
<thead>
<tr>
<th>Possible Patterns of Response</th>
<th>Assumptions Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Task 3: 1 match</td>
</tr>
<tr>
<td>1</td>
<td>NC</td>
</tr>
<tr>
<td>2</td>
<td>C</td>
</tr>
<tr>
<td>3</td>
<td>NC</td>
</tr>
<tr>
<td>4</td>
<td>C</td>
</tr>
</tbody>
</table>

The children who have the potential to experience a contradiction in Task 5 are those showing the patterns 2 or 3 on the conservation tests (Table 4.1) and, additionally, the pattern 4 on the assumptions tests (Table 4.2).
Task 5

Two phases of this task were scored. These were:

1. The conservation phase. The child was scored as giving a conservation response or a non-conservation response on both aspects of this problem, that is, on the conservation of number of matches problem and on the conservation of length of roads problem. The scoring was the same as for Task 1 and 2, and the same patterns of response, as well as the same constraint \((NC, C)\) should not occur) are found in this Phase 1 task. This Phase 1 task constitutes a check on the results found in Tasks 1 and 2.

2. The construction phase. The score obtained on this phase of this test was the measure of the child's "reaction to contradiction". The ordinal categories used in Experiment 1 were applied to the children's responses in this section of Task 5. It was necessary to insert two extra categories of response not found in the responses of the children in Experiment 1. It is possible that these additional categories were necessary because more younger subjects were used in this Experiment than in Experiment 1. (See Appendix 3b for the ordinal scale).

After the protocols had been scored using the ordinal categories, the protocols were separated into two groups. These were:

1. Those which indicated that the child did not recognise a contradiction (which would have been categorised either as "refusal" or "non-recognition of contradiction" in Experiment 1), and

2. Those which indicated that the child had recognised a contradiction (which would have been categorised either as "recognition of contradiction" or "resolution of contradiction" in Experiment 1).
As was noted in Experiment 1, the children who did not recognise a contradiction used only one response strategy or switched between two strategies without seeming discontented with their responses. The children who recognised the contradiction continually denied the equality of length of their roads despite their attempts to build roads "of equal length", and were puzzled by the failure of their attempts. (See Appendix 3a for each child's results and Appendix 3c for examples of protocols.)

4.3 RESULTS

4.3.1 "Initial Situation" for the Subjects

The number of children, by age, showing the response patterns indicated in the discussion on scoring is presented in Table 4.3. The results of both the conservation tests and the Phase 1 test are presented.

Table 4.3: Number of children of each age responding in each pattern on the conservation tests and the Phase 1 test.

<table>
<thead>
<tr>
<th>Pattern of Response</th>
<th>Conservation Tests</th>
<th>Phase 1 of Task 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 year olds</td>
<td>6 year olds</td>
</tr>
<tr>
<td>1. NC NC</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2. C NC</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3. NC C</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4. C C</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
On the basis of these figures it was concluded that the responses for the 5 year olds and the 6 year olds could be combined for the rest of the analysis.

It may be noted that, in the conservation tests, two children responded in the 'NC C' pattern which (according to theoretical argument) should not occur. As this pattern disappeared in the Phase I test it would appear to be the result of some sort of measurement error (inattention on the part of the child, or answering a different question from that which was asked by the Experimenter etc.) The children classified as scoring 'NC C' in the conservation tests are inferred to be in a position to recognise a contradiction for the purposes of the rest of the analysis.

The consistency of scoring between the two sets of tests (conservation and Phase I) was good. Only four children scored inconsistently. Two of these were the NC C children in the conservation test.

As the children showing different stage responses on the two conservation tests (i.e. the patterns 2 and 3) are potentially facing a situation involving a contradiction, and children showing the same stage responses (i.e. the patterns 1 and 4) are potentially facing a situation with no contradiction, it can be concluded from Table 4.3 that nine children were potentially facing a situation involving a contradiction and 10 were not (on the basis of the conservation tests) and eight children were potentially facing a situation involving a contradiction and 11 were not (on the basis of the Phase I test).

However, it was noted in Section 4.2.8 that to be potentially facing a situation involving a contradiction the child must also behave in the most advanced way on the two assumptions tests. The number of
children responding in the four possible ways to the assumptions tests are shown in Table 4.4.

Table 4.4: Number of children responding in each pattern to the assumptions tests.

<table>
<thead>
<tr>
<th>Patterns of Response</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. NC NC</td>
<td>4</td>
</tr>
<tr>
<td>2. C NC</td>
<td>1</td>
</tr>
<tr>
<td>3. NC C</td>
<td>1</td>
</tr>
<tr>
<td>4. C C</td>
<td>13</td>
</tr>
</tbody>
</table>

To be potentially facing a situation involving a contradiction the child must be at different stages of development on the conservation tests (i.e. "C NC" (or "NC C")) and meet both "assumptions criteria" (i.e. score "C C" on the assumptions tests). The number of children for which those two conditions hold can be seen in Tables 4.5 and 4.6. In Table 4.5 the child's performance on the conservation tests and the assumption tests are shown, and in Table 4.6 their performance on the Phase I Test and the assumptions tests.

The use of the two sets of tests, the conservation tests and the Phase I Test, is to show that the same conclusions can be drawn regardless of which set of tests are used to assess the child's "initial" level of performance.
Table 4.5: Cross tabulation of the children's responses on each pattern of the conservation tests with performance on the assumptions tests.

<table>
<thead>
<tr>
<th>Assumptions Tests</th>
<th>Conservation Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. NC</td>
</tr>
<tr>
<td>1. NC NC</td>
<td>2</td>
</tr>
<tr>
<td>2. C NC</td>
<td>0</td>
</tr>
<tr>
<td>3. NC C</td>
<td>0</td>
</tr>
<tr>
<td>4. C C</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 4.6: Cross tabulation of the children's responses on each pattern of the Phase I test with their performance on the assumptions test.

<table>
<thead>
<tr>
<th>Assumptions Test</th>
<th>Phase I Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. NC</td>
</tr>
<tr>
<td>1. NC NC</td>
<td>2</td>
</tr>
<tr>
<td>2. C NC</td>
<td>1</td>
</tr>
<tr>
<td>3. NC C</td>
<td>0</td>
</tr>
<tr>
<td>4. C C</td>
<td>0</td>
</tr>
</tbody>
</table>

The numbers of subjects in the intersecting groups are outlined. It can be seen that, using either test of conservation performance there are five children in the sample of 19 potentially facing a situation involving a contradiction. Fourteen of the 19 children should find their solutions to the variety of questions posed to be consistent and non-contradictory. Thus, as many as five children are in a position to recognise the contradiction in the Task 5.
4.3.2 Potentially facing a contradiction as compared to recognising a contradiction

The children were scored on the construction phase of the Task 5 using the ordinal categories devised in Experiment 1. Details of each child's score are given in Appendix 3a. No child "resolved the contradiction". All the "recognition of contradiction" responses were manifested by "attempts at resolution" (DF7). After each response had been scored on the extended set of categories the reactions of the children were classified as showing "recognition of contradiction" or showing "non-recognition of contradiction".

The number of children of each age classified in each way is shown in Table 4.7.

Table 4.7: Number of children of each age who recognise or do not recognise the contradiction in Task 5.

<table>
<thead>
<tr>
<th>Age</th>
<th>Do Not Recognise Contradiction</th>
<th>Recognise Contradiction</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 year olds</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>6 year olds</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>9</td>
</tr>
</tbody>
</table>

This table shows that nine children were scored as having recognised a contradiction in Task 5. If the finding in this table is compared with that in Tables 4.5 and 4.6 (which showed that potentially five children face a situation involving a contradiction), it seems that four children who should be reasoning in a consistent non-contradictory manner are "attempting to resolve" (DF7) a "contradiction"! This result must suggest that there is something amiss with the test
involving a contradiction (Task 5) as four children who should find the situation non-contradictory are "attempting to resolve" some "contradiction". If we compare the individual children potentially facing a situation involving a contradiction with those who actually recognise a contradiction even stranger results are revealed. Table 4.8 and 4.9 show these cross tabulations.

Table 4.8: Cross tabulation of number of children potentially facing a contradiction (from the conservation tests) and those recognising the contradiction.

<table>
<thead>
<tr>
<th>Behaviour in Task 5</th>
<th>Potentially in a situation involving a contradiction</th>
<th>Potentially in a situation involving no contradiction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recognised Contradiction</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Did Not Recognise Contradiction</td>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 4.9: Cross tabulation of number of children potentially facing a contradiction (from Phase I test) and those recognising a contradiction.

<table>
<thead>
<tr>
<th>Behaviour in Task 5</th>
<th>Potentially in a situation involving a contradiction</th>
<th>Potentially in a situation involving no contradiction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recognised Contradiction</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Did Not Recognise Contradiction</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

The circled figures in Tables 4.8 and 4.9 show the number of children who should, according to tests of the child's reasoning about number and length, deduce consistent, non-contradictory answers when
using both strategies in the task involving a possible contradiction (Task 5) but who are "attempting to resolve" (DF7) the "contradiction"!

The fact that, at most, three (Table 4.9) of the five children who are potentially facing a situation involving a contradiction recognise the contradiction is not a strange result. The theories do not suggest that simply because one encounters contradictory responses one must be aware of this. Indeed, the first stage of the Inhelder, Sinclair and Bovet (1974) four stage model of reaction to contradiction (i.e. the stage of non-recognition of contradiction or "switching" of strategies) is found in children who have scored a "C NC" pattern on their pre-test, as they used only those children in their experiment, and these children should have been potentially facing contradictory answers. The anomalous result however is that six, or even seven children who according to conservation and assumptions tests should experience consistent, non-contradictory solutions to the various tests should experience consistent, non-contradictory solutions to the various problems showed puzzlement, uncertainty and conflict (i.e. "attempt to resolve" (DF7) the "contradiction") in a situation which should be consistent and non-contradictory for them.

4.4 DISCUSSION

The findings of this experiment are rather disconcerting. Several conclusions, it seems, could be drawn. All of these reflect poorly on the work that has been done in examining the effect of encountering contradictions upon thought and development using the situation 1 of DF1. These conclusions are the following:

1. The conservation "pre-tests" are an inaccurate measure of the child's understanding of certain concepts.
2. The measures of "reaction to contradiction" are inaccurate or incorrect.

3. The task which supposedly raises a contradiction between the child's concepts of number and of length in fact raises other contradictions of which the experimenter is not aware and which are not indicated by the pre-test performances.

4. The child's "attempts at resolution" (DF7) in the task are not attempts to resolve a contradiction but are a reflection of confusion about some other aspect of the task.

There are, however, several problems with the study.

The first problem is whether the results obtained could be due to "measurement error". In any case where one is attempting to infer a relationship between "A" and "B", it is possible to construct a two by two table. This is shown in Figure 4.22.

<table>
<thead>
<tr>
<th>Status of B</th>
<th>A</th>
<th>~A</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>~B</td>
<td>(3)</td>
<td>(4)</td>
</tr>
</tbody>
</table>

Figure 4.22: A two by two table representing the four cells (1 - 4) of the relationship "A is related to B".

The present study can be described in these terms. In this experiment we have suggested that the children will "attempt to resolve" a contradiction only if their pattern of reasoning is such that they might see a contradiction. In this case we may call the capability of seeing the contradiction "A", and the recognition of the contradiction (and attempting to resolve it) "B". We are endeavouring to determine whether the relationship "B implies A" holds. That is, we wish to determine whether the child must be capable of seeing a contradiction before (s)he
will be able to recognise it. Clearly, if a child whose pattern of reasoning is such that (s)he should not see a contradiction (A), nevertheless "attempts to resolve" the contradiction (B), then the relationship "B implies A" cannot hold. Further the basic sense of the experiment is lost, and one or more of the four conclusions drawn from this experiment must apply.

In terms of the two by two table, for the relationship "B implies A", then, the cells 1, 3 and 4 (A.B; A.\bar{B}; \bar{A}.\bar{B}) may all be validly filled. However, cell 2 (\bar{A}.B) cannot.

In the present experiment the following percentage of responses was found in each of the cells (see Table 4.10).

Table 4.10: Percentage of responses which can be classified in each cell of a two by two table.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>\bar{A}</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>13</td>
<td>34</td>
</tr>
<tr>
<td>\bar{B}</td>
<td>13</td>
<td>39.5</td>
</tr>
</tbody>
</table>

(a) derived from Tables 4.8 and 4.9.

The presence of entries in cell 2 (\bar{A}.B), \textit{prima facie}, seems to negate the implication that the child must be capable of seeing a contradiction before (s)he is able to recognise it. That is, the basic sense of the experiment has indeed been lost.

However, it might be argued that these entries in cell 2 are all due to measurement error. This possibility cannot be excluded, but it seems to be unlikely, given the data presented in Table 4.10 and the following reasoning.

First, we can note that erroneous scoring of a "\bar{B}" child (not recognising a contradiction) as a "B" child (recognising a contradiction)
is very unlikely. In this case, erroneous entries in cell 2 are children from cell 1 who were incorrectly scored as A.

Second, a child could be assigned to A in two ways, namely, by passing all the tests, or by failing most or all of the tests. It may be assumed that any child assigned to cell 2 because (s)he passed all the tests was correctly classified (see Footnote 20a). However, a child who failed most or all of the tests might have been misclassified.

It follows that if the entries in cell 2 were all due to errors of measurement they should be children who were classified as A because they failed all the tests.

In fact, three out of the six or seven children who fell into this category did so because they passed all the tests. That is, almost one half of the entries in this category could not be due to measurement error.

The presence of these children is sufficient to disconfirm the hypothesis that there is a relationship between the capability of seeing the contradiction and the recognition of the contradiction. As the logic of this experiment dictates that the capability to see the contradiction must precede the recognition of contradiction this suggests that one or more of the conclusions drawn at the commencement of this "Discussion" section may apply.

While it has been shown that the results of the experiment are not due entirely to measurement error, a second problem remains with this study. This is that the general methodology of this experiment is not

20a In the type of scoring used in this experiment, where a child is required to pass stringent criteria to be scored as "passing" a test, the most likely form of measurement error is a "false negative". That is, children who are capable of passing a test (in A or B) are erroneously failed.
identical to that used by Inhelder, Sinclair and Bovet (1974). The methodology used in the present experiment is cross-sectional. That is, children of different ages have been tested at one point of time. The methodology used in the Inhelder, Sinclair and Bovet study was an operatory-training-study methodology. In other words, it was interventionist and longitudinal (in the sense that the children were tested on several different occasions). While the cross-sectional method seems to be sufficient for determining the children's reaction to contradiction, an advocate of the training method would argue that this is not so. They would argue that a cross-sectional methodology examines the structural principles of intellectual and cognitive development, whereas the training methodology examines the functional aspect of intellectual and cognitive development (Bovet, 1982, personal communication). They would assert that an examination of the functional aspect of development is necessary to assess the possible role of contradiction in cognitive development.

Interestingly, in this experiment we have replicated the findings of the Inhelder, Sinclair and Bovet study with our cross-sectional study. The problematical finding in this research has derived from the inclusion of two extra groups of children in this study. These were the children who failed both "pre-tests" (i.e., conservation of number and conservation of length) and who passed both "pre-tests". Inhelder, Sinclair and Bovet included only those children who passed the conservation of number, but failed the conservation of length, pre-test. Our finding is that, even with these two extra groups, the findings of the Inhelder et al study can be replicated. That is, certain of these children "attempt to resolve" the contradiction. However, the children in these two groups should not be aware of any contradiction.
However, as the methodology used in the present study is different from that used by Inhelder, Sinclair and Bovet (1974) a stronger test of the situation 1 of DF1 would require the use of the same methodology in our partial replication as that used by Inhelder et al, that is an operatory training method.

Whichever method is employed a third problem arises. This is the inferential nature of the work in this area.

In the psychology of cognitive development the child's reasoning is always inferred from his or her behaviour. The child answering a conservation test is simply responding to a certain problem. The experimenter infers that the child is or is not therefore at the concrete operational stage, that his or her thought is or is not "reversible", and that (s)he is therefore capable or incapable of a certain level of cognitive performance on other tasks. While this problem of inferring the child's thought from his or her behaviour exists in all the research on cognitive development it is even more relevant to studies of the effect of contradiction on thought using situation 1 of DF1. If we present a situation containing a contradiction to a child (s)he may not see the contradiction. If we present a situation with no contradiction inherent in it, (s)he may find contradictory elements. Despite extensive testing, we can never know whether the child will see a contradiction in certain tasks or not. We can only infer that (s)he has or has not seen the contradiction.

Given this position with research into contradiction between two internally represented beliefs we appear, in Experiment 2, to be left with an insoluble problem. On the one hand, the children's reactions seem to show a clear confusion about contradictory propositions. On the other hand we cannot show why they should see the situation as contradictory.
Our Experiment 2, therefore, indicates some of the problems in using the situation 1 of DF1. When using this method, questions of the following type must be asked: Are the subjects in this experiment really being presented with situations involving a contradiction? Are they reacting to a contradiction in their "attempts at resolution" (DF7)?

As has been indicated, these questions cannot be answered. Because of the inferential nature of experimentation involving a contradiction between two internal representations it is not possible to know what the child really perceives and is really doing.

It seems that the best alternative that we have available in the research on the child's reaction to contradiction is to use the situation type 2 of DF1 that is, a contradiction between an internal representation and an external source of information. Here the child's beliefs about the situation can be elicited verbally (although the process of eliciting the beliefs is still open to the problems of inferring the child's actual belief) before the external source of information is presented to the child. Once the (contradictory) external source of information has been presented we know that the child has been presented with a situation involving contradiction. Whether or not the child acknowledges this contradiction is then experimental evidence of the child's reaction to the contradiction.

The situation type 2 of DF1 has been used in Experiment 1 and provided interesting data. In the following experiment this second experimental paradigm (i.e. the situation type 2 of DF1) will again be used to examine the child's reaction to contradiction.
In this experiment tasks involving the situation type 2 of DF1 (a contradiction between an internally represented belief and an external source of information) were presented to children of different ages.

Both the situation type 1 and 2 of DF1 had been used in Experiment 1. It was found in that experiment that the children's reactions to contradiction differed depending upon the type of situation used. Following up the research with situation 1 of DF1, however, it was found that serious methodological problems occurred. Situation 2 of DF1 was used in this experiment, then, to provide a situation in which the subject is definitely presented with a contradiction to which (s)he must respond (even if only by ignoring it).

This experiment, then, was designed to give a clear answer to the questions previously posed about the effect of contradiction on reasoning.

One aim of the experiment was to discover whether children were able to recognise a contradiction, and at what age they were able to do so. Another aim was to find how the children reacted to a contradiction once it had been recognised.

In order to fully understand the children's recognition of and reaction to contradiction a distinction was made between two types of information which could be received from an external source. This distinction is between information which relates to physical knowledge and information which relates to logico-mathematical knowledge.
For Piaget, physical knowledge derives from physical experience. A task involving physical experience is one where the subject learns about the properties of the object from the object. Thus the object is, in a manner of speaking, informing the child about itself. Logico-mathematical knowledge derives from logico-mathematical experience. In a task involving logico-mathematical experience the child learns about his or her own actions upon objects. Thus the subject is constructing knowledge based upon the organisation of his or her activity (Piaget, 1971a).

Inhelder, Sinclair and Bovet (1974) state that the processes which may bring the child to conservation could be different in the case of each type of knowledge. With physical phenomena the child can compare what (s)he has predicted with what actually happens. In logico-mathematical tasks the child's reasoning process must be consistent and non-contradictory.

It seems reasonable to assume therefore that, in the case of physical knowledge, it is important for the subject to accept, without distortion, the information provided by the environment about his or her prediction so that (s)he may be informed about the object. In logico-mathematical tasks however it is not so important for the child to pay attention to environmental information in the course of the construction of his or her ideas.

It therefore seems reasonable that the type of information which is presented to the child may influence his or her reaction to this information if it is in contradiction with his or her beliefs.
To support this view we may note that in Experiment 1 the tasks involving the situation 1 of DF1 both involved logico-mathematical knowledge. The tasks involving situation 2 of DF1 involved, largely, physical knowledge (the floating and sinking task clearly involves physical experience and knowledge; the conservation of volume task can be seen as physical in so far as it refers to a property of volume (i.e. that it conserves across transformations of shape). Conservation itself however is a logical concept, endowed with logical necessity, thus the conservation task included both sorts of knowledge21). It may be recalled that in Experiment 1 it was found that the child's reaction to contradiction varied depending on whether the task was presented as a situation type 1 or a situation type 2 task. In the situation type 2 tasks the children eliminated the contradiction (they labelled the external source of information only as "true"). In the situation type 1 tasks they attempted to resolve the contradiction (they labelled both representations as "true"). Following the present discussion we see that it is also possible that the child's reaction to the contradiction may have differed because of the type of knowledge involved. The reasoning outlined above (that in a situation involving physical knowledge the contradiction must be recognised early whereas in the situation involving logico-mathematical knowledge contradiction need not necessarily be recognised), is supported by the findings of Experiment 1 as in the physical task the external source of information was labelled as "true" whereas in the logico-mathematical tasks two representations were labelled as "true" and the child became puzzled.

21 This type of knowledge has also been described by Piaget in his work on spatial relations. He considers the knowledge to be constructed by "infralogical" or "sublogical" operations rather than by logico-mathematical operations. (Piaget, 1956).
It is interesting to note that in their 1974 book, Inhelder, Sinclair and Bovet, reasoning from the same premises, reached quite different conclusions. They made some specific assertions about the effects of contradictions in logical and physical problems. They stated that

in logical problems the contradictions lead either to regression or to rapid progress, while in physical questions conflicts between the resistances of reality and the subject's schemes (...) are far more tenacious. (Inhelder, Sinclair & Bovet, 1974, p. 264).

This statement is in direct contradiction to the conclusions reached above. The experiment to be described here should determine how children do, in fact, react to contradictions in the two types of task.

Experiment 3 will use tasks involving logico-mathematical knowledge and tasks involving physical knowledge presented in a situation type 2 of DF1 to elucidate the question of whether or not children react to contradiction depending upon the type of knowledge involved in the contradiction. While it is impossible to ensure that the children will predict incorrectly in each task, and so encounter a contradiction, the tasks were designed so that it was extremely likely that the children would be incorrect in their predictions. The children's reactions to the contradictions in each of these tasks will also be examined in terms of the model described in Chapter 2 to determine a general description of children's reactions to contradiction.

5.1 METHOD

5.1.1 Experimental Design

Two logico-mathematical tasks and two physical tasks were given to children from four different age groups. Additionally, a partly physical task was given to some children to determine whether it followed
the pattern of the logico-mathematical tasks, or the physical tasks, or neither. Tasks 1 and 2 were logico-mathematical tasks, Tasks 3 and 4 were physical tasks and Task 5 was a partly physical task. The design is shown in Figure 5.1.

<table>
<thead>
<tr>
<th>Age in years</th>
<th>Logico-mathematical</th>
<th>Physical</th>
<th>Partly Physical</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Task 1</td>
<td>Task 2</td>
<td>Task 3</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td>Task 4</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td>Task 5</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 5.1: Experimental Design of Experiment 3.

5.1.2 Description of Tasks

The five tasks were the following:

(a) Task 1: Addition and Subtraction (adapted from Piaget, 1979).

Materials: 20 red plastic counters; 20 blue plastic counters; small plastic bucket; a white card 12 cms by 10 cms.

Procedure: In this task two vertical rows of counters were placed on the table. Each row contained six counters of the same colour. One row contained red counters and the other blue. The rows were approximately 10 cms apart. The remaining counters of both colours were left in the plastic bucket within reach of the children. The test contained five subtasks. These were: 1) subtraction; 2) subtraction and addition (transfer); 3) addition; 4) subtraction and transfer; and 5) unseen transfer.
In the subtraction subtask one row of counters was completely covered by the white card after the subject had been shown that the two rows contained six counters each. Then, one counter was removed from the visible row. The children were then asked how many counters would be needed to equalise the rows again, and to explain how they had calculated that number. They were asked to take the number of counters that they had calculated from the bucket and add them to the visible row. The card was then removed and the children asked if both rows had the same number of counters. If the child had made an incorrect prediction a contradiction was encountered at this time. The two rows were then restored to their original number (six in each) and one was completely covered with the card. The procedure was repeated with three counters being subtracted, and sometimes, with the younger children, with two counters subtracted.

In the second subtask (transfer), a counter was subtracted from the visible row as before, but in this task it was added under the card to the non-visible row, and the children were asked how many counters would be needed to equalise the visible row with the collection under the card, and to explain how they had calculated the number. The children were asked to add the number of counters they had calculated to the visible row, the card was then removed.
and the children asked whether or not the two rows were equal in number. If an incorrect prediction had been made a contradiction was encountered. The "transfer" subtask was repeated with two, three and four counters being transferred from one row to the other.

In the third subtask (addition) one counter was added to the nonvisible row from the plastic bucket and the children were asked to equalise the rows and were then shown both rows and sometimes encountered a contradiction. The subtask was repeated with two and three counters being added to the nonvisible row.

In the fourth subtask (subtraction and transfer) some counters were subtracted from the visible row but some were transferred to the nonvisible row and some were retained. For example, two were removed from the visible row, one transferred to the nonvisible row and one retained. The children were asked again how many counters were needed to equalise the two rows and were shown the results of their additions. This subtask was repeated with different numbers of counters being subtracted and transferred.

In the final subtask (unseen), both of the rows were covered with the card and made invisible. The children were then told that, although they didn't know how many counters were in each row now under the
card, both rows were equal in number. The children observed one counter being removed from one row and transferred to the other and asked how many counters would be needed to equalise the rows. After placing the counters under the card both cards were removed so that the child could see the two rows. If an incorrect prediction had been made a contradiction was encountered. This subtask was repeated with two and three counters being transferred from one covered card to another.

(b) Task 2: Permutations (adapted from Piaget and Inhelder, 1975).

Materials: 40 red counters; 40 blue counters; 40 green counters; 40 yellow counters.

Procedure: Using two colours (e.g. red and blue) the children were asked to combine the two colours in all possible ways using each colour only once in each combination. The combinations red and blue, and blue and red were normally produced. The children were then given counters of a third colour and asked to predict how many different arrangements of the three colours they could make using each colour once in each arrangement. They were encouraged to make them. The subject sometimes contradicted him or herself by making more or less arrangements than predicted. When the children stated that they had made all possible arrangements they were asked if they were using a 'system' to develop the different arrangements, and to explain the system.
Depending on the number of arrangements that had been generated, the experimenter sometimes encouraged the children to look for some more possibilities. The subject again encountered a contradiction if (s)he could create more arrangements. The children were then given a fourth colour and asked to predict the number of arrangements that they could make with four colours. They were then encouraged to make as many as they could. Again, when the children stated that they had finished the "system" used was discussed. The children who had been able to develop an extendable system were sometimes asked if they could calculate how many arrangements would be possible with five colours.

(d) Task 3: Mirror Reflections (adapted from Piaget, 1974).

Materials: Sixteen letters of the alphabet (ABCEHIJKLMNPTXY) written in black block letters on white cards 12 cms x 10 cms.
A board with a container to accept a mirror 16 cms by 12 cms. The angle of the mirror could be varied so that every child could see the letter reflected in it.
A "letter-stand" to allow the child to stand the letter vertically in front of the mirror.
Paper.
A black felt-tipped pen.
A pink felt-tipped pen.
A mirror 16 cms by 12 cms.
Procedure: The children were asked to draw a certain asymmetrical letter of the alphabet. They were then asked to draw it as it would look if reflected in a mirror (e.g. B, A). After drawing the reflected letter they were shown the letter reflected in the mirror and asked if they had predicted correctly. A contradiction was encountered if an incorrect prediction had been made. After drawing and evaluating four or five asymmetrical letters the children were asked to draw a symmetrical letter (e.g. A) and a prediction of its mirror reflection. After seeing the reflection in the mirror the children were asked to explain why this letter did not reverse as had the previous letters. A series of symmetrical letters was presented. The children were then presented one by one with a mixture of letters, some symmetrical and some asymmetrical. After each prediction the child viewed the result in the mirror and at times encountered contradictions. The experiment was concluded with the presentation of two letters, one asymmetrical and the other symmetrical marked with a pink spot. After the subject was asked to draw the reflection of an asymmetrical letter (L) with a pink spot on one arm (i.e. L) the subject was presented with a symmetrical letter (X) which also had a pink spot on one arm (i.e. X). The children were asked to predict how the symmetrical letter would look when reflected. After seeing both the reflected letters the child was asked to explain how the pink spot on the "X" had
reversed whereas the "X" itself had not. Because of the nature of the letter used in each case this task is said to contain three subtasks. These are (1) the asymmetrical letters, (2) the symmetrical letters and (3) the mixture of letters.

(d) Task 4: Spring (adapted from Piaget, 1974).

Materials: Spring (A) 4 cms long and 1 cm wide with 25 spirals.
Spring (B) 2 cms long and 4 cms wide with five spirals.
Spring (C) identical to the 2 cms spring, threaded with beads packed tightly end to end. The beads were prevented from falling off by sticking tape around each end.
Spring (D) made by threading wire through elastic. Four cms of the elastic without wire protruded from each end of the wire. The entire length was threaded with tightly packed beads. The wire wound into four coils and the total resembled a spring with long ends.

Procedure: The children were shown the two springs A and B and allowed to spend some time stretching them. They were then asked whether the number of spirals would remain constant when the spring was stretched, and whether the length of the wire increased when the spring was stretched (conservation of length question).
They were then shown the spring C on which beads were threaded and asked to predict if more beads could be fitted on the spring when it was stretched (this again attempts to elucidate the question of whether the wire lengthens when the spring is stretched). A contradiction was encountered if the child predicted that more space would result.

Finally the "spring" D made of elastic was presented and the child asked to predict if more beads could be fitted on this "spring" when it was stretched. The children were shown, and asked to explain why, in this case, more beads could be fitted whereas in the previous case they could not. The children were expected to encounter a contradiction in this prediction.

(e) Task 5: Area and Perimeter (adapted from Bang and Lunzer, 1965).

Materials: A board with nails hammered into it.

The nails formed squares 10 cms x 10 cms; 18 cm x 2 cms; 16 cms x 4 cms and two nails were 20 cms apart.

A continuous piece of string 40 cms long that fitted exactly around all the squares (the string was tied with a small knot).

Twenty-five 2 cms x 2 cms cardboard squares stuck into five lengths of five squares.

A board that thumb tacks could be pushed into.
Forty 2 cms x 2 cms cardboard squares stuck into four lengths of eight squares and two lengths of four squares.

A string 52 cms long that fitted exactly around the 10 cms x 16 cms rectangle.

The string had a thumb tack through one end.

A box of thumb tacks.

Procedure: This task has two parts. In the first, a joined piece of string was put on the 10 cms x 10 cms square and the children invited to fill the square with cardboard "grass" (25 units being possible). They were then asked, if the joined piece of string was then placed on the 18 cms x 2 cms rectangle, whether they could still fit in all the "grass". They were invited to try, and to explain why it did not all fit. If they had predicted that it would fit they encountered a contradiction. They were then asked if it would fit into the 16 cms x 4 cms rectangle and again invited to try. As an aid to explanation the string was then looped about the two nails 20 cms apart.

In the second part, 40 squares were set out in a rectangle 10 cms x 16 cms and a string "fence" erected around the figure with drawing pins at each corner. The fence exactly fitted the "paddock". The squares were then rearranged to a 8 cms x 20 cms rectangle and the children asked whether the fence would still fit, and
to explain why. The children were then shown that the fence did not fit. If they had predicted that it would fit they encountered a contradiction. A figure of 4 cms $\times$ 40 cms was then constructed and the children asked if the string would fit and to explain their response.

5.1.3 Subjects

Sixty-four children from a Canberra Primary School were used as subjects. There were sixteen 5 year olds from Kindergarten; sixteen 7 year olds, fourteen from Grade 2 and two from Grade 1; sixteen 9 year olds from Grade 4; and sixteen 11 year olds from Grade 6. The child's age was taken as his or her age last birthday. Each age grouping contained eight males and eight females.

5.1.4 Selection of Subjects

The children were selected randomly, by listing all the children of the correct age from each grade, then taking children at equidistant intervals on the list, until eight males and eight females had been selected.

5.1.5 Order of Presentation of Tasks

Each child was given two tasks, one physical and one logico-mathematical. Both the combination of tasks and the order of presentation of logico-mathematical and physical tasks were controlled by systematic inversion. Eight possible orders of presentation resulted. (See Appendix 4c). Each possible order was presented twice in each age group of 16 children. Task 5 was presented third to every child who completed the first two tasks in 15 minutes or less. Its place of presentation was therefore fixed. A conservation of number test was
given to each 5 year old performing Task 1, at the completion of the
other tests.

5.1.6 Materials

Tape recorder and cassette tape for each child.
Record sheets for each task.

5.1.7 Procedure

Each child was interviewed individually. The testing place was an
empty classroom in the school. The child was asked to seat him or her­
self beside the experimenter, who turned on the tape recorder, and,
guided by the record sheet, (previously designed to act as a mnemonic
for the order of presentation) asked the child to complete the first,
and then the second task. Testing took approximately 20 minutes. The
child was then asked to send the next child who had been selected to
the experimenter.

5.1.8 Scoring

During the interview with each child, the experimenter recorded any
visible manipulations made of the materials (e.g. all the permutations
made by the child in Task 2), and other information that could comple­
ment the tape recording of each interview. After testing, the tape
recording for each child was transcribed by the experimenter. Examples
of transcriptions can be found in Appendix 4d. Finally a 'protocol'
for each child was prepared for each task, tracing the child's pattern
of predictions and observations of the outcomes, and the correctness of
both.
5.2 RESULTS

In the type of situation used in this experiment where a series of predictions are required from the child, "recognition of contradiction" can be defined operationally as the change from an incorrect prediction to a correct prediction. Such a change in behaviour could indicate either "resolution of the contradiction" (DF6) as the outcome information in the prediction-outcome situation prompts the child to resolve the contradiction; or "elimination of contradiction" (DF3) as the child ignores the reasoning involved in arriving at his or her prediction and attempts to match the outcome information (i.e. the prediction is labelled as "false" and the outcome as "true"); or an "attempt to resolve the contradiction" (DF7) as the child maintains the belief in the truth value of both his or her reasoning and the outcome but is unable to resolve the two, which results in puzzlement, confusion and ultimately "compromise solutions" which may be correct predictions.

The difference in this experiment between "resolution of contradiction" (DF6) and "elimination of contradiction" (DF3) is that in the case of the resolution of contradiction the subject understood the phenomenon and continued to be correct on each prediction after having encountered a contradiction. In the case of the elimination of contradiction the subject only continued to be correct for those few questions where a direct equivalence could be drawn with the item on which (s)he had encountered the contradiction.

The Task 1 (a logico-mathematical task) and Task 3 (a physical task) are particularly suited for this kind of "response sequencing" or "prediction sequencing" analysis.
5.2.1 Prediction Sequencing in Tasks 1 and 3

Response sequencing or prediction sequencing can be calculated only for each subtask as to calculate across subtask changes would give spurious sequences. Thus, for Task 1 (the addition and subtraction task) five subtasks were given (addition, subtraction, transfer, transfer then subtraction, and unseen). Hence five sets of sequences can be derived. Two of these can be combined. These are the sequences on the addition subtask and the sequences on the subtraction subtask. This results in four sequencing scores for each child (see Appendix 4a.A). For the Task 3 (the mirror task) three sets of sequences can be derived (asymmetrical letters, symmetrical letters, and the mixture of letters including those with the pink spot). (See Appendix 4a.D). The results for the Task 1 (addition and subtraction) are presented in Table 5.1. The scores are the percentages of transitions of each type which were obtained by dividing the mean number of transitions of each type for each age group by the mean number of questions asked in that subtask (shown in the \( \bar{x} \) row).

The table seems to show that only on the addition and subtraction subtasks do the 5 year old children perform equally to the other age children. This shows that they have understood the basic numerical operations and the task instructions. The basic addition and subtraction subtasks can be called the "control" task, as few contradictions were encountered in this subtask, and the other subtasks regarded as the "contradiction" tasks. On these "contradiction" tasks it was found that while the 9 and 11 year olds rarely move from an incorrect prediction to a second incorrect prediction, the 5 year old, and occasionally the 7 year old, certainly does.
Table 5.1: Percentage of transitions of each type made by children of each age in the addition and subtraction task.

<table>
<thead>
<tr>
<th>Type of transition</th>
<th>Addition and subtraction totalled</th>
<th>Transfer</th>
<th>Subtraction then transfer</th>
<th>Unseen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
<td>7</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>C-C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I-I</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-I</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I-C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \bar{X} )</td>
<td>3.75</td>
<td>2.9</td>
<td>2</td>
<td>2.9</td>
</tr>
</tbody>
</table>

(a) Transitions are: Correct prediction to correct prediction (C-C); Incorrect prediction to incorrect prediction (I-I); correct prediction to incorrect prediction (C-I); incorrect prediction to correct prediction (I-C).
The same transition scores can be calculated for the mirror task. Table 5.2 shows the percentage of transitions of each type for each age.

In this table it can be seen that even the youngest children rarely move from an incorrect prediction to an incorrect prediction and that an incorrect prediction often leads to a correct prediction.

It may be concluded from Table 5.1 that on a logico-mathematical task 5 year olds and some 7 year olds, do not change their predictions after an incorrect prediction. However most 7 year olds and all 9 and 11 year olds do. On a physical task, however, (Table 5.2) children of all ages quickly align their predictions with the observed outcomes.

This result seems to support the hypothesis that in the case of physical tasks the child will recognise the contradiction at an early age, whereas in the logico-mathematical task the child does not recognise the contradiction until a later time.

Nevertheless it was apparent from a reading of the actual protocols that the figures presented in Tables 5.1 and 5.2 did not accurately reflect the children's performances. In the addition and subtraction tasks the children did seem to be aware of their errors. The problem with Table 5.1 may be that there were many different ways of solving the addition and subtraction problems. If the children attempted to change an incorrect prediction to a correct prediction, but their method of solving the problem were again incorrect, it would appear they had not recognised the contradiction. In fact they may have recognised it, and may have attempted a correction. If we call each of the methods of solving the problem "a strategy" and determine how many strategies each child used in the various problems then it may be demonstrated that the young children do recognise the contradiction.
Table 5.2: Percentage of transitions of each type made by children of each age in the mirror task.

<table>
<thead>
<tr>
<th>Type of Transition</th>
<th>Asymmetrical</th>
<th>Symmetrical</th>
<th>Mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 7 9 11</td>
<td>5 7 9 11</td>
<td>5 7 9 11</td>
</tr>
<tr>
<td>C-C</td>
<td>54 100 100 100</td>
<td>73 100 100 100</td>
<td>53 90 87 86</td>
</tr>
<tr>
<td>I-I</td>
<td>9 0 0 0</td>
<td>0 0 0 0</td>
<td>6 0 0 0</td>
</tr>
<tr>
<td>c-I</td>
<td>14 0 0 0</td>
<td>13 0 0 0</td>
<td>17 10 0 0</td>
</tr>
<tr>
<td>I-C</td>
<td>23 0 0 0</td>
<td>13 0 0 0</td>
<td>24 0 13 14</td>
</tr>
<tr>
<td>( \bar{x} )</td>
<td>2.2 1.5 1.9 1.4</td>
<td>1.5 1.1 1.4 1.4</td>
<td>2.4 1 2 2.5</td>
</tr>
</tbody>
</table>
5.2.2 Strategies in the Addition and Subtraction Task

In this task a definite number of strategies for solving the problem can be defined. These include a strategy of equivalence (i.e. the child reasons that one counter (or two etc.) has been removed, thus one (or two) must be replaced); a qualitative increase (i.e. the child reasons that one counter (or two, three, four etc) has been removed thus two (three, four, five etc.) must be replaced); full or partial calculation (i.e. for transfer of two counters the child notes that from the original column with six counters two have been removed thus four remain, and that the covered row had six counters, and now has two extra, so $6 + 2 = 8$, thus eight (covered) minus four (visible) leaves a difference of four). The number of different strategies used by each child is easily determined (see Appendix 4a.A). Table 5.3 shows the number of strategies used by the children in each subtask of the addition and subtraction task.

Table 5.3: Mean and mode of the number of strategies used by the children of each age in each subtask of the addition and subtraction task.

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Addition and subtraction totalled (Control)</th>
<th>Transfer (Contradiction)</th>
<th>Subtraction and transfer (Contradiction)</th>
<th>Unseen (Contradiction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in years</td>
<td>Mean</td>
<td>Mode</td>
<td>Mean</td>
<td>Mode(s)</td>
</tr>
<tr>
<td>5</td>
<td>1.2</td>
<td>1</td>
<td>2.1</td>
<td>2; 3</td>
</tr>
<tr>
<td>7</td>
<td>1.6</td>
<td>1</td>
<td>2.5</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>1.6</td>
<td>2</td>
<td>1.5</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>1.6</td>
<td>2</td>
<td>1.5</td>
<td>1</td>
</tr>
</tbody>
</table>
This table shows that whereas the older children use the same numbers of strategies in each of the subtasks, the younger children use an increased number of strategies on the contradiction subtasks as opposed to the control subtask. The data presented in Table 5.1, showing that the young children frequently move from an incorrect to an incorrect solution on a logico-mathematical task therefore needs to be modified, as although the young children are still incorrect on a subsequent prediction, a correction has been attempted. It can be concluded, then, that the young children do recognise a contradiction between their prediction and the observation and attempt a correction of their prediction on a subsequent attempt.

5.2.3 Type of Reaction to Contradiction in Tasks 1 and 3

In order to test the Model proposed in Chapter 2 the nature of the child's reaction to the contradiction needs to be determined.

The problem in such an analysis is to differentiate whether the child has "eliminated the contradiction" (DF3) or "attempted to resolve the contradiction" (DF7). The difference, by definition, is that in the "elimination of contradiction" the child has labelled one representation as true and the other as false. In the "attempt to resolve contradiction" both representations remain labelled as true and the child becomes perplexed. Scoring the protocols amounts to inferring whether the child is labelling both representations as true or one as true and the other as false. Evidence for "elimination of contradiction" consisted of the child arguing that the answer must be 'x' because "last time it was ..." or "before I saw that it was ...". The child may also admit that the answers "make no sense" but appear to be untroubled by this. Evidence for "attempts at resolution" included
hesitations, puzzlement, compromise solutions, distortions of the data, and, in some cases, refusal to attempt a response.

Both "elimination of contradiction" and "attempts to resolve contradiction" constitute a "recognition" of the contradiction. "Non-recognition of the contradiction" is noted when the children see no discrepancy between their prediction and the outcome, or maintain that the outcome is what they had predicted.

The protocols were scored for "non-recognition of contradiction" (DF8), "elimination of contradiction (DF3), "attempt at resolution of contradiction" (DF7) and "resolution of contradiction" (DF6) (see Appendix 4b). The number of children of each age reacting in each way is shown in Table 5.4.

Table 5.4: The number of children of each age reacting in each way on Task 1 and Task 3.

<table>
<thead>
<tr>
<th>Type of reaction</th>
<th>Task 1 (addition &amp; subtraction)</th>
<th>Task 3 (mirror)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 7 9 11</td>
<td>5 7 9 11</td>
</tr>
<tr>
<td>Non-recognition</td>
<td>1 0 0 0</td>
<td>2 0 0 0</td>
</tr>
<tr>
<td>Elimination</td>
<td>7 8 5 5</td>
<td>5 4 4 1</td>
</tr>
<tr>
<td>Attempt at resolution</td>
<td>0 0 0 0</td>
<td>0 0 0 0</td>
</tr>
<tr>
<td>Resolution</td>
<td>0 0 3 3</td>
<td>3 3 4 7</td>
</tr>
</tbody>
</table>

Table 5.4 shows that contradictions are either eliminated or resolved. No "attempts at resolution" were noted in these tasks. The Tables 5.3 and 5.4 show that in both the logico-mathematical and physical task even the youngest children attempted corrections of their

21a The reliability of the scoring will be discussed in Chapter 6.
predictions following a disconfirmed prediction. There is no difference in the children's reactions to the two types of task. From Table 5.4 we can conclude that in both these tasks the children recognised the contradiction at an early age and responded to it by eliminating it from their reasoning.

As four of the eight children of each age discussed in these analyses performed the addition and subtraction task as well as the mirror task these findings are of great interest. They show not only that children performing both tasks behaved in the same way on each, but that children performing only one of the tasks behaved in the same way as those performing both tasks.

Analysis of the other tasks presented in Experiment 3 supports the conclusion that in both types of task the child recognises the contradiction and modifies his or her subsequent prediction. The analysis of these tasks will follow.

In the Tasks 2, 4 and 5 the large number of sequential predictions that had been required in the Tasks 1 and 3 were not elicited. Consequently, in analysing the Tasks 2, 4 and 5 for "recognition of contradiction" other evidence that the subjects were modifying their predictions in line with the observed outcomes needed to be used. An individual analysis of each task will show how this was done.

5.2.4 Task 2: Permutations

The analysis on this task was restricted to 7, 9 and 11 year olds only as the 5 year old children did not understand the concept of order, and hence rows of different orders, and thus would make what Inhelder and Piaget (1964) have called "graphic" collections or classify the
counters by colour. They refused to predict the number of rows they could make, and even after several were made, with the aid of the experimenter, they could not say how many rows existed. (See Appendix 4a.8 for each child's responses).

In this task, the younger children frequently constructed as many rows as they had predicted, both with three and four counters. The older children however were not bound by the number they had predicted when it became obvious that more combinations were possible. Table 5.5 shows the number of children constructing the number of rows they had predicted.

Table 5.5: The number of children of each age creating the number of rows they had previously predicted.

<table>
<thead>
<tr>
<th>Age in years</th>
<th>7</th>
<th>9</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creating number predicted</td>
<td>11</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Not creating number predicted</td>
<td>5</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Total number of children</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
</tbody>
</table>

When, however, the experimenter indicated to the children who had created the number predicted that they might not have included all possibilities (but also that they might well have) some children were prepared to add extra combinations, despite their predictions. Table 5.6 shows the number of children constructing the number of combinations they had predicted after the experimenter had suggested that more combinations may be possible. (Appendix 4a.6 gives the data for individual children.)
Table 5.6: The number of children of each age creating the number of rows they had predicted after discussion with the experimenter.

<table>
<thead>
<tr>
<th>Age in years</th>
<th>Creating number predicted</th>
<th>Not creating number predicted</th>
<th>Total number of children</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>6</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>15</td>
<td>16</td>
</tr>
</tbody>
</table>

Despite the finding that more young children create the number predicted ($\chi^2 = 7.49, df = 2, p = 0.05$) relatively few younger children are not prepared to change their response in the face of a disconfirmed prediction. This supports the previous finding that the children will modify a subsequent prediction after recognising a disconfirmed prediction.

5.2.5 Task 4: The Spring Task

Unfortunately many of the children did not react to this task as had been hoped. Many of the children in the younger age groups (i.e. 5 years and 7 years) assumed that they were being "tricked" and answered in an inconsistent manner. The two sets of answers that should have been consistent were the child's response to conservation of length and his or her prediction about the first spring, and his or her prediction about the first spring and his or her prediction about the second spring. As all the 7 year old children had conserved on the conservation of length section of the test these predictions should not have been
difficult for them. However, Table 5.7 shows the number of young children behaving in an inconsistent way on these two sets of predictions.

Table 5.7: The number of young children behaving consistently and inconsistently on the spring task.

<table>
<thead>
<tr>
<th>Sets of Predictions</th>
<th>Conservation → Spring 1</th>
<th>Spring 1 → Spring 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Consistent</td>
<td>Inconsistent</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 years</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>7 years</td>
<td>2</td>
<td>6</td>
</tr>
</tbody>
</table>

The inconsistent reactions of these young children resulted in only two of the 16 5 and 7 year olds being presented with a disconfirmed prediction made about the first spring.

The older children, also expecting to be "tricked", examined the materials carefully and noticed the elastic in the second spring. They therefore avoided making incorrect predictions. (See Appendix 4a.E for each subject's responses.)

It is not possible on this task then to use an index of change of predictions. However in the task, each child attempted to deal with the difficult subject matter and the more subtle contradictions that this raised were of interest and were measured. This can be seen in Section 5.2.7.

5.2.6 Task 5: The Area and Perimeter Task

This task was given to those few children who had the time to complete it. Three 7 year olds; six 9 year olds and five 11 year olds
were given the area task. Two 7 year olds, six 9 year olds and four
11 year olds were given the perimeter task. The number of children
making incorrect predictions in the area task was fewer than expected.
Table 5.8 indicates the number making a correct and an incorrect
prediction.

Table 5.8: The number of children of each age making correct and
incorrect predictions on the area task and on the perimeter task.

<table>
<thead>
<tr>
<th>Age in years</th>
<th>Area</th>
<th>Perimeter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correct Prediction</td>
<td>Incorrect Prediction</td>
</tr>
<tr>
<td></td>
<td>Correct Prediction</td>
<td>Incorrect Prediction</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

On the area task the one 9 year old and one of the 11 year olds modified
their subsequent prediction to match the outcome they had observed. The
other two 11 year olds did not. In the perimeter task all the children
making an incorrect prediction changed this on the subsequent prediction.
(See Appendix 4a.F for individual data.)

5.2.7 Type of Reaction to Contradiction in Tasks 2, 4 and 5

Given the difficulties encountered in deriving measures of the
effect of the contradiction on the child's reasoning in the Tasks 2, 4
and 5 the index of "type" of reaction to contradiction in these tasks
gains further importance. It was calculated not only to test the Model
proposed in Chapter 2 but also to give a measure of the child's
recognition of contradiction. Even in those tests where the child made a correct prediction, or made so few predictions that changes from a correct prediction to an incorrect prediction could not be quantified, the child was nevertheless dealing with difficult subject matter and was constantly encountering contradictions. It was possible to evaluate the child's reactions to these contradictions as was done with Tasks 1 and 3. The same categories of reaction (non-recognition of contradiction, elimination of contradiction, attempt to resolve contradiction and resolution of contradiction) may be scored for each child. (See Appendix 4b). An additional category of response - refusal - was also scored in the permutations task. It was noted earlier that refusals could indicate an "attempt to resolve" the contradiction (DF7). In this case however the refusal response appeared not to indicate puzzlement about the problem but an inability to conceptualise ordered rows. Hence the child was not able to comply with the instructions of the task.

The number of children reacting in each way on the three tasks is shown in Table 5.9.

Table 5.9: Number of children of each age reacting in each way on Tasks 2, 4 and 5.

<table>
<thead>
<tr>
<th>Type of reaction</th>
<th>Task 2 (Permutation)</th>
<th>Task 4 (Spring)</th>
<th>Task 5 (Area &amp; Perimeter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refusal</td>
<td>7 0 0 0</td>
<td>0 0 0 0</td>
<td>0 0 0 0</td>
</tr>
<tr>
<td>Non-recognition</td>
<td>0 1 0 0</td>
<td>0 0 0 0</td>
<td>0 0 0 0</td>
</tr>
<tr>
<td>Elimination</td>
<td>1 7 8 8</td>
<td>8 6 4 1</td>
<td>0 3 5 4</td>
</tr>
<tr>
<td>Attempt at</td>
<td>0 0 0 0</td>
<td>0 1 0 0</td>
<td>0 0 1 0</td>
</tr>
<tr>
<td>resolution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resolution</td>
<td>0 0 0 0</td>
<td>0 1 4 7</td>
<td>0 0 0 1</td>
</tr>
</tbody>
</table>
Table 5.9 shows two things. These are, first, that most of the children of all ages recognise a contradiction in this situation type 2 of DF 1 and second, that the children react to the contradiction by eliminating the contradiction or by resolving it. "Attempts at resolution" (DF7) are rare in these tasks.

5.2.8 Conservation of Number Results from the 5 Year Old Children

The eight 5 year old children attempting Task 1 were given a conservation of number test. The child was scored as giving a conservation response or a non-conservation response (see p. 83 for criteria). It was found that three children gave non-conservation responses and five gave conservation responses. There was no relationship between conservation and Task 1 performance. (Appendix 4a.A gives the conservation performance of the 5 year old children.)

5.3 DISCUSSION

This experiment was conducted to find at what age children recognise a contradiction, and how they react to it, once it is recognised.

It was found in all the tasks used that at 5 years of age the children could recognise a contradiction.

The reaction to the contradiction once it was recognised was, in almost every case, to eliminate it from the situation. That is, the external source of information, generally, was labelled as "true" and the child's reasoning as "false". Normally, if the contradiction was not eliminated it had been resolved.

It was suggested at the commencement of the chapter that in physical tasks the children would eliminate the contradiction, but in
logico-mathematical tasks they may not do so. In contrast, Inhelder, Sinclair and Bovet (1974) had suggested that in logico-mathematical tasks the children would eliminate the contradiction but in physical tasks they may not do so. In fact, neither suggestion was correct. It has been found in this experiment that there were no differences in the children's reactions depending upon the type of knowledge involved. The children behaved in the same way on all the tasks.

Two other points may be noted. The first is that Piaget (1928) hypothesised that children did not recognise contradictions until after they had attained the concrete operational stage. It has been found in this experiment (and in Experiment 1) that children recognised a contradiction between an internally represented belief and an external source of information at all ages, and hence at all developmental stages (as was demonstrated explicitly in Experiment 1). It seems clear then that the hypothesis that children require concrete operational reasoning to recognise contradiction is disconfirmed.

Second, in terms of the Model described in Chapter 2 it has been found the children react to contradiction by systematically eliminating it from their thinking. This follows the path towards the Endpoint Number 2 on the Model. Thus the path towards Endpoint Number 2 of the Model seems to be the most accurate description of the children's reaction to contradiction.

It was previously noted that if the path towards Endpoint Number 2 described the behaviour of children encountering a contradiction it was most unlikely that contradiction had a causal role in cognitive development.
This, in fact, appears to be what has been found. In a situation where the children have been positively presented with a contradiction they have eliminated the contradiction from their thinking until they have reached an age at which they can resolve it. They have then done so. However the contradiction has not been instrumental in this advance in cognitive development.

The results of this experiment therefore seem to indicate that contradiction is not a causal agent in cognitive development.

In Chapter 6 this argument will be amplified.
CHAPTER 6

DISCUSSION OF THE PREMISE THAT ENCOUNTERING A CONTRADICTION IS A CAUSAL AGENT IN COGNITIVE DEVELOPMENT

In the previous three chapters experiments designed to examine the child's reaction to contradiction have been described. Experiments 1 and 2 constituted, largely, studies of the methodology used to investigate contradiction. They culminated in Experiment 3 which was used to examine the child's recognition of and reaction to contradiction. Experiment 3 yielded two findings. These were:

1. Children, from age 5 years, and at the pre-operational and concrete operational stages of development (and therefore, it is assumed at all ages and stages of development), are able to recognise contradictions.

2. In general, children react to contradictions by eliminating them from their thinking, at least until they have developed to the point where they can resolve the contradiction, at which time they do so.

In Chapter 2 a model of possible reactions to encountering contradictions was outlined. This model was derived from the definitions of the terms relating to children's reactions to contradiction. It was found when defining the terms that they were not mutually exclusive but that in some instances, a child's response could be assigned to two different reaction categories. A model representing the relationships between the terms was proposed. The model is repeated here in Figure 6.1.

It was asserted in Chapter 2, however, that the model also had developmental significance. It was further suggested that if it was found that Endpoint Number 2 (or Endpoint Number 1) most accurately
Figure 6.1: A schematic representation of the continuum of possible responses by children encountering a contradiction.
described the children's reactions to contradiction, when the encountering of contradiction could not be a motivating force in development. Rather, if the Endpoint Number 2 described the children's behaviour, then the implication is that their cognitive development proceeds until they reach the point where they are capable of resolving the contradiction, and then they do so.

If, on the other hand, the path of the model to Endpoint Number 3 (or Endpoint Number 4) was found to describe the children's reaction to the contradiction, then it is still possible that encountering a contradiction is a causal agent in development since the occurrence of an "attempt to resolve" a contradiction is a necessary (but not a sufficient) condition for contradiction to be a causal agent.

From the results of the first experiment it appeared that the children's reaction to contradiction was dependent upon the type of situation used to present it. In tasks where the situation creating the contradiction was a relationship of incompatibility between two internal representations, the path to Endpoint Number 3 of the model described the child's reactions. In tasks where the situation creating the contradiction was an incompatible relationship between an internal representation and an external source of information, the path to the Endpoint Number 2 of the model described the child's reaction. This finding is consistent with the psychological literature, as it is tasks of the situation 1 of DF1 that have been used principally to develop the concept of "contradiction" as a causal agent in development.

The second experiment, however, showed that a task exemplifying situation 1 of DF1 contains many methodological problems. From Experiment 2 a variety of disconcerting conclusions could be drawn:
that the measure of "internal representations" was not adequate; that the measures of reaction to contradiction were not adequate; that the task designed to create the situation of a contradictory relationship was not adequate; or that the children were not, in fact, reacting to a contradiction when they responded to the task. Any of these conclusions suggests that inferences drawn from this type of task about the child's reaction to contradiction may be invalid. On the basis of the findings of Experiment 2 it was decided that, in examining the question of the child's reaction to encountering a contradiction, research should be restricted to the situation 2 of DF1, that is, to contradictions between an internal representation and an external source of information.

Experiment 3 used only this type of situation but included two different types of knowledge in the contradiction. It was found in this experiment that irrespective of the type of knowledge involved children from 5 years of age recognised a contradiction and that they reacted to the contradiction by eliminating it. Few "attempts at resolution" (DF7) were registered. The children resolved the contradiction when they had reached the point in their development at which they were able to understand the concepts.

However, certain methodological problems are encountered in all the research presented in Part 1 of the thesis. Some of these problems have been mentioned previously, others have become increasingly obvious as the research continues. The problems are the following:

1. The research is inferential. This allows errors of measurement to occur. Exactly what errors have occurred, and how seriously these have affected the results cannot accurately be determined. The possibility of measurement
error forces us to be cautious in drawing conclusions from the research presented.

2. As was shown in Experiment 1 (Chapter 3, page 81), the tasks vary considerably in difficulty. While it was not shown in the analysis of Experiment 3, the same is equally true. In Experiment 3 the Mirror Task (Task 3) constituted an easier task than either the Addition and Subtraction Task (Task 1) or the Spring Task (Task 4), with the Permutations Task (Task 2) being the most difficult of all. Interestingly, it is hard to predict in which of the tasks it will be easy or difficult to recognise a contradiction. As mentioned in Chapter 3, the age of acquisition of each of the concepts is not an accurate indicator of the level of difficulty of recognising a contradiction in that situation. Rather, the order of difficulty of the tasks can only be determined after the tasks have been presented. While task difficulty must surely have some effect on the results obtained, it is difficult at this stage to determine exactly what that effect is. The data collected in these experiments could be used in future research in this area for matching tasks with respect to their level of difficulty.

3. It might be claimed that the findings regarding the "type" of recognition of contradiction encountered (i.e. elimination of contradiction as opposed to attempt to resolve the contradiction) are consequences of the way the tasks have been scored. For example, if, in a task using the situation 2 of DF1 (e.g. the mirror task), the children could not react in a way which could be scored as "an attempt at resolution", then it would not be surprising to find that no children fell into this
category. In response to this claim, however, it is felt that the tasks used in this study did allow for a sufficient variety of responses, and that the scoring methods have captured that variety. For example, in the conservation of volume task (Task 4, Experiment 1), distortion of data and attempts at resolution were possible, and indeed expected. Scoring categories existed for these responses. However, no child responded in a way which could have been classed in one of these categories. Further, in the example given above, it is clear that an exemplar of "an attempt at resolution" behaviour could have occurred (e.g. distortion of the mirror image) and this possibility was included in the scoring categories used. However, the doubt that exists about the adequacy of the scoring categories suggests that more care must be taken to ensure that the possible types of reaction are equivalent in all tasks before clear conclusions about the causal role of contradiction can be drawn. Again, the experience gained in these studies may help in the design of further studies in this area.

4. Errors in the assignment of various responses of the children to the different categories of response defined in Chapter 2 is a possible source of measurement (or "classification") error. It might be argued that an objective method of classification should be employed. While this could well increase the inter-rater reliability there is no guarantee that arbitrarily defined formal classification criteria would achieve a validity greater than (or even equal to) that of the observers' intuitions which are the basis of the clinical method.
However, the findings of the studies presented in this section of the thesis may initiate the development of reliable and valid indices for the allocation of responses to scoring categories.

5. Finally, as already suggested in Chapter 4, it may be objected that the findings reported in this section of the thesis could be products of the cross-sectional methodology used. The only definitive answer to such an objection will be to conduct a training study extending over several sessions, relating to both the situations 1 and 2 of DF1.

Despite these methodological problems, the experiments in this section of the thesis have provided interesting data. In particular, the findings of Experiments 2 and 3, in conjunction with the proposed Model, suggest answers to the question of whether contradiction plays a causal role in cognitive development, and possibly more importantly, suggest further important questions which must yet be posed.

Taking the findings of the previous experiments at face value, it seems that the path to Endpoint Number 2 most accurately describes the child's reaction to contradiction. That is, the children react to the contradiction by eliminating it rather than by attempting to resolve it. This implies that contradiction may not be a causal agent in development. Rather cognitive development may occur for some other reason (Piaget would suggest that the equilibration process motivates development). It may be that once the child has developed cognitively to a certain level of understanding (s)he is able to resolve the contradictions (s)he encounters. The resolution of the contradictions, however, may not contribute to the development.
This conclusion is consistent with Piaget's position as outlined in Chapter 1. However, Piaget also claimed that children did not recognise contradictions prior to the concrete operational stage of development. This claim does not seem to have been supported by the present experiments. Rather, the children seem to be aware of contradictions but eliminate them from their thinking. The fact that Piaget appears to be incorrect in saying that contradictions are recognised only after the stage of concrete operations in no way damages his position regarding the reaction of children to contradictions, once they are recognised.

Of course, in view of the methodological problems discussed above, great caution must be exercised. This section of the thesis has presented preliminary and exploratory studies and further work is required before a firm conclusion is possible. In particular, it is necessary to confirm the present results by studies using a training-study methodology.

It was stated in the introduction that there are two reasons for studying the effect of contradiction on reasoning. The first was that contradiction has been hypothesised to be a causal agent in development. Chapters 3, 4 and 5 of this thesis have indicated that it may not be. This brings us to the second reason for studying contradiction. This was that since contradiction is a logical concept, the study of the child's understanding of contradiction is of interest simply as a study of the development of the understanding of a particular logical concept.

Chapter 7 reviews the literature concerning the study of the concept of contradiction as a logical concept. Chapters 8 and 9 will then describe two studies examining the child's understanding of contradiction as a logical concept. This constitutes Part 2 of the thesis.
PART 2

THE STUDY OF CONTRADICTION

AS A LOGICAL CONCEPT