Child development and the aims of road safety education (No.01)

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Executive Summary

1. Background

Pedestrian accidents are one of the most prominent causes of premature injury, handicap and death in the modern world. In children, the problem is so severe that pedestrian accidents are widely regarded as the most serious of all health risks facing children in developed countries. Not surprisingly, educational measures have long been advocated as a means of teaching children how to cope with traffic and substantial resources have been devoted to their development and provision. Unfortunately, there seems to be a widespread view at the present time that education has not achieved as much as had been hoped and that there may even be quite strict limits to what can be achieved through education. This would, of course, shift the emphasis away from education altogether towards engineering or urban planning measures aimed at creating an intrinsically safer environment in which the need for education might be reduced or even eliminated. However, whilst engineering measures undoubtedly have a major role to play in the effort to reduce accidents, this outlook is both overly optimistic about the benefits of engineering and overly pessimistic about the limitations of education. At the same time, a fresh analysis is clearly required both of the aims and methods of contemporary road safety education. The present report is designed to provide such an analysis and to establish a framework within which further debate and research can take place.

2. Setting objectives

No educational programme can expect to succeed unless it is founded on clear and explicitly-stated objectives. Without these, the programme would be unfocused and evaluation impossible. Unfortunately, this basic requirement has not been well served by road safety initiatives in the UK. Many programmes in this country set themselves only the most general of aims, such as 'reducing accidents'. Such aims are perfectly laudable but are far too broad to be functional as educational objectives. Where programmes do set more fine-grained objectives, the majority are concerned with improving children's *knowledge* about traffic or instilling good *attitudes* towards safety. Implicit in such programmes is the assumption that changes in knowledge or attitudes will lead to changes in actual traffic *behaviour*. However, this confounds a secondary objective (improving knowledge) with a primary objective (improving behaviour). Whether the one leads to the other is an empirical question requiring demonstration. In fact, the evidence suggests that there is no direct link between knowledge and behaviour at all, raising serious questions about the validity of much traditional road safety education.

Deciding how to set concrete objectives, then, remains a fundamental problem in road safety. We believe the most scientific way of doing this would be to provide a detailed analysis of the pedestrian task, breaking it down into the component skills and strategies required to deal with the various problems encountered in traffic. Understanding the skills and strategies needed to interact with traffic would seem an obvious starting-point for the development of educational objectives. For example, if it could be demonstrated that children lack the skills needed to tackle a particular road task, then an appropriate objective might be to teach those skills. If unable to benefit from such training, for example until a certain stage of psychological development had been reached, it might still be possible to develop a more limited strategy suitable to the skill level of younger children. In the extreme case, it might be necessary to recommend that the child should not tackle certain road tasks at all. However, all such decisions should be based on solid empirical data concerning the skills that children possess at different ages and on whether acquisition of such skills is possible.

The argument being made is that pedestrians require a range of fundamental skills in order to interact safely with traffic. They must also learn to deploy these skills strategically at the roadside. While a definitive taxonomy is probably not possible, we believe the following are among the most critical psychological skills involved in road behaviour. It should also be noted that many tasks will require the deployment of several underlying psychological abilities at the same time.

Detecting the presence of traffic: the detection of traffic involves a range of basic processes including selective attention; visual search; resistance to distractibility; co-ordination of visual and auditory

information; and the perception of crossing locations as safe or dangerous (in terms of the opportunities they afford for detecting approaching traffic).

Visual timing judgements: this requires the pedestrian to determine a vehicle's direction and rate of movement so that accurate time-to-contact judgements can be made. Such judgements provide information about the time available for crossing.

Co-ordinating information from different directions: the pedestrian rarely has to deal with traffic approaching from a single direction: thus, timing and other judgements must be made in relation to vehicles approaching from two or more directions. This requires the ability to divide attention; to hold information in memory; and to co-ordinate and integrate this information.

Co-ordinating perception and action: this involves the ability to relate the time *available* for crossing to the time *required* to cross. The latter will vary according to characteristics of the individual's own movement as well as to factors such as the width of the road. Such knowledge about movement capability must then be calibrated to visual information about the time available for crossing so that realistic safety margins can be set and other decisions made.

3. Skill development in children

Even crossing a simple road, then, requires competence in a range of primary perceptuo-motor and cognitive skills. If these skills are not properly developed, the pedestrian's crossing decisions will almost certainly be inadequate. From an educational point of view, it is therefore vital to know how these skills develop in childhood and what level of skill can be expected in children of different ages. It is also essential to know whether baseline performance can be improved through education or training and, if so, at what age intervention is most likely to be effective.

3.1 Potential for training

The evidence reviewed in the report demonstrates clear developmental trends on a wide range of psychological skills related to traffic behaviour. However, it also suggests that many of these skills are considerably more advanced in even young children than has previously been assumed. Moreover, the evidence strongly suggests that many of them may be amenable to training, provided that appropriate training methods are employed. This outlook stands in marked contrast to a widely-held view in the road safety field that children are inherently incapable of dealing with the traffic environment until they have reached a certain level of cognitive development, typically the Piagetian stage of concrete operations. We argue that such a view is based on early and somewhat misguided interpretations of Piagetian theory, which considerably underestimated the abilities of the young child.

3.2 Behavioural training

Consistent with this, there is a substantial literature specifically within the field of road safety, demonstrating the success of training a variety of road crossing skills, provided this is carried out in a meaningful context that closely simulates the road environment. For example, recent studies have demonstrated significant improvements in children's ability to make roadside timing judgements (Lee *et al*., 1984; Demetre et al., 1992); find safe places to cross (Ampofo-Boateng *et al*., 1991); plan safe routes (Thomson *et al*., 1992); cross at parked cars (Rothengatter, 1981); and cross safely at junctions (Rothengatter, 1981). Furthermore, such training can be successfully employed with very young children. Whereas pre-eminent classroom techniques such as the Green Cross Code cannot even be recommended for use with children under seven years of age (on account of the verbal skills that they require), when taught *behaviourally* such strategies can lead to significant improvements in the roadside judgements of children as young as four years (Rothengatter, 1981). By contrast, evaluation of knowledge-based approaches has provided little evidence to suggest that they are effective in improving children's roadside judgements.

As stated above, this stems in part from early interpretations of Piagetian theory, according to which young children's traffic decisions are limited by their age and stage of cognitive development. However, contemporary developmental theory views Piagetian models of development as considerably more flexible than was previously thought. Indeed, the major bodies of developmental theory share a number of features

which convincingly explain why practical training approaches are successful and why knowledge-based approaches are not.

4. Developmental theorists

4.1 J.J. Gibson

Although not strictly a developmental theorist, the work of J. J. Gibson has made major contributions to understanding of the development and acquisition of perceptuo-motor skills. In Gibsonian terms, the pedestrian task is essentially a perceptuo-motor problem rather than one of higher-order interpretation and cognitive construction. Gibson's theory of perception states that, through evolutionary pressure, the visual system has become attuned to salient temporal information in the optic array specifying *directly* the time-to-contact of approaching objects or surfaces, thus eliminating the need for cognitive construction based on information about speed and distance. Furthermore, for Gibson, perception is ultimately bound to action, and environmental events are perceived in terms of the potential for action which they afford. Thus, the developmental task is one of attunement and refinement of the visual system to temporal information in the optic array and the actions which such information affords. One major implication of this is that perceptual judgements and motor responses can only be learned in the context in which they occur, or at least in close analogues of them. Perceptuo-motor learning is thus a bottom-up process, progressing from learning in specific contexts to more generalised conceptions. Practical road safety training thus works because it provides the opportunity for this process to take place.

4.2 Piaget

This general pattern of learning is also implicit in the hugely influential work of Jean Piaget. For Piaget, learning proceeds from context-bound actions (beginning in infancy with reflexes) towards increasingly generalised conceptual understanding. The key mechanism of change is the child's co-ordination of initially separate pieces of knowledge about different events, which occurs as they seek to understand and resolve conflicts between their expectations and actual experience. For example, if the child found that it took longer than expected to cross an unfamiliar road, s/he might then notice that the road was also wider than those previously encountered. In this way, co-ordinating information about different events allows them to perceive the more general relationships between road width and crossing time. This Piagetian emphasis on learning as a bottom-up process of construction from specific actions in specific contexts bears clear similarities to Gibson's account of the development and acquisition of perceptuo-motor skills. It also stands in marked contrast to the practice in many road safety programmes, where knowledge is taught at a general level in the belief that this will then transfer to the many specific situations to be faced at the roadside.

4.3 Vygotsky

The idea of learning as a bottom-up process introduces the work of L. S. Vygotsky, widely regarded alongside Piaget as the other great theorist in developmental psychology. For Vygotsky, all thought is the mental equivalent of action and has its origins within action. For example, counting the number of books on a shelf is the mental analogue of the developmentally earlier task of physically moving the objects into a row while counting. The second point of importance in Vygotsky's theory is that all organised action takes place in conjunction with those who have already mastered it (e.g. the child counting with an adult). This introduces the crucial Vygotskian notion of the *zone of proximal development (ZPD)*. The ZPD is a psychological rather than a physical space, referring to the difference between that which the child can achieve alone and that which s/he can potentially achieve whilst working with a more competent other. The ZPD is thus the space within which learning occurs and learning itself is a process of *internalising directed activity*. For Vygotsky, then, learning is necessarily grounded in a *social context*, whereas Piaget conceived of learning as being largely a process of internal construction within the individual (albeit one which could be socially motivated). However, in common with Piaget, Vygotsky considered learning to be a bottom-up process with complex activities building upon simpler ones, with the range encompassed by the zone of proximal development advancing as learning progresses.

Developmental theory, then, almost with one voice argues for the natural progression of understanding from action to concept. It follows that pedestrian training methods will be most effective when they operate in

accordance with this progression rather than when they work against it. From this point of view, practical training methods are successful because they begin at the correct point in the developmental sequence. Knowledge-based approaches are much less successful because they do not.

5. Rate of development

There remains the important question of the age at which training should begin. Previously, Piaget's stages of development have been interpreted as representing biological constraints on the rate of development. That is, a child would not be able to perform a given task until the appropriate level of cognitive development had been reached. Such assertions led researchers such as Sandels (1975) to argue that children below the age of 8-9 years must be inherently unsafe pedestrians. In fact, as mentioned earlier, the cognitive requirements of the pedestrian task may be less than has been assumed, and the basic perceptuo-motor skills ought theoretically to be within the capabilities of even young children. More importantly, Sandels' argument is based on a misconception of the significance of stages in Piagetian theory. Given the bottom-up nature of the process of construction, it is more appropriate to view Piaget's stages as emergent characteristics of the developing child rather than overarching constraints. The Piagetian stages map out what might be a typical progression in the average child in the absence of educational intervention and are now regarded as considerably more elastic from a timing point of view than was previously supposed. Indeed, a child may perform at several different Piagetian stages at one and the same time, depending on the nature of the tasks and other factors. The interpretation of developmental stages as rigid, age-bound categories precluding educational intervention is certainly unwarranted. The real strength of Piagetian theory is now regarded as lying in its account of the *process* of development rather than in any indication of the *timing* of specific developmental changes. There is nothing in this account to suggest other than that practical training should be successful with children as young as 4 years of age, providing it offers the right kinds of experience.

6. Generalisability of learning

In devising any training programme, a major issue to be addressed is the extent to which we can expect abilities learned in one context to generalise to others. This issue is a topic of much debate in contemporary developmental psychology but, on balance, the evidence suggests that there is a marked tendency for knowledge to be compartmentalised. Transfer from one task to another is possible, but the tasks must bear functional similarities to each other. Such correspondences must also be salient for the learner. Current road safety programmes which assume that children will spontaneously extend understanding gained in one context (e.g., the classroom) to behaviour in another (e.g., the roadside) are therefore poorly supported both by theory and by empirical evidence. The implication is that it would be better to focus on promoting development from scratch in the context in which the learning will be used - i.e., at the roadside or something closely analogous - than in general discussions about what one might or might not do while sitting round a table.

7. The social context of training: interactive learning

Developmental theory provides clear indications, then, as to why practical training carried out in a meaningful context has proved to be more successful than classroom based methods. It also suggests that, so long as the focus is on promoting appropriate action in close analogues of the road environment, training could easily begin with children as young as 4 or 5 years of age. In addition to this, contemporary extensions of Piagetian and Vygotskian theory also provide a framework for the development of appropriate training methods, utilising what has become known as *interactive learning* (i.e., the learning that takes place through social interaction).

7.1 Peer collaboration

As noted above, for Piaget it is conflict between ideas and experience that provides the impetus for conceptual advance, by necessitating resolution of the conflict. This points to the potential role of peer discussion in learning, particularly when children work together in a group. In such cases, the group becomes a forum for the exchange of ideas as to how the task might be solved and, because peers typically share the same communicative style and are less inhibited about talking with each other, this usually permits

a fairly full airing of different views. During such exchanges, there is thus a strong probability that children will be exposed to ideas that are different to their own and that internal cognitive conflict will be created. The subsequent personal resolution of this conflict results in development. There has been much research in recent years investigating the effects of this kind of peer collaboration. The evidence not only supports the general principle that such learning is effective, but also suggests that it has particular impact on *conceptual* advance (Howe, Tolmie and Rogers, 1992; Tolmie, Howe, MacKenzie and Greer, 1993).

7.2 Peer tutoring

By contrast, the Vygotskian emphasis on the role of guided action has been applied to a different interactive learning technique, that of peer tutoring. Peer tutoring refers to a dyadic interaction in which one partner, who is the more competent, tutors the other, less competent partner. The asymmetry of this relationship meets the basic condition for establishing the zone of proximal development. Research into the processes and outcomes of peer tutoring indicates positive effects on learning in line with the predictions of Vygotskian theory, particularly as regards the opportunities it affords for structuring the activity of the less competent partner. This evidence also suggests that peer tutoring is best suited to the development of skills, as opposed to reasoning or problem-solving tasks (Damon, 1984). However, there are clear signs of limitations in children's role-taking abilities, their ability to tailor verbal directions, and their sensitivity to the needs of others (e.g. Peterson, 1972) which limit the effectiveness of peer tutoring. For these reasons it is possible that adult-child interaction, when it operates along similar lines, may hold more promise for road safety training with younger children. There are considerable parallels between peer tutoring and this form of adult-child interaction since, as Rogoff (1986) points out, the interaction remains one of guided participation and is as much a step away from direct instruction as peer tutoring is.

In the context of road safety education, then, it seems likely that adult-child interaction has the potential to make concrete the skills involved in safe road crossing and thus fulfil an important and effective role in any training programme. Peer collaboration could be applied to fill a complementary role in the development of conceptual understanding of the traffic environment and the deployment of skills, although this would entail careful task design to ensure that group dialogue was channelled along productive lines (see Tolmie *et al*., 1993).

We suggest that interactive learning techniques hold considerable promise in the context of road safety education. Moreover, there is a growing literature which clarifies how such techniques might be applied most effectively. Whilst it remains necessary to identify precisely how we might capitalise on them in the specific context of road safety, studies of adult-led group training of children to find safe crossing places provides an existing example of the benefits of interactive learning methods. Such a training procedure has been found to produce significant improvements in children's judgements, making them behave like older, more experienced pedestrians (Thomson *et al*., 1992). Few other studies appear to have tackled the development of road safety understanding in this way, but the early signs suggest that it holds considerable promise.

8. Conclusions

In this report we argue that children need a range of fundamental psychological *skills* in order to interact with traffic, together with the ability to deploy these *strategically* in different traffic situations. We argue that viable objectives in road safety education would be to operationally define such skills and strategies and devise appropriate training procedures whereby they might be improved. If successful, such training would yield direct and measurable changes in children's actual behaviour in traffic, not merely changes in what they can *say* about traffic when questioned by adults. Whilst a long-established tradition in road safety asserts that many of these skills cannot be improved through education until a particular stage of development has been reached, we challenge that view and argue that it is inconsistent with modern research in psychology or, indeed, with the majority view among developmental psychologists. In addition, recent studies that have attempted to improve children's performance on a range of clearly-defined pedestrian skills have produced empirical evidence that such skills can be accelerated, providing appropriate training is given. The critical aspect would appear to be that the training should be *practical* in nature. Contemporary educational approaches arising out of the work of major theorists such as Piaget and Vygotsky provide

further ideas as to how the benefits of practical training might be maximised by adapting techniques from the field of interactive learning. Such approaches deserve to be explored in the effort to derive educational interventions capable of leading to tangible improvements in children's ability to cope with the traffic environment.

Abstract

This report examines the skills and abilities needed by proficient pedestrians, the extent to which road safety education aids the growth of these skills in children, and what developmental psychology has to say about the form that effective education should take. The authors argue that confusion between teaching children *about* the traffic environment and teaching them how to *behave* within it has led to an emphasis on classroom activities and learning of abstract rules. Neither appear successful when compared to programmes that give children practical training and experience. Developmental psychology indicates this is because learning proceeds most naturally from specific behaviours in specific contexts towards the gradual elaboration of more general understanding. It follows that road safety education should begin by teaching appropriate behaviour within realistic contexts, with more explicit knowledge building up gradually from this experience. Interactive learning techniques, in particular adult-led guidance of behaviour at the roadside combined with peer discussion of the rationale for that behaviour, present the best methods of intervention because they capitalise on the natural process of learning. There is no reason why training of this kind should not begin at the start of primary school.

Introduction

Road accidents are one of the most prominent causes of premature illness, handicap and death in the modern world. Indeed, a recent report from the Royal College of Physicians stated that accidental injury "is probably the most serious of all the major health problems in the developed countries". The problem is particularly marked in child pedestrians, who typically suffer a casualty rate four times that of adults at all levels of severity. When we take into account that children are much less exposed to traffic than adults (and therefore have many fewer 'opportunities' to get knocked down), this trend becomes even more marked (e.g., Howarth, Routledge and Repetto-Wright, 1974). Little wonder that one authority has described accidents as "for children, the plague in modern guise" (Rothengatter, 1981a). In spite of significant improvements since the 1960s and 70s, epidemiologists continue to regard pedestrian accidents as of epidemic proportions and a profound cause for concern (e.g., Malek, Guyer and Lescohier, 1990; Pless, 1991). The government has responded by joining its European partners in pledging to reduce road casualties by a third before the year 2000. The question is, how might this best be done?

In the case of child pedestrian accidents, educational measures have long been introduced as a means of teaching children how to cope with traffic and substantial resources have been devoted to their development and provision. However, although accident rates have undoubtedly decreased over the last 30 years, it is remarkably difficult to know how much of this may be attributed to the effects of education and how much to other factors. The situation has been exacerbated by the fact that few educational measures introduced at either local or national level have been evaluated with regard to their effectiveness in improving children's traffic behaviour (Singh, 1982; Thomson, 1991). Moreover, Hillman, Adams and Whitelegg (1990) have cogently argued that a major factor underlying the decrease in child casualties between 1971 and 1991 was a dramatic reduction in *exposure* to traffic, caused by greatly increased parental anxiety towards their children's safety. In general, there seems to be a widespread feeling at the present time that educational measures have not achieved as much as had been hoped and that there may even be quite strict limits on what can be achieved through education. This would shift the emphasis away from education altogether towards engineering or urban planning measures aimed at creating an intrinsically safer pedestrian environment where the need for education would be reduced or even eliminated.

There is no doubt that engineering and urban planning have central roles to play in the effort to reduce pedestrian (and other) road casualties. However, the outlook described above is both overly optimistic about the benefits of engineering and overly pessimistic about the limitations of education. At the same time, there is no doubt that a fresh analysis is required both of the aims of road safety education and the methods by which those aims are met. For these reasons, we believe the time is right for a wide-ranging debate on the aims and objectives of road safety education. The present report is designed to provide the framework for such a debate.

In this report, we attempt to re-examine what it is to be a pedestrian, paying particular attention to the skills and abilities that underlie proficient traffic behaviour. We argue that one of the central aims of road safety education should be to teach such skills. We also argue that children must learn how to deploy the skills appropriately in the different traffic situations that will confront them. Although task analysis has been advocated by road safety researchers for many years as a means of defining what it is that pedestrians must learn to do (and this has led to fundamental reappraisals of the aims of road safety education in some countries), the analysis of pedestrian behaviour has remained relatively shallow. Instead, attention has focused on a few simple, supposedly global rules for safe pedestrian behaviour together with the broadly attitudinal shortcomings of vulnerable pedestrians. Such approaches have been essentially atheoretical, usually offering little more than lip service to theories of learning and development. The result, we believe, is a range of educational measures that are far less effective in preparing children to face traffic than needs be the case.

The report is divided into six main sections. In Chapter 1 we examine the aims and objectives of road safety education, commenting on current objectives and how these might be improved. We also analyse the pedestrian task with particular emphasis on the psychological skills and processes that are involved. We then review what is known about the development of such processes in childhood. Finally, we consider whether

development might be promoted through appropriate training. In Chapter 2, we review both the content and methods of road safety education, with particular reference to the skills described in Chapter 1, commenting on the relative effectiveness of the different approaches that have been attempted to date. We pay special attention to practical training methods, which appear to be by far the most effective in preparing children to deal with real traffic situations. In Chapter 3, we consider why this should be the case. We also present an in-depth analysis of the major theories of development and learning, with emphasis on the work of Piaget and Vygotsky, spelling out the implications for road safety education. In Chapter 4, we expand on a particular educational approach that has recently evolved out of these major theoretical traditions and shows exceptional promise in promoting the development of mathematical and scientific concepts. We offer some suggestions as to how this approach might be applied in the field of road safety education in Chapter 5. Finally in the Conclusions we summarise the main threads of our argument and make recommendations on the basic and strategic research that we believe is now needed in order that effective tools for road safety education be developed.

Chapter 1
Aims and objectives of road safety education

1.1 Establishing objectives in road safety education

No educational programme can expect to succeed unless it is founded on clear and explicitly stated objectives. Without these, the programme would be unfocused and evaluation as to whether it had achieved what it set out to achieve would be impossible. Moreover, whilst educational programmes are always formulated with an ultimate goal in mind, that goal is never a satisfactory educational objective in itself. For example, the principal goal of road safety education is to reduce child pedestrian accidents. However, this is far too broad to be functional as an educational objective. Any educational programme must set more restricted objectives and show how these will contribute towards fulfilment of the ultimate goal. Thus, teachers of French cannot simply argue that their objective is to teach students how to speak the language: they are required to define a set of far more specific objectives and show how these will lead progressively towards increased fluency. Defining what these objectives should be is a difficult task but one that is of paramount importance to the effectiveness of any educational programme. Not surprisingly, the problem of objective setting has long occupied a central place in educational science (e.g., Bloom, 1956). Unfortunately, as we shall see in Chapter 2, this problem has been poorly addressed in traditional road safety education. We shall therefore attempt to clarify at the outset what we believe the aims of road safety education should be. We also outline a framework within which appropriate educational objectives could be set.

Objectives can be categorised along a range of dimensions but in road safety the two that have figured most prominently are *general-specific* and *primary-secondary* (e.g., Rothengatter, 1981a). General objectives, whilst not as broad as ultimate goals (such as reducing accidents), remain very global and cannot normally be attained except by means of more specific objectives. Examples that have proved generally acceptable include that children *avoid dangerous situations* and that they *behave safely* (OECD, 1978). Such objectives are perfectly sensible but they are not very helpful to the designer of an educational package: what exactly do we mean by 'behave safely', for example? In order to operationalise such terms, it is necessary to specify far more concrete objectives and show how these will contribute towards attainment of the general objective. Unfortunately, although attempts have been made to categorise specific objectives, sometimes in considerable detail(e.g., Sheppard, 1975; van der Molen, 1981a), there has been remarkably little agreement as to what these should be. According to Rothengatter (1981a), about the only generally accepted concrete objective is that children should look before crossing and even then there is no agreement as to what they should look *for* or how they should behave on the basis of what is seen. The fact is, most road safety programmes simply do not set concrete objectives or show why the proposed programme should lead to a reduction in accident rates. To a large extent, it seems almost to be assumed that if the material deals with road safety at all, then it is bound to have beneficial effects (Thomson, 1991). As we shall see, there are no grounds for so optimistic a view.

Related to the distinction between general and specific objectives is the primary-secondary distinction. Primary objectives relate directly to the goal: secondary ones merely have an enabling or facilitative role - in the sense that a knowledge of mathematics is a necessary prerequisite to the study of engineering, for example. In road safety these two kinds of objective are frequently confounded. For instance, it is widely assumed that increasing children's *knowledge* about traffic, or developing positive *attitudes* towards safety, will help reduce children's vulnerability to accidents. However, this can only be expected if changes in knowledge and attitudes lead to a primary objective, namely changing how children *behave* in traffic. The underlying aim is to improve children's traffic behaviour, not to increase their knowledge *per se*. The latter is therefore a secondary objective. Whether or not it leads to changes in the primary objective is something that requires empirical demonstration. In fact, there does not appear to be a direct link between knowledge and behaviour at all, raising serious questions about the validity of a great deal of traditional road safety education (Rothengatter, 1981a,b; Ampofo-Boateng and Thomson, 1990). We return to this issue in Chapter 2.

1.2 Formulating concrete objectives in road safety education

The fundamental problem in road safety education, then, is still to decide what constitute valid aims and objectives. How is this to be done? A common approach has been to seek the opinion of experts or others who might be expected to have insight into the problem. Groups commonly consulted include road safety officers, the police, parents and teachers. Such an approach was used in developing the Green Cross Code (Sargent and Sheppard, 1974) and in shaping the 38 objectives formulated by Sheppard (1975) in his influential paper on the graded acquisition of pedestrian skills. However, it is a moot point as to whether the intuitions of adults or even experts represent the best way of determining the content of road safety education. In fact, these intuitions are sometimes rather limited. For example, crossing the road near visual obstructions is heavily implicated in pedestrian accidents, particularly in children (e.g., O' Donoghue, 1988; Assailly, 1992). Yet parents, teachers, road safety officers and the police, when asked to state the most important skills needed to cross the road, relegated the choosing of a site where visibility was good to a secondary level of importance (Foot, Chapman and Wade, 1982). Similar opinions were expressed during formulation of the Green Cross Code (Sargent and Sheppard, 1974). In fact, young children have very little ability to recognise dangerous roadside locations, generally judging them to be perfectly safe (Ampofo-Boateng and Thomson, 1991). Thus, expert opinion is by no means a foolproof source of information concerning the abilities and limitations of children. Whilst such insights are valuable, they need to be guided by far more objective data concerning the behaviour of children in traffic (Vinje, 1981; van der Molen, 1981b).

A more scientific way of establishing objectives would be to analyse the problems posed by the traffic environment; the **strategies** by which an experienced pedestrian might solve these problems; and the underlying **skills** required in order for appropriate strategic behaviour to be possible. Understanding the skills needed to interact with traffic and the strategies by which they are deployed would seem to be an obvious starting point for the development of educational objectives. For example, if it could be shown that children lack the skills needed to tackle a particular road task, an appropriate educational objective might be to teach those skills. If children were unable to benefit from such training until a certain age were reached, it might nevertheless be possible to teach a more limited strategy that would suit the skill level of younger children. In the extreme case, it might be necessary to recommend that the child should not tackle certain road tasks at all. However, such recommendations should be based on solid empirical evidence concerning the skills that children possess at different ages and on whether or not it is possible to accelerate acquisition of the skills through training.

1.3 Analysing the road crossing task

The first attempts to analyse the road crossing task and its underlying functional processes were made by Older and Grayson (1974) and Avery (1974). More detailed analyses have been made by van der Molen (1981a), who used task analysis to identify over 200 sub-divisions of the road crossing task; and Vinje (1981), who attempted to outline both the functional processes involved in road crossing and their development. Older and Grayson argued for a basic distinction to be made between *location* selection and *time* selection, dividing each into four stages: observation, perception, judgement and decision. For example, traffic must first be perceived (by which the authors seem to mean that its presence must be detected) and this requires observation. Judgements must then be made about its distance and movement, separately for each direction, and this information stored in short term memory. This information is then retrieved for use in reaching a decision as to whether or not to cross. The procedures involved in actually crossing must then be retrieved from long term memory, where it is assumed they have previously been stored.

Older and Grayson's distinction between time and location selection is a good one as we shall see, but their four underlying stages are rather too global to be useful as a means of setting educational objectives. In fact, each of these stages could be further subdivided (cf. van der Molen, 1981a) and, in any case, often seem to overlap with respect to the psychological processes involved. For example, the authors' distinction between perception and judgement is arbitrary and does not accord with distinctions that would follow from any identifiable theory of perception or cognition. Moreover, the analysis tends to confound basic psychological processes (such as distance perception) with strategic processes (such as the setting of safety margins). This distinction is important because a pedestrian might accurately assess the time to arrival of an approaching

vehicle, yet fail to use this information in a strategically acceptable way - for example, by leaving an inadequate safety margin when selecting a traffic gap to walk through. In fact, there are substantial effects of age (and possibly also of gender) on the strategies that road users adopt when deploying basic perceptual and cognitive skills. A clear distinction should therefore be made between these processes.

A similar analysis to that of Older and Grayson was made by Avery (1974), except that estimating the speed of approaching vehicles was included as a judgmental variable. In addition, this author attempted to review the development of these processes on the basis of the literature available at that time. This analysis was later extended in an influential paper by Vinje (1981), who reviewed the functional capacities of young children in relation to what she considered to be key pedestrian tasks. In addition, she took the significant step of relating these capacities to developmental theory, specifically that of Jean Piaget. On the basis of this analysis, Vinje listed a series of objectives which she considered viable with children of different ages, taking into account the functional capacities that could be assumed in each age group. She also suggested some simpler strategies that might be taught to younger children who would not have the capacity to make more sophisticated judgements. These proposals were operationalised in a series of important studies at the University of Groningen's Traffic Research Centre and now form the basis of much road safety education for young children in the Netherlands (e.g., Vinje, 1981; Rothengatter, 1981, 1984; van der Molen, 1981b, 1983, 1989).

The argument being made, then, is that pedestrians require a range of fundamental skills in order to interact safely with traffic. They must also learn to deploy these skills appropriately through the development of suitable strategies, which will necessarily vary from one traffic situation to another. Whilst it is probably not possible to provide a definitive taxonomy, in the following section we attempt to specify at least the most critical psychological skills that are engaged in pedestrian behaviour. We then review what is known about the development of such skills in children of different ages. Finally, we consider from a theoretical point of view whether or not it might be possible to promote development in inexperienced children through appropriate training.

1.4 Skill and pedestrian behaviour

1.41 Detecting the presence of traffic

Obviously, pedestrians have to look for traffic in the first place if they are to avoid it. Having looked (in the sense of pointing their heads in the right direction), they also have to 'see' it. This will depend on the effectiveness of a number of underlying processes. For example, an effective *visual search* strategy will be required in order to detect the presence of a vehicle. This in turn will require at least some conceptual representation of how cars move about the road environment - otherwise pedestrians would have no idea of where to look and where not and their visual search would be poorly structured and inefficient. The pedestrian's *attention* is also clearly involved - that is, their ability to focus on relevant cues whilst ignoring irrelevant ones. Since irrelevant objects or events are frequently more interesting than relevant ones, this raises the problem of *distractibility* - a problem of considerable importance in child pedestrian behaviour, as we shall see. Additional factors influencing whether or not the pedestrian succeeds in detecting the presence of a vehicle will include the accuracy of their *auditory localisation*, together with their ability to co-ordinate auditory and visual information. Pedestrians also have to recognise that certain roadside locations obstruct their view of traffic (e.g. when crossing near parked vehicles or similar obstructions, at a bend, on the brow of a hill, etc.). Such locations reduce the chances of detecting an approaching vehicle from the outset. We can see, then, that even detecting the presence of vehicles depends on a whole series of underlying psychological skills. Unless pedestrians develop competence in these they may fall at the first hurdle by failing even to detect that a vehicle is present.

1.42 Visual timing judgements

Although far more complex than commonly supposed, the judgements referred to above represent no more than the first step in the process of crossing even a simple road. Once a vehicle has been detected, a range of judgements concerning the vehicle's movement must be made. Firstly, the pedestrian must determine if the vehicle is moving at all and, if so, in what direction. If the vehicle is on an approach path, then the *time-to-*

contact of the vehicle must be determined: that is, the time available before the vehicle reaches the pedestrian's projected crossing path. Such timing judgements become particularly important on busier roads where it is not possible to wait for traffic to clear, as it sometimes is on quieter roads. These skills depend on the observer's sensitivity to a range of optical variables related to time-to-contact. Distance and velocity perception would also seem to be implicated, together with the ability to integrate these variables with respect to time. Recently, it has been proposed that higher-order variables are also available to specify time-to-contact in a more direct way. Pedestrians must become attuned to the information afforded by such variables and learn how to co-ordinate their movement to them.

1.43 Co-ordinating information from different directions

There are few occasions on which a pedestrian is required to deal with a single direction. Normally, pedestrians must cope with traffic coming from at least two directions - and from three or four in the case of many intersections. This means that information must be picked up separately for each of several directions and all the timing and other judgements made in relation to each of them. Thus *memory* and the ability to *divide attention* between tasks become crucial (the latter throwing up once again the problem of distractibility). Finally, the information has to be co-ordinated and processed in real time - and all within a rather short period, given the speed with which the road environment can change. This will depend on the efficiency of a whole range of central processing functions. The complexity of the road situations that a pedestrian can tackle will doubtless reflect both the maturity of these functions and the efficiency of the strategies that have been developed for using what are known to be limited resources.

1.44 Co-ordinating perception and action

Although the perceptual skills described above are crucial to pedestrians, they would be meaningless if taken in isolation. In order to reach a decision as to whether it is possible to cross safely, the pedestrian must relate the time *available* for crossing to the time *required*. The latter will, of course, vary as a function of road width as well as the individual's movement characteristics. In order to anticipate the time needed to cross, pedestrians thus need knowledge of their own *movement capabilities* and must be able to calibrate such knowledge to visual information specifying road width. As adults, we are not normally aware of this calibration unless it changes, as when one temporarily becomes lame. In the elderly, the calibration may gradually change as movement becomes more restricted. Children must learn to calibrate from scratch. In addition, they must keep the calibration in tune as they grow.

1.5 The development of pedestrian-related skills in children

It can be seen, then, that crossing even a simple road requires competence in a range of primary perceptuo-motor and cognitive skills. If these are not properly developed, the pedestrian's crossing decisions will almost certainly be inadequate. It is therefore vital to know how these skills develop in childhood and what level of skill can be expected in children of different ages. Only when baselines have been established in this way would we be in a position to consider the implications for education or training. We turn to this question in the present section.

1.51 Looking behaviour

Notwithstanding the considerable importance attributed to this in road safety education, the evidence suggests that children frequently step into the street without looking for traffic. In a recent major study involving over 10,000 observations throughout the highly populated Central Belt of Scotland, for instance, more than 50% of children in the age range 4-14 were estimated not to have looked for traffic before stepping into the road (Scottish Development Department, 1989). Moreover, this represents an average figure: younger children were even less likely to look. Similarly, Valavuo (1976) when observing children at a fairly busy road found that only a third of 7 and 8 year-olds made head movements in both directions before crossing (although this figure increased if traffic was actually approaching). In a long and detailed review of the literature, van der Molen (1981b) found that the estimated proportion of children failing to look varied somewhat from one study to another but was nearly always substantial, with identifiable age trends.

A similar pattern of findings has been reported in studies of accident victims. For example, Grayson (1975a) estimated that 39% of the child victims he interviewed had not looked at all before crossing, a figure also supported by the Scottish study whose researchers estimated that 25% of the victims they interviewed had 'almost certainly' failed to look either way before crossing and a further 12% had 'most likely' failed to do so. Other studies have reported evidence of partial looking - for example, in only one direction. A common error at junctions is that children fail to look for traffic approaching from behind them. They seem to be preoccupied with looking to right and left and fail to realise the importance of checking for vehicles approaching from the rear (e.g., van der Molen, 1983). This error occurs even though looking "all round" is the instruction taught by the Green Cross Code. The failure is no doubt a partial contributor to the high accident rates associated with crossing at junctions in children.

It might be felt that the way to deal with this is simply to tell children to look more. As we have seen, however, the problem is not so simple. The problem is that young children need a much clearer idea of what they are supposed to look *for*. It is not just a question of ensuring they point their heads in the right direction: it is a question of being attuned to the information required to make appropriate judgements. What this information is, seems far from self-evident to young children and one often has the feeling that they do not really understand what they are meant to be doing when told to 'look'. Sometimes they seem to be merely going through a kind of ritual that involves turning their heads from side to side. We have seen children doing this quite faithfully but at such speed as to have no hope of registering anything.

Such behaviour illustrates a common tendency of children to apply rules they have been taught in a rather blind and rigid manner without proper comprehension of the purpose underlying the rule. Such rigidity is a problem not just in road safety education, but in all education. It is especially serious, however, where education programmes favour a rule-based approach and where children learn the rules out with the context to which the rules apply. We return to this problem in Chapters 2 and 3. In any event, it seems clear that just telling a child to 'look' before crossing may have relatively little meaning for small children. Their behaviour needs to be far more closely directed than this.

1.52 Selective attention and visual search

One likely reason why children do not detect traffic even after 'looking' in the right direction is that their attention and visual search strategies are inadequate. The ability to scan the visual field in a systematic way and to attend selectively to relevant features are obviously crucial in pedestrian (as in other) behaviour. Unfortunately, such processes are not easy to measure since they do not correspond to overt behaviours. Pedestrian researchers have therefore tended to restrict themselves to rather inadequate indices, such as whether or not the child moved his head. However, several interesting findings allow us to speculate a little further on the likely state of these internal processes when children are engaged in 'looking'. In addition, there is an extensive theoretical literature on the development of attention and visual search that we examine in this section.

A surprising finding reported in several studies is that accidents quite often happen to victims who did, in fact, look before crossing but somehow failed to 'see' the approaching vehicle. For example, in his study of child victims, Grayson (1975a) estimated that 31% of them had 'looked but not seen' the striking vehicle. A similar conclusion has also been drawn with regard to accidents involving the elderly as many as 70% of whom, for one reason or another, appear not to have seen the striking vehicle (TRRL, 1972). These failures cannot easily be put down to what the man in the street would call 'eyesight' problems: that is, to acuity or other visual defects. A more likely reason is that their visual search was inadequate. In fact, even ordinary adults make errors of this type from time to time. Most people have had the experience of looking out for cars before crossing the road only to find themselves stepping out under the wheels of a bicycle! Somehow, the fact of being primed for cars can make us blind to other vehicles, including ones that are perfectly 'visible'. Such errors, probably attentional in origin, are known as 'cognitive failures' (Reason, 1990) and seem to be uncomfortably common. Certainly, most people have little difficulty in finding examples in their own experience. In children who have not yet developed the skills, such errors can be expected to be much less the exception than the rule.

Laboratory studies of children's attention and visual search are certainly consistent with this view. Studies of children's eye movements as they visually explore objects or scenes show that these are inefficient and

unstructured by comparison to adults or older children. Similarly, when asked to scan pictures or text for particular cues, they take much longer than adults to find them and make more mistakes. For example, in a key study Vurpillot (1968) examined the visual fixations of children between 3 and 9 years while engaged in a complex discrimination task. A systematic scanning pattern did not appear until around the age of 5, becoming more widely deployed in children over the age of 6 years. Younger children carried out only partial search and their discriminations were thus made on the basis of limited information. Similarly, Zinchenko, Van Chizti-tsi and Tarakanov (1965) reported age-related differences when children between 3 and 6 years of age were asked to inspect an irregular shape which they were told they would later have to identify. The eye movements of a second group of children were photographed during the later recognition phase. In the inspection phase, younger children tended to fixate on the centre of the figure whereas older children looked almost exclusively along the contours (i.e. at the most informative parts of the figure). Interestingly, the younger children looked at the contours more during the recognition phase although, in the absence of such movements during inspection, much of the critical information would presumably have been missed.

Such findings are consistent with the theory of perceptual learning proposed by Gibson (1969), according to which "...what is learned can be described as the detection of properties, patterns and distinctive features" (1969, pg. 77). According to Gibsonian theory, perceptual learning is a process by which the child becomes increasingly tuned to optical information specifying properties of the environment and thus becomes increasingly capable of differentiating between similar stimuli (Gibson, 1966). For example, Gibson and Gibson (1955) asked children aged between 6 and 11 and adults to identify a standard four-coil scribble in a pack of cards containing both the target scribble and a range of variants. Younger children made more errors, especially as the number of distinctive features shared by the target scribble and its comparison increased.

The notion that as children grow older they become increasingly sensitive to the distinctive features of stimuli and less dominated by the global attributes is supported by a programme of research by Nodine and his colleagues. For example, Nodine and Steurle (1973) measured the eye movements of kindergarten, first and third graders (presumably between the ages of 4 and 7 years) when looking at enlarged letters. They found that as age increased there was an increasing focus on distinctive features and on the number of such features examined. These findings point to a more strategic pattern of search in older children, with attention being increasingly focussed on features that are task-relevant and less on those that are merely interesting or attractive.

This shift from unsystematic to actively organised search is a central feature of development and has been well documented in numerous studies as diverse as haptic exploration (e.g., Abravanel, 1968; Klein, 1963; Piaget and Inhelder, 1956), selective listening (e.g., Doyle, 1973; Maccoby and Konrad, 1966), and selecting cues from a perceptual array (e.g., Pick and Frankel, 1973; Smith, Kemler and Aronfreed, 1975). According to Wright and Vliestra (1975), young children *explore* the environment in a spontaneous and playful manner, with their attention driven by the salience of surrounding stimuli rather than by logical features of the task at hand. As they mature, there is a shift towards increasingly organised and active *search* in which attention becomes more intentional and goal directed and therefore more governed by information relating to the demands of the task. The child thus concentrates more on relevant features, filtering out those that are irrelevant. This shift starts to take place relatively early and is quite apparent by the time children have reached six years of age. However, there is a transitional period between the ages of 6 and 9 when salient features continue to capture the child's attention. When these are distracting or irrelevant they can be a major source of interference to the child, forcing them back into the earlier, exploratory search mode (e.g., DeMarie-Dreblow and Miller, 1988; Miller, Haynes, DeMarie-Dreblow and Woody-Ramsey, 1986). Wright and Vliestra go on to suggest that these differences in the nature of information-processing are what underlie the concept of *impulsiveness* and that the distinction sometimes proposed between impulsive and reflective children (e.g., Messer, 1976) mirrors corresponding differences in cognitive style.

Which stimuli children find most salient and whether this remains consistent across a particular age group is not entirely clear. Some writers have suggested that *colour* is a dominating perceptual dimension amongst 3-4 year-olds, who focus on it in preference to other stimulus attributes, whereas around the age of 5 a preference emerges for *form* (Corah, 1964; Suchman and Trabasso, 1966a,b). This developmental shift may

be formally related to the shift from exploration to search since colour presents itself in dense, global blocks whereas form involves attending to contours and edges. Corresponding findings have been found in the haptic mode where younger children focus on information about texture at the expense of information about *shape* (e.g., Gliner, Pick, Pick and Hales, 1969). Similar preferences have been found in studies of spatial orientation. For example, 5 year-olds tend to code the position of objects in terms of their location relative to external *landmarks*. Older children and adults, on the other hand, often use an *action-based* framework for defining spatial positions: for example, an object's position in space might be defined by the number of paces needed to reach it, or the *time* that would be required to do so (e.g., Thomson, 1980,1983; Tagg, 1990; Thomson and Tagg, 1992). This developing focus on perception-action relationships has implications for the sorts of information that children of different ages can be expected to centre on at the roadside and for the kinds of judgements they will spontaneously make. The development of these perception-action relationships certainly merits further study.

Consistent with the view that children focus on some attributes at the expense of others, we have found that when asked to memorise the location of targets in a room, 5 and 7 year-olds often become preoccupied by the nature of the targets themselves and seem to have difficulty in ignoring these attributes in favour of the spatial ones (Tagg, 1990). This effect was sufficiently marked that Tagg found it necessary to replace the original targets (brightly coloured images of animals) with plain, mundane ones. Only in this way could she focus the children's attention on the relevant spatial variables and divert their attention away from the highly salient but irrelevant target attributes. Similarly, in observing the strategies used in learning a route through their neighbourhood, Allen, Kirasovic, Siegel and Herman (1979) found that older children and adults make effective use of landmarks, especially in 'marking' critical points on the route such as corners where a change of direction is necessary. Younger children also remembered landmarks but, unlike older subjects, these were seldom of much use in coding the route. Instead, the landmarks that young children remembered were all high impact ones like colourful window boxes or a cat sitting by a bright door. Thus, young children remember stimuli in an incidental way, based on their intrinsic attractiveness, rather than focussing strategically on stimuli that are functional as landmarks and help in memorising the route. It seems likely that children will be attracted by many different kinds of stimuli that they encounter in the natural environment and these will remain an important source of distraction until such time as the child's attention becomes directed more by the logic of the task rather than by the salience of incidental cues.

Finally, once children have started to develop systematic attentional strategies, it appears that the effort required to direct their attention in this way may be so great for the transitional child that it interferes with other aspects of the task. For example, DeMarie-Dreblow and Miller (1988) employed a task in which children had to remember relevant versus irrelevant items hidden behind doors. When children were required to open the doors, recall was better amongst 9 year-olds than 7 year-olds. However, when an experimenter opened the doors on the child's behalf, this difference disappeared. The interpretation is that the effort of implementing a systematic strategy of door opening placed such a demand on the younger children that it interfered with the recall aspect of the task. Thus, although capable of producing a reasonably organised search strategy, the children were unable to capitalise on this when an additional task was introduced (Guttentag, 1984; Bjorklund and Harnishfeger, 1987).

The importance of visual search and attentional control in pedestrian behaviour is obvious and, given the developmental trends, would seem to be an area deserving of far more investigation than it has received up to now. There is also no doubt that distractibility is one of the most important features of child behaviour and seems to be associated with a large proportion of accidents. For example, one of the commonest accidents occurs when a child dashes out into the street, often in the vicinity of parked cars or other obstructions. Van der Linden and Goos (1975) estimate that 70% of child accidents in Holland are of this type. Such behaviour does not seem to happen purely at random. Dashouts often seem to occur when the child becomes distracted by something, often of a social or emotional nature, such as the appearance of a friend on the other side of the street or the arrival of an ice-cream van. Sandels (1974) estimates that factors of this kind are involved in up to 50% of the accidents to children under the age of ten. These observations are certainly consistent with the view that distractibility and impulsiveness may be associated with young children's susceptibility to interference from salient but irrelevant cues. If correct, this would suggest that impulsiveness may not be a completely fixed and inevitable feature of the young child's personality (as is often assumed) but may instead reflect undeveloped visual search strategies and immature attentional

control. This raises the possibility that such skills might be amenable to training. We return to this in Chapter 2.

1.53 Visual timing

Clearly, this is one of the most important of all road crossing skills. Every pedestrian must learn to estimate accurately the time that will elapse before an approaching vehicle arrives at their intended crossing point. They must also learn to relate the time that is *available* for crossing to the time that is *required* to do so. The latter will vary according to the pedestrian's walking speed and other aspects of their locomotion, and to the width of the road. Such timing skills are of less importance on quiet roads where a pedestrian might simply wait for the road to clear before crossing. On busier roads, however, this is often not feasible. To cope successfully with modern traffic, it is essential that pedestrians learn to identify gaps in the traffic flow that are safe to pass through and differentiate them from those that are not. Observational studies of pedestrians in traffic suggest that such skills are well developed in adults and even young teenagers (e.g., Routledge, Howarth and Repetto-Wright, 1976; van der Molen, 1981; McLaren, 1993). In children, on the other hand, they are not (Routledge et al., 1976; Lee, Young and McLaughlin, 1984).

It is normally assumed that such judgements depend on distance and velocity perception together with the ability to integrate these variables with respect to time. The accuracy of both distance and velocity perception appears to vary as a function of age (Zeigler and Leibowitz, 1957; Salvatore, 1974) and when asked to use these skills to make judgements about the safety of gaps in traffic, children make many errors compared to adults (Hoffman, Payne and Prescott, 1980; Lee *et al*., 1984; van Schagen, 1988). Not until about 11 years of age does the accuracy of such judgements approach that seen in adults. Moreover, many authors have stressed the difficulty that younger children have in integrating such information to make temporal or duration judgements. For example, where distance and velocity have to be integrated, children tend to focus on one variable at the expense of the other and the resulting judgement is thus erroneous (Piaget, 1969). This effect has been found in many of the classic Piagetian reasoning tasks and is usually explained in terms of the characteristics of pre-operational thinking as expressed in Piaget's general theory of development (e.g., Piaget, 1955a). These characteristics are further discussed in Chapter 3. The effect has frequently been assumed to depend on maturational factors over which education can have little or no control, with competence appearing around 9 years of age. This has often been thought to pose a barrier to the kinds of judgement that can be expected in younger children and to limit what road safety should attempt to teach at this age (Sandels, 1975; Vinje, 1981).

However, whilst recognising that younger children are indeed limited in their timing judgements, numerous writers have found evidence of more sophisticated reasoning in pre-operational children when the problems have been set up in other ways (e.g., Berndt and Wood,1974; Levin, 1979; Wilkening, 1981; Ross, 1993). For example, Berndt and Wood (1974) and Levin (1979) attribute at least part of the difficulty to attentional problems caused by the fact that children find some cues more salient than others. This, of course, has already been discussed in the previous section. It must also be borne in mind that the studies discussed in the present section are all concerned with the child's *conception* of the relationship between variables such as distance, velocity and time. However, there is no simple relation between the child's conception of time and duration and the perceptuo-motor judgements they make in the world. For example, it is by no means obvious that the ability to catch a ball depends on the catcher's ability to explain the relationship between distance and velocity or, for that matter, any other variables. Indeed, extremely fine visuo-motor timing is typical of the behaviour of most species - including relatively primitive ones such as flies, spiders and honey bees - none of whom will ever attain the stage of concrete operational thinking. No species other than humans do this, yet this does not stop them making the most delicate timing judgements hundreds of times a day. Not surprisingly, children also demonstrate fine examples of such timing long before concrete operational thought has developed, and in activities such as gymnastics, dance or music they occasionally reach standards higher than can be achieved by most adults. It is thus almost certainly a serious error to assume that basic perceptuo-motor judgements depend on higher conceptual development, a point of view forcefully put by a number of influential theorists (e.g., Gibson, 1979; Michaels and Carrello, 1981; Gibson, 1988; Demetre, Lee, Pitcairn, Grieve, Thomson and Ampofo-Boateng, 1992). This does not mean to say that age differences with regard to such skills do not exist. However, it is not consistent with the view that

children are biologically incapable of learning them until concrete operational thought has appeared. This means that younger children may be able to learn such skills, given appropriate training.

This point of view is strongly supported by recent evidence that time-to-contact information is, in any case, directly specified in the optic array at the eye and does not have to be deduced from lower-order variables like distance and velocity in the first place. In a series of important papers, Lee and his colleagues have shown that time-to-contact is specified by the inverse of the rate of dilation of an approaching object's projection on the retina and that this information is independent of information about distance or velocity: that is, time-to-contact is specified directly (see Lee, 1976, 1980 and Lee, Young, Reddish, Lough and Clayton, 1983 for the theory on optical timing). Sensitivity to this variable has been demonstrated empirically in studies where distance information has been eliminated but where accurate timing judgements were nevertheless made (e.g., Schiff and Detwiler, 1979; Todd, 1981). The discovery has had a profound effect on visual science and an extensive literature has now confirmed the importance of this optical variable (known as t) in controlling timing judgements. Examples of real-world activities in which t has been shown to play a decisive role include running, ski jumping, long jumping, and hitting and catching in a variety of skilled tasks such as table tennis, cricket and baseball (see Valenti and Pittenger (1993) for a range of articles on this theme). It also seems to control timing behaviour in many other species, including birds (e.g., Lee and Reddish, 1981) and insects (e.g. Wagner, 1982). In humans, timing judgements improve over a long period of time, finally flattening out in the early teenage years (Williams, 1983). However, they are seen in remarkably mature form as early as a few weeks from birth (von Hofsten, 1982, 1983). Students of motor behaviour normally attribute the improvements that are seen as the child grows older to improved *deployment* of timing information - that is, to better perceptuo-motor coordination - rather than to improvements in visual judgement per se (e.g., Gabbard, 1992). Again, this suggests that such abilities may be amenable to training, given appropriate methods. We examine studies which have attempted to do this in Chapter 2.

1.54 Perception of dangerous locations

Perhaps an even more critical ability than the one discussed in the previous section is the ability to identify locations or situations on the road that are intrinsically dangerous and where crossing should not be attempted (or where a special strategy is needed). The Green Cross Code, or even the much more sophisticated timing skills described above, are of little value if the child considers it safe to put them into practice on the brow of a hill, for instance. Other features that are intrinsically dangerous include parked cars; locations where the road is obscured by hedges, bushes, or other street 'furniture'; sharp bends; and a variety of junctions and intersections. The features that such sites have in common is either that they obscure the child's view of traffic (and drivers' view of them); or they involve complex traffic movements which tax the child's visual search and information-processing capacities. Moreover, such sites seem to be over-represented in child accident statistics, suggesting that there may indeed be a causal link (ONSER, 1982; Ampofo-Boateng, 1987; Assailly, 1992).

Whether appropriate action is taken when confronted with such situations will obviously depend on whether or not the pedestrian recognises the intrinsic threat posed by them in the first place. However, current countermeasures do not take this problem seriously, scarcely recognising it as a problem at all. In fact, the Green Cross Code simply instructs children to "first find a safe place", which assumes that they know how to do so. Moreover, as previously noted, when questioned about priorities in safety education, parents, teachers, road safety experts and the police all relegated finding a safe site to a secondary level of importance (Foot *et al*., 1982). But can children, in fact, find safe places to cross the road? Do they even recognise dangerous sites when they see them? If not, the crossing skills that are the main focus of attention in most current road safety education will be largely undermined.

It turns out that young children show very little ability to recognise what is dangerous about such sites and will readily choose to cross there if given the opportunity to do so. In a series of experiments designed to examine children's reasoning in such situations, Ampofo-Boateng and Thomson (1991) found that children under 9 years of age tend to focus on a single factor in making such judgements. If the children can see a car anywhere in the vicinity, they judge the site to be dangerous. On the other hand if no cars can be seen, they judge the location to be safe. Thus, locations that completely obscure the child's view of the road are

frequently regarded as safe. Younger children completely fail to realise that such sites are dangerous precisely *because* no cars can be seen. Only from about 9 years of age do children begin to appreciate that the brow of a hill or an obscured bend with overhanging trees and bushes is a dangerous place to cross the road.

Our impression in these studies was that the children were relying on a rule they had been taught, namely 'don't cross if you can see any cars coming'. If none was visible, they simply assumed that none was present. This would seem to be another example of the inflexible way in which young children tend to behave following rule-based approaches to teaching. Only older children spotted the danger of such situations and suggested solutions such as moving to a clearer position nearby. These findings suggest that young children under the age of 9 years must often be at considerable risk on the road. They certainly should be taught how to make such judgements, and at an early stage given how basic they are in pedestrian behaviour. We review attempts that have been made to do this in the next chapter.

1.55 Information processing

Information processing is, of course, implicit in most of the judgements that have already been discussed in earlier sections. However, several further aspects of information processing should be briefly discussed at this stage. These concern central processing capacity and divided attention; short term memory; and speed of information processing.

The problem of attention has already been discussed in considerable detail but further comment is merited in relation to the problem of divided attention. This term refers to the ability to perform two tasks at the same time, such as driving and talking; or listening to music whilst writing an essay. Many studies have examined our ability to perform tasks simultaneously and have investigated how performance changes with experience (see Keogh and Sugden, 1985 for a review). Since attention and central processing capacity are limited, the process is essentially one of learning how to allocate limited resources to the different tasks as efficiently as possible so that both can be performed to some criterion of adequacy. Very often, subjects spontaneously define one task as primary and the other secondary and distribute their resources accordingly. In the early stages of learning, however, dividing attention in this way is extremely difficult and subjects often find it hard to keep both tasks going. They also suffer interference between the tasks and make many errors. A good everyday example of these difficulties that most people have experienced is the early stages of learning to drive.

Developmental studies show clear age trends with regard to the ability to divide attention, with older children performing better than younger ones on a range of dual tasks (e.g., Guttentag, 1984; Wickens and Bendel, 1982). The improvement with age does not seem to result from structural changes in the underlying capacities, however. Rather, the child - like the inexperienced adult - learns to use his limited resources more efficiently. With experience, the skills become increasingly automated and thus less of a burden is placed on central processing. Subjects also develop strategies which allow them to distribute their attention more effectively during execution of the tasks. The same point is generally agreed in relation to memory and information processing capacities. Whilst short-term memory does appear to increase between 3 and 7 years of age, this seems to reflect the relatively inefficient way in which younger children encode information rather than the absolute size of the store (Gabbard, 1992). Similarly, speed of information processing as measured by reaction time improves markedly with age. For example, Surwillo (1977) estimates that a 5 year-old takes as much as five times as long to process one 'bit' of information as a 17 year-old, with most improvement taking place between the ages of 6 and 12 years. Again this implies that, as children grow older, they become more efficient at picking up relevant information, making decisions on the basis of it, and organising appropriate behavioural responses. Since the major limiting factors again appear to be strategic rather than structural, this suggests that appropriate training might reasonably be expected to have a facilitative effect on the development of such functions.

1.6 Can road skills be trained?

In this chapter we have argued that pedestrians require competence in a range of basic psychological skills and must learn how to deploy these strategically at the roadside. Developmental trends exist with respect to almost all these functions, with children generally approaching adult levels of performance around 11-12

years of age (though development may continue up until the early twenties in some cases). The critical question is, can we promote development of these skills in younger children through appropriate educational intervention? And can children learn to deploy the skills which they do possess in a strategic way, if they are given appropriate experience?

1.7 Characteristics of the pre-operational child

The answer that road safety has generally given to these questions is no. At best, it has been argued that children are severely constrained in what they can learn until an appropriate stage of psychological development has been reached. This point of view is particularly associated with the work of Sandels (1975), whose extensive and influential pioneering work on child pedestrian behaviour in Sweden led her to the conclusion that "... it is not possible to adapt fully young children (under 10 years) to the traffic environment. They are biologically incapable of managing its many demands" (Sandels,1975). So strongly did Sandels feel about the issue that she suggested efforts should be directed primarily at separating children from traffic altogether. Children's biological limitations were also stressed by Vinje (1981), though she expressed considerably more optimism about what could be achieved through education and training. Nonetheless, the emphasis was on adapting strategies to the limited skills that could be expected in young children. There was no consideration that the underlying skills might themselves be amenable to training.

This outlook stems directly from a common interpretation of the Piagetian theory of development (e.g., Piaget, 1955a). In this powerful and influential theory, Piaget stressed that development proceeds by way of four main stages. The second or 'pre-operational' stage, occurring between the ages of 2 and 7 years, is of particular relevance to road safety education. In this stage, Piaget claimed that the child's thinking is at first very concrete, bound to the immediate present, and strongly centred on single aspects of experience in a rather rigid way. As a result, children have difficulty with tasks where the integration of two or more variables is required. In these cases, the pre-operational child typically fixates on one aspect of immediate experience at the expense of others. Examples of this mode of thought can be seen in Piaget's classic 'conservation task' experiments. For instance, water might be poured from a tall, thin container into a short, fat one and the children asked if there is more, less or the same amount of water as before. Older children realise that volume is a function of both the height and the width of the containers and correctly reply that the amount of water is conserved. Younger children, on the other hand, fixate on one variable and ignore its relation to the other. As a result, they incorrectly argue that the amount of liquid changes when it is poured from one vessel into the other. The same finding can be seen in many other tasks where it is necessary to combine variables in this way. An example that is particularly relevant in the present context is the judgement of which of two trains travelling at different speeds and over different distances will arrive at a certain point first (Piaget, 1969). According to Piaget, children are unable to differentiate time and space until the age of 8-9 years and so make many errors on such tasks. As in the previous example, they tend to fixate on a single cue when making such judgements and thus make incorrect time-to-arrival judgements. The implication for road crossing is obvious. This basic effect, known as *centration*, is linked to a closely-related effect known as *egocentricity*, in which children find difficulty in adopting the perspective of another person, both literally and metaphorically. As in the conservation tasks, pre-operational children tend to fixate on their own point of view, typically attributing to other observers the same view of an object or scene as they themselves enjoy. This has been invoked to suggest that children may think that drivers can see them whenever they can see the driver. If correct, such findings would have important implications for road safety education and for what kinds of judgements could be expected of children under the age of 8 - 9 years. Moreover, since Piagetian theory is often considered (erroneously) to be fundamentally maturational in character, it has frequently been assumed that development depends largely on the passage of time. This would mean that little, if any, acceleration could be expected as a result of education or training and all we can do is protect children "until childhood has been matured out of them" (Sandels, 1975). In general, this is held to occur around 9 years of age (Sandels, 1975; Vinje, 1981).

We take up this problem in detail in Chapter 3, but it is worthwhile to briefly consider the merits of the position at this stage. As we shall see, developmentalists are now considerably less convinced about the inflexibility of the Piagetian stages than some earlier writers appear to have been. Indeed, a large amount of research over the past 10 to 15 years has comprehensively demonstrated that children can frequently learn to solve problems ahead of the supposedly 'correct' developmental stage - and sometimes far in advance of it.

Whether or not this happens depends on numerous factors associated with the language and methodology used and the precise way in which the task is set up (see, for example, Donaldson, 1978). The situation thus seems far from as inflexible as has often been assumed.

In addition, there has recently been an upsurge of interest in empirical investigations aimed at accelerating such development, including studies conducted in the context of road safety. For example, roadside training programmes aimed at improving visual timing skills have been undertaken with children as young as 5 years of age with extremely encouraging results (e.g., Lee *et al*., 1984; Young and Lee, 1987; Van Schagen, 1988; Demetre *et al*., 1992; Demetre, Lee, Grieve, Pitcairn, Ampofo-Boateng and Thomson, 1993). Similarly, the effectiveness of training in improving the ability of 5 year-olds to find safe places to cross the road has been demonstrated in recent studies by Thomson, Ampofo-Boateng, Pitcairn, Grieve, Lee and Demetre (1992); Thomson (1993); Tucker (1993); and Ampofo-Boateng, Thomson, Grieve, Pitcairn, Lee and Demetre (1993). Even studies aimed at reducing children's vulnerability to distraction and impulsive behaviour have been undertaken with encouraging results (Limbourg and Gerber, 1978). We review these studies in detail in the next chapter. However, enough has been said to suggest that the broad sweep of psychological research is inconsistent with the simplistic view that development is constrained to follow a fixed path and is not amenable to intervention through educational means.

1.8 Conclusions

In this chapter we have argued that children need a range of fundamental psychological *skills* in order to interact with traffic, together with the ability to deploy these *strategically* in different traffic situations. We have argued that viable objectives in road safety education would be to define operationally such skills and strategies and devise appropriate training procedures whereby they might be improved. If successful, such training would yield direct and measurable changes in children's actual behaviour in traffic, not merely changes in what they can say about traffic when questioned by adults. Whilst a long-established tradition in road safety asserts that many of these skills cannot be improved through education until a particular stage of development has been reached, we challenge that view and argue that it is inconsistent with modern research in psychology or, indeed, with the majority view among developmental psychologists. In addition, recent studies that have attempted to improve children's performance on a range of clearly-defined pedestrian skills have produced empirical evidence that such skills can be accelerated, providing appropriate training is given. We now go on to examine these issues in some detail. In Chapter 2 we examine the aims and methods of current educational provision, commenting on the effectiveness of the different approaches that have been attempted. In Chapter 3 we analyse theories of child development, searching for a sound base from which educational approaches might emerge, and attempting to account for the relative effectiveness or otherwise of the different approaches reviewed in Chapter 2. Finally, in Chapter 4 we examine approaches that we believe have particular merit in the effort to devise effective training programmes and should help children develop traffic skills and strategies in a progressive and theoretically meaningful way.

Chapter 2
Current methods in road safety education

In the last chapter, we outlined a range of skills that are required to interact safely with traffic. We also stressed that pedestrians must learn to deploy these skills efficiently at the roadside. In this chapter, we examine the extent to which such skills are in fact taken into account by current road safety education. We also assess what the content of current programmes typically is. In addition, we review the *methods* by which road safety education is taught. It is important that these issues should not be confused. If a programme fails, it may be that the content of the programme was inappropriate to bring about the desired changes in the child. However, it might also be that the method selected for doing so was inappropriate. It is thus extremely important to distinguish these factors as far as possible in assessing the effectiveness of any road safety technique.

2.1 Road safety education - current provision

In combating road accidents most countries have some kind of national scheme, often one that is integrated into the school curriculum. Additional programmes might also be introduced at a more local level as the authorities in different regions attempt to improve on the available materials or deal with problems that particularly affect pedestrians in their own area. Such schemes vary quite widely with respect to the methods they employ but are much more unified when it comes to programme content. In the vast majority of cases, the aim is to provide children with broadly conceptual knowledge about the traffic environment and instil suitable attitudes towards safety. The rationale behind this approach is seldom, if ever, explicitly stated. However the assumption seems to be that if children first develop a general conceptual and attitudinal framework, then they will be better able to generalise to the diversity of real traffic situations than they would if training were to focus on more specific situations. The approach is thus a 'top-down' one, in which learning is assumed to proceed from the general to the specific. In fact, this view contradicts virtually every theory of learning and development, all of which agree that learning typically progresses in the converse direction: that is, from specific, concrete situations to the gradual elaboration of abstract conceptual knowledge. We discuss this issue in detail in Chapter 3. However, it is worth noting at the outset that there are likely to be problems with any approach that starts from such erroneous assumptions.

In addition to the acquisition of knowledge and appropriate attitudes to safety, a central aim of road safety education in the UK is to teach the Green Cross Code. The Code was introduced in 1971 and was conceived as a simple, general-purpose strategy that children could learn without too much difficulty and that would be applicable to a wide variety of road crossing situations. In fact, it quickly became apparent that the Code was rather too difficult for younger children to learn, and so a simpler version (Stop, Look, Listen, Think) was introduced for use with the under 7s. The Green Cross Code has long held a pre-eminent position in British road safety education and, in fact, much road safety material takes the teaching of the Code as its primary goal.

In spite of their manifest importance in pedestrian behaviour, no effort has been made in the UK to teach any of the skills that were discussed in Chapter 1. Indeed, there seems to be little recognition of the sophistication of the skills that are needed to interact with traffic (Ampofo-Boateng and Thomson, 1990; Thomson, 1991). Nor is any serious attempt made to increase the child's strategic competence as their experience and exposure to traffic changes, though this has long been advocated (e.g., Sheppard, 1975; Vinje, 1981). Instead, the Green Cross Code is typically regarded, even by experienced pedestrians, as a sort of universal 'golden rule' that is assumed to apply to most, if not all, road crossing situations. It is seldom recognised that the Code is an elementary strategy that becomes unsuitable when more complex traffic situations are encountered. As a result, even adults tend assume that the Code is the 'right' way to cross - in spite of the fact that adults invariably develop quite different strategies for interacting with traffic and seldom behave in accordance with the precepts of the Green Cross Code (Thomson, 1991).

Numerous methods of teaching this material have been attempted but, in practice, the vast bulk of road safety education takes place in the classroom. The material is almost exclusively verbal: that is, children learn by being told what to do rather than by actually doing anything. The approach is thus almost entirely

centred on the acquisition of knowledge and the development of appropriate attitudes rather than tackling behaviour directly. Despite an OECD review (OECD, 1978) recommending the development of practical training methods, there is relatively little practical training in the UK at the present time. Similarly, little attempt is made to provide children with guided roadside experience, although recent efforts have been made to establish a national traffic club in which children would receive roadside training from their parents (e.g., Downing, 1981; Bryan-Brown, 1993; West, Sammons and West, 1993).

2.2 Techniques of road safety education

One useful way of classifying techniques for ease of assessment is according to how closely they simulate real traffic experiences (Rothengatter, 1981a). After all, we might well imagine that the closer the education process can stick to the real thing the better. Techniques, in fact, vary from those that take place in the natural traffic environment; to semi-natural simulations, for example in blocked off streets with no traffic; to traffic parks or gardens where a lesser degree of realism is maintained; to much more abstract mock-ups in the school gym or playground. Finally, teaching might take place in the classroom, in which case there would be no element of realism at all (although slides, films or other devices can be rather effective in illustrating traffic situations).

In fact, most traffic education in this country takes place in the classroom through verbal means and training by any of the former methods would be unusual. At best, children might receive some simple instruction in the playground (for example, they might go through the motions of the Green Cross Code with lines on the ground serving to mark the kerb and road; or a simple pedestrian crossing might be simulated). More elaborate set-ups are few and far between (although they have been common enough in other areas of traffic education, such as cycle training). Evaluating the potential of classroom teaching is therefore of some importance.

2.21 Classroom techniques

Making general statements about the effectiveness of classroom teaching is complicated by the variety of activities that can constitute classroom teaching. However, there is general agreement that, in spite of widespread use, classroom instruction by purely verbal means is a poor way to teach road safety and is certainly inferior to most other methods. At best, such teaching may improve children's knowledge about road safety. Unfortunately, such knowledge does not seem to generalise to behaviour in the traffic environment. Numerous studies have reported a failure of transfer from knowledge to behaviour in this way and few have provided evidence of success (see Rothengatter (1981) and Ampofo-Boateng and Thomson (1990) for reviews). Indeed, children whose performance in traffic is very poor have sometimes been shown to exhibit rather good knowledge about road safety (Ryhammer and Berglund, 1980). This lack of correspondence between knowledge and behaviour is the single most serious criticism of classroom teaching as a whole. Even worse, the results of such instruction can actually have negative effects, because the increased knowledge that children exhibit when asked questions about road safety can create the false impression that their ability to face the road environment is improving. If this is not the case, then a dangerously misleading attribution may be made that the child's competence has increased when, in fact, it has not. This point illustrates the crucial importance of validating knowledge acquisition against behavioural change and illustrates very clearly the validity problem discussed in Chapter 1. Unhappily, there appears to be a widespread assumption that improved knowledge will - almost self-evidently - result in better performance on the road. There appear to be no grounds for this assumption. At the very least, verbal methods need to be supplemented by other material in order to have a hope of success (e.g., Rothengatter, 1987). This effectively undermines much of the everyday road safety education that children receive.

Verbal methods, then, are only likely to work where they focus firmly on the behaviour that the child needs to adopt. Even here, there is likely to be considerable difficulty for two reasons. Firstly, the language and concepts used may be beyond the understanding of young children, even if they seem perfectly straightforward to adults. For instance, in investigating the words and concepts contained in the materials used to teach road safety in Dutch schools, Groos (1977) and Meyer and Vinje (1978) found that such commonly- used words as "pedestrian" or "pavement" were frequently not understood by young children. Simple concepts often referred to in road safety such as "left and right" or "being careful" were also

frequently misunderstood. Such problems are commonly experienced by the designers of road safety packages. For example, in designing the Green Cross Code, considerable effort had to be made to produce a wording that would be comprehensible to young children (Sargent and Sheppard, 1974). Moreover, continuing concern has been expressed about the ability of younger children to understand even the final version. Sheppard (1975) found that nearly a third of the words in the Code were incorrectly read or not read at all by 20% of children tested in a follow-up study. So serious was the problem with younger children that a greatly simplified code (Stop, Look, Listen, Think) was produced for children under 7 years. Note that this does not necessarily reflect what young children are or are not capable of learning: it reflects what they can learn *by verbal means*. We examine below what they can learn when methods that are less dependent on verbal competence are employed.

More important than misunderstanding of individual words, verbal instructions are often far too general to transfer to children's behaviour. The example of "being careful" given above is a case in point: what behaviour exactly constitutes "being careful"? Another instruction frequently given to children is to look before crossing the road. But as we saw in Chapter 1, this is also vague: the child needs to know much more precisely what to look for and also needs a clear idea as to what they should do on the basis of what is seen. Thus a second major problem with verbal rules or procedures is that young children frequently have difficulty in determining from verbal instructions what appropriate behaviour would be. The effect is far more marked when instructions are given out of context. In Chapter 1, we gave examples of such inappropriate application of verbal rules to roadside judgements. Sometimes, children seem to be merely reciting the rules they have learned, almost as a talisman for warding off danger (Preston, 1980). These problems of context are well known amongst developmental psychologists and are known to be a problem when developing educational materials. Unfortunately, this evidence has so far had little impact in road safety.

These points raise fundamental questions about how effective any purely verbal educational method can be, particularly when used in settings where the language is not solidly secured to the objects or behaviour to which it refers. One can only speculate about the effectiveness or otherwise of the much more open-ended verbal instruction given by police officers or RSTOs (RSOs) during their visits to the classroom. Verbal instruction when used in isolation and without the very clearest understanding of the child's conceptual and language difficulties, then, would seem to be at best a hazardous technique, particularly with children whose familiarity with traffic is at the most elementary level. It would seem that verbal instruction needs to be supplemented by something considerably more concrete if road crossing skills are to be learned.

2.22 Books and other printed materials

By far the most widely used supplement to verbal instructional methods are books, posters and other printed matter. Although such materials are seldom evaluated at all (Gerber, Huber and Limbourg, 1977), such evidence as there is suggests that they are not particularly effective, at least on their own. Once again it appears that while such material may increase children's knowledge, this does not readily transfer to their behaviour (Schioldborg, 1976). In fact, most of the evaluation work that has been undertaken with these materials is *process* rather than *outcome* evaluation. The concern is thus with establishing that the material can be understood by the children, that they find it interesting, that it has face validity for the professionals involved, and so on -- rather than with whether the child's roadside behaviour changes as a result of using it.

Process evaluation is certainly important, as numerous studies show. For example, Colborne and Sheppard (1966) examined the extent to which children between the ages of 5 and 7 understood the message in a poster designed to discourage them from rushing into the street. It was found that the vast majority of 5 year-olds failed to grasp the message and only about half of 7 year-olds did. When the poster was broken up into a sequence of pictures, however, the message was much better understood by both age groups. Firth (1973), investigating posters made by the Tufty Club, examined the ability of children to understand what was implied when pictures of street layouts were shown from various viewpoints, such as oblique or 'bird's-eye' views. She found such pictures could indeed cause difficulty for young children. Problems have been found with a range of other pictorial devices, including the use of dotted lines to convey the path someone might take and other conventional symbolism. Too much inessential detail also causes difficulties. Thus, process evaluation is obviously important in the development of materials. Even more important, however, is

outcome evaluation designed to assess whether the children actually behave more safely as a result of what they have learned.

The results of such studies as have addressed this question have unfortunately provided little support for the effectiveness of printed materials. For example, a major source of printed materials in the UK has been the Tufty Club, which illustrates good road sense through the behaviour of an attractive squirrel character. Recently, Tufty has emerged in a new guise thought to be more appropriate for children in the 1990s. These materials serve the important function of bringing road safety to the attention of very young children and their parents. Whether they lead directly to improved road behaviour is questionable, however. Earlier versions of these materials were evaluated by Firth (1973) who did find improvement in road crossing knowledge when the books were read to children individually over a two-week period. However, this did not generalise to a behavioural test or to tests using a model set-up. In a later study, Antaki, Morris and Flude (1986) found that children trained with Tufty materials did not even exhibit superior road safety knowledge to peers who had not received such training when tested using video and picture cards.

In a frequently quoted study, Schioldborg (1974, 1976) conducted an extensive evaluation of the Norwegian Traffic Club, which operated by means of twice-yearly mailings of material to parents. The evaluation showed, amongst other things, a substantial difference in accident rates between the children of members and non-members amounting to 20% in the country as a whole and as much as 40% in the Oslo area. This study is often quoted as illustrating the benefits of traffic clubs and has been behind recent attempts to mount similar ones in this country (e.g., Downing, 1981). The difference in accident rates was matched by the results of tests of traffic knowledge which showed members to be clearly superior to non-members. However, when these groups were unobtrusively filmed in the streets near their schools and their behaviour later appraised, the results were much less convincing. Members did display slightly better behaviour on some of the criteria but on most there was no improvement at all. Moreover, the effect was only found when the children were alone: when accompanied by others, the member/non-member difference disappeared. This major mismatch between accident rates and the behaviour which the children actually displayed suggests that the decrease in accidents cannot be unequivocally attributed to improved road behaviour. Indeed, since membership was voluntary, it is quite possible that the parents who enrolled their children had more protective attitudes to begin with, thereby creating a bias in the results. Alternatively, it may be that parents became increasingly aware during the course of the programme of just how vulnerable their children were (something that is quite common when parents get involved in road safety education), causing them to adopt more protective attitudes as a result. In either case, the difference between members of the traffic club and non-members would reflect differences in *exposure to risk* rather than differences in the child's *behaviour* as a result of training.

Finally, a marked aspect of the Scandinavian traffic clubs was the effort they made to persuade parents to use *practical* training: indeed, the study is often quoted as illustrating the benefits of a practical approach. Consequently, it is not possible to consider the study as supporting the effectiveness of printed materials *per se*.

In summary, none of these findings give much reassurance that books, posters or other printed materials are very effective in improving children's readiness to face the roads. It seems undoubtedly true that their knowledge improves as a result of such material. Unfortunately, there is scant evidence that their behaviour out on the street changes to match.

2.23 Film techniques

Appealing extensions to printed materials are those that make use of film, video or slides because of their ability to illustrate material that is difficult to verbalise such as movement or behaviour sequences. It is also well known that such media can be successful both in securing and holding children's interest.

A number of packages involving this type of material have been constructed but, once again, few of these have been evaluated (Singh, 1982). Such studies as have been attempted (mainly on an experimental basis) reveal rather mixed results. In a well-known early study, Pease and Preston (1967) evaluated a road safety propaganda film "Mary Had a Little Lamb", aimed at teaching children how to use the kerb drill. Although the film was attractive and had a relatively clear-cut objective, when later tested in a simulated road-crossing

situation 5 and 6 year olds who had seen the film did not show superior ability to use the kerb drill relative to children who had not seen it. Moreover, the study raised a number of questions concerning children's ability to generalise from films that have implications for the use of visual media in general.

Other film approaches have been somewhat more successful. For example, McKelvey (1978) presented children with filmed shots of approaching traffic in an effort to teach them how to distinguish safe gaps where crossing could be attempted from unsafe ones that should not be accepted. McKelvey found that the youngest children (up to grade 3) showed improved ability to discriminate gaps after training, provided they received plenty of feedback during the training sessions. However, this improvement was not seen in older children. Moreover, whether such improvements would transfer to judgements at the roadside was not assessed.

Similarly, Colborne (1971) used slide presentations to teach crossing behaviour to 7 and 8 year-olds. The children were later tested in a traffic garden and some beneficial effects were found. On the other hand, Nummenmaa and Syvanen (1970) found that, whilst slide presentations increased traffic knowledge in 5-7 year-olds, they had no influence on their behaviour in the traffic environment, a finding later replicated for films (Nummenmaa and Syvanen, 1974). However, if the film was supplemented by practical training (the children received roadside training from their parents), there was a marked improvement in the behaviour exhibited in the traffic garden tests. The authors concluded that the practical training on real roads had been decisive. However, the role of the films *per se* was much more ambiguous.

2.24 Video techniques

Similar conclusions must apply to video productions if these are used as a simple alternative to films. However, video offers a flexibility not available to film in that 'local' productions can be made illustrating, for example, dangers in children's own locality. They may even incorporate the children themselves as subjects. It is possible that material targeted in this way may be more effective than general productions. Certainly, the use of video feedback has taken an important place in athletics and sports training. Few studies have systematically explored this approach in road safety, however.

Cyster (1980) reports that video sequences in which children saw themselves and their friends made a considerable impact on primary school children, as shown by their ability to vividly recount details of the recording two or three weeks later. However, one can hardly be sure that it was the road safety content of the production that made the lasting impact. No effort was made to determine memory for the specifically road safety features of the video. More encouragingly, Valavuo (1976) taught children using videos of their own road behaviour (they had earlier been unobtrusively filmed) and found some later behavioural improvement. This was not the case for controls who had received an equal amount of conventional instruction. This suggests that the feedback capabilities of video may well be worth exploring. Certainly, the recent use of video feedback by police to demonstrate to drivers their own earlier dangerous behaviour suggests that this can have a powerful impact. Of course, in such cases drivers probably find it in their best interests to perceive their previous behaviour as shocking. Nevertheless, it is not hard to see potential in this approach and further research in this direction certainly seems merited.

On the whole though, and despite many appealing aspects, it is difficult to disagree with Singh's (1982) conclusion that there is really no convincing evidence of substantial benefits following instruction with most of the film or video material that has been produced to date. Certainly, there is no evidence of changes in everyday road behaviour. However, we have stressed that any technique is only as good as its content and it may be that films or videos focusing on some of the skills or behaviours discussed in Chapter 1 might produce beneficial results. We have already mentioned examples in which an effort was made to improve roadside timing judgements. It would seem to be well worth while exploring whether such materials could be made more effective. Similarly, film or video might form useful illustrations of safe and dangerous locations and of what would be appropriate behaviour at such locations. Whether this would lead to changes in children's behaviour is, of course, an empirical matter requiring validation. However, there seems to be enough suggestion of potential in such materials when properly directed to make the effort worthwhile.

2.25 Behavioural techniques

Much less widely used than the above techniques are simulations or practical training of some sort that involve an element of active, behavioural participation by the child. Simulations might take the form of test tracks, traffic gardens or more limited set-ups in the playground, school hall or gym. Alternatively, training might take place in the real traffic environment in which case more elaborate problems could be tackled. For example, Young and Lee (1987) and van Schagen and Rothengatter (1986) used such an approach to assess and train visual timing and gap acceptance skills. A basic question with any simulation is, of course, the extent to which it successfully imitates the real world. However, the evidence to date suggests that a behavioural approach using life-like set-ups is by far the most promising approach to road safety training, and that the more life-like the task, the more likely it is to induce appropriate learning.

For example, in an early (unpublished) study, Johansson (1967) compared the effectiveness of training in a real traffic situation with training in the school yard and traffic garden. The real training situation proved superior to the other conditions. Sandels (1975) reported two experiments conducted with 6 and 7 year olds in which the benefits of training in streets closed off to traffic was compared to traffic gardens and schoolyard training. A further experiment compared the effectiveness of street training in relation to classroom instruction. The results showed that training in the real streets was superior to classroom training and also superior to training in the schoolyard and traffic garden.

Similarly, Saska (1971) found real street training superior to training in a traffic garden, whilst those trained in the latter also performed better than controls. Colborne (1971) found that traffic garden training was superior to classroom instruction for 6 year-olds although the effect was not found with 7 year-olds. An important finding in the Saska study was that the benefits of real world training were much more marked in *younger* children. This is consistent with the view already expressed in this report that early training should concentrate on behaviour, with verbally-oriented material being reserved for older children. Unfortunately, current educational approaches seem to operate mainly in the opposite direction: that is, insofar as practical instruction is given at all, it tends to be with older children. From the psychological point of view, this seems to be the wrong way round. We discuss this issue in detail in the next chapter.

Recently, there has been an upsurge of interest in practical training methods and several series of studies have attempted to teach well-defined behavioural skills of the kind described in Chapter 1. Since these studies sought to combine clearly specified *content* with detailed behavioural *methods*, we believe these deserve particularly careful consideration.

2.26 Training visual timing skills

The importance of these skills has already been discussed in Chapter 1. Here, we examine the extent to which it might be possible to promote their development in young children. Approaching the problem in this way represents a considerable change in current practice. As we have seen, the Green Cross Code simply advises children to wait until the road is clear before crossing. Such advice may be functional for the very young child who crosses mainly quiet roads where it is feasible to wait for the traffic to clear. However, on many roads, if pedestrians waited for the road to clear completely, they would be waiting all day. Moreover, as we saw in Chapter 1, children often apply such rules in a very rigid way, sometimes refusing to cross if a car is anywhere to be seen at all. Sometimes, this applies to cars that are stationary, moving in the opposite direction or so far away that they can barely be seen. This degree of rigidity is not functional and suggests that the children are not simply adopting a conservative criterion of safety but are blindly following a rule. Obviously, at some stage the child must learn to cross in a more efficient manner, choosing gaps in the traffic that are safe to pass through and rejecting those that are not. We might argue about the age at which such training should begin, but that the skills must be learned cannot be doubted.

Eventually, everyone becomes highly proficient in making these judgements, as studies of adult crossing behaviour demonstrate (e.g., Routledge et al., 1976; Lee *et al*., 1984; McLaren, 1993). In fact, adult behaviour is very different from what road safety teaches. For example, adults do not stop at the kerb as the Green Cross Code advises, because adults tend to assess the situation well before approaching the kerb so they have less need of kerb delay. When assessing the traffic situation, adults tend to look ahead at upcoming gaps, estimating if they are large enough (in *temporal* terms) to pass through. Having anticipated

the arrival of a suitable gap, they tend to step out smartly after the first car has passed, thereby making the gap to the next vehicle as large as possible. Such behaviour would appear to be rather skilful and is obviously necessary in order to cross busier roads.

Children, on the other hand, show none of this anticipation. Instead, children look at each car in isolation, paying little attention to others until the first one has passed. They also do not seem to concentrate on the variables that are really critical in making crossing judgement. For example, they are more likely to focus on characteristics such as the car's colour, size, etc., rather than on the spatio-temporal variables that are necessary in making strategic judgements. Children certainly do not seem able to identify the most relevant variables spontaneously and this would seem to be an important task for road safety education.

Unfortunately, current educational methods do not appear to be very effective at doing this. Indeed, although *everyone* comes to adopt the adult strategy sooner or later, it seems that children both develop and test these skills entirely on their own, experimenting on real roads, and without any guidance whatsoever. Eventually they become quite skilled at it. Unfortunately, many do not do so without mishap.

It is obvious that such skills must be learned. Two questions then arise. Firstly, at what age might children be expected to benefit from such training? This question is crucial, because it has been widely assumed that the psychological capacities required to make such judgements do not normally appear until around 9 years of age (see Chapters 1 and 3). Secondly, what would be an appropriate training method? Since visual timing is a basic perceptuo-motor skill, it seems unlikely that it could be acquired by purely verbal means in the classroom. Practical experience would seem to be essential, preferably in a naturalistic setting. However, we can hardly ask children to start walking out in front of passing vehicles in order to practice such judgements: a safe alternative must be found.

2.261 The pretend road method

One ingenious way of doing this has been developed by Lee and his colleagues at Edinburgh University (Lee *et al*., 1984; Young and Lee, 1987). Their method is to set up a 'pretend' road parallel to a real one. The children view traffic approaching on the real road but they cross on the adjacent pretend one. This means that they make genuine visual timing judgements and co-ordinate their movements to that information in the normal way. However, because they do not cross the real road, no harm comes to them if they make mistakes. Indeed, such mistakes provide feedback and promote learning. Tests with adults show that their behaviour when crossing the pretend road is virtually identical to their behaviour when crossing real roads. Thus, the pretend road seems like a simple yet effective simulation that could be used both to assess timing skills in children and to teach the skills in a realistic but safe environment.

When children were tested on the pretend road, a number of characteristic features emerged. Firstly, children tended to be extremely conservative in their judgements, missing many opportunities where they could have crossed in complete safety. Among 5 to 7 year-olds, as many as 45% of safe gaps were rejected in this way. Adults, on the other hand, rejected only about 10% of such gaps.

Secondly, children also made a small number of 'tight fits': that is, they accepted gaps which were too short to pass through safely and which would have put them at risk if accepted on real roads. Such tight fits were made on a relatively small number of crossings (9%) and adults also sometimes made tight fits. Nevertheless, tight fits only need to be made once. The fact that children did this on a number of occasions just in the short time during which they were tested (and when they were probably behaving more cautiously than usual to please the experimenter) is a cause for concern.

Children were also inefficient in their use of the time that was available to them for crossing. Adults and older children would typically look ahead, anticipating whether approaching gaps would be large enough to pass through. Once the leading car had passed, they would them step out promptly behind it, thereby maximising the time available before the next car arrived. Indeed, adults would often have a 'negative delay': that is, they would step out *before* the leading car had passed, tucking in behind it. Younger children, on the other hand, showed none of this anticipation. Generally, they would not even consider whether it might be possible to cross until after the leading car had passed and would then lose more time trying to decide whether they should go or not. Many perfectly safe opportunities to cross were routinely missed in this way.

Finally, young children were much less consistent in their judgements than adults. This inconsistency was found in the size of gaps they chose on different occasions; in the time they allowed to elapse before stepping out; and in the time they took to cross the road.

2.262 Training visual timing on the pretend road

Recently, several studies have investigated the possibility of improving these skills through training (Young and Lee, 1987; Demetre *et al*., 1992, 1993). Training was conducted with 5 year-olds and simply involved getting the children to cross the pretend road, and discussing their performance with them after each crossing.

After six half-hour training sessions (at the rate of about two per week), significant improvements were apparent. There was a marked reduction in the number of missed opportunities, which appeared to be due to an improvement in *anticipation* of suitable gaps in the traffic. That is, the children were looking ahead to assess gaps before the leading car arrived. They also stepped out more briskly after the first car passed, showing that decisions were being made earlier and more efficiently.

It is important to note that the reduction in missed opportunities was not due to the children simply 'going earlier', in a blind sort of way. Had this happened, there would not just have been a decrease in missed opportunities: there would have been an *increase* in the number of tight fits. However, this did not happen. The children were thus not simply learning to behave in a riskier fashion to reduce the time they spent waiting at the kerb. Rather, they were improving their strategies and skills on the road.

Finally, children's judgements became more consistent, showing that they had improved their criterion as to what is an acceptable gap, and even their crossing times became more consistent, again making comparisons of the time available relative to the time required to cross easier to calculate.

These findings, then, show how a practical, behavioural approach may hold promise as a means of teaching children as young as 5 years some of the more complex skills that are needed to deal with traffic. Note that it is very difficult to see how these skills could possibly be taught through verbal rules or, indeed, through any current classroom approaches. Wherever practical perceptual and motor skills are involved, it seems unlikely that we will find effective substitutes for behavioural training.

2.263 Alternatives to the pretend road method

One drawback of the pretend road method is that it requires access to a fairly wide piece of ground next to a real road where the pretend road can be set up. In many areas this would not be feasible, making it difficult to capitalise on the method. Recently, Demetre *et al*. (1993) have adapted the pretend road method in an effort to make it more readily usable, by devising variations in which the children make judgements whilst standing at the kerbside. These variations have both advantages and disadvantages over the pretend road: on the credit side, the children receive a more natural view of the traffic because they stand right at the kerb and not a whole road width away. On the other hand, the child does not actually cross, so quite a lot of valuable information about the co-ordination of action to perceptual information is lost.

In fact, children's performance appears to be quite similar in these various cases. Following training, reductions in missed opportunities were observed without any increase in tight fits, as in the pretend road studies. Similarly, there was an improvement in starting delays. Thus, although the children did not have the opportunity to test their judgements by actually crossing, the kerbside versions of the task would seem to offer a viable alternative to the full pretend road method where the latter is difficult to set up. Similar approaches have recently been developed by researchers elsewhere, again with encouraging results (e.g., van Schagen, 1988). Further research on the refinement of such methods certainly seems merited. For example, we are currently interested in whether training with *video recordings* of traffic gaps or experience using *computer simulations* of such tasks might improve children's skills and generalise to roadside judgements. Currently, no research has tackled these problems but the interest of the research is obvious.

In conclusion, these methods offer a way of providing children with meaningful roadside experience that seems to improve their pedestrian skills after remarkably little training. Considering that the subjects in most of these studies were as young as 5 years of age, the findings are hard to reconcile with the common view

that maturational factors preclude acceleration of such skills until several years later. It appears that the critical factor is the appropriateness of the training method, not the age of the child.

2.27 Perception of safe versus dangerous locations

In the previous chapter, we highlighted the problem of how children select places to cross the road when they are neither accompanied nor close to controlled crossing facilities. In such cases children must find for themselves safe places at which to apply the Green Cross Code. As we saw in Chapter 1, children below the age of about 9 show remarkably little insight into the factors that render sites safe or dangerous and they will readily cross at dangerous locations if given the opportunity to do so (Ampofo-Boateng and Thomson, 1991). Once again this limitation is not recognised by current educational methods, yet children's extremely limited ability to appreciate the intrinsic dangers posed by a wide variety of roadside locations must frequently render them vulnerable on the road. Methods are therefore urgently required to improve such judgements.

Several studies have recently attempted to address this problem. Thomson *et al*. (1992) and Ampofo-Boateng *et al*. (1993) developed a training procedure which could be used either at the roadside or using a model set-up in the classroom. In addition, the method was adapted for use either with individual children or with groups of up to five children working co-operatively. The training was conducted with 5 year-olds, who were trained by means of six 30-minute sessions at a rate of one or two per week. The resulting judgements were compared to those of older children as well as to age-matched controls. The training procedure was designed to improve the children's conceptual understanding of danger rather than merely to instil a list of 'dos' and 'don'ts', but we defer discussion of the details of the procedures until Chapter 5. The training was entirely conducted either in the real world (in the streets near the children's school), or using a table-top model of a traffic environment in the classroom.

The results of the individual training study showed very substantial improvements in children's judgements, with the proportion of safe routes rising from 10% to 75%. Remarkably, this placed the five-year olds at about the same level as untrained eleven year-olds (Ampofo-Boateng *et al*., 1993). Moreover, the children's justifications of the chosen routes showed evidence of far greater insight than was apparent before training. Thus, the children were not simply learning to go through a series of steps or procedures in a blind way. The training proved fairly robust, although there was a definite drop-off in the two months following the end of the programme, after which the number of safe routes fell to about 50%. This suggests that some refresher courses would be needed to maintain the full gains that the programme had induced. However, no significant further deterioration took place over the ensuing 6 months so that, 8 months after training, the judgements of trained children were still closer to those of nine year-olds than to those of untrained five year-olds. Interestingly, there was no difference between those trained at the roadside or on the model (though, of course, the children who were trained on the model had received some real-world experience during the pre-testing which took place at test sites on real roads).

In a subsequent study, children were trained in groups of five and substantial improvements were again observed (Thomson *et al*., 1992). Interestingly, the improvements seen immediately after training were less than in the individual study (around 40% as opposed to 75% of the routes were considered to be safe). However, unlike the individual study, there was no deterioration in the two months after the programme ended. It is interesting to speculate as to why the training should have proved more robust in this case. One possible answer is that the amount of attention the children received in the individual study was so great that an 'unnatural' amount of progress was made: that is, the improvements really went beyond what the children were capable of sustaining in the long term - an effect that is quite often seen following intensive educational experience. Thus, once the intensive educational support was withdrawn, the children gradually floated down to a more sustainable level taking into account their age and experience. Nevertheless, that level is far above what could be expected in untrained five-year olds. Considering that these improvements were induced after only six short training sessions, we might well ask whether further improvements might not be induced simply by lengthening the programme by a few sessions.

Recently, this research has been extended in significant ways. In a series of ongoing studies involving two especially vulnerable communities in Glasgow, Thomson (1993) has reported preliminary results of a programme in which parents taught safe place finding to groups of (other people's) children. The results

show that parent volunteers can produce improvements that are at least as good as those achieved by 'expert' trainers. Similarly, Tucker (1993) and Davies, Guy and Murray (1993) have recently adapted this programme into a traffic trail for use by teachers in schools. Again, improvements were seen following training. Thus, various adaptations of practical training programmes have all produced improved judgements in what is a rather difficult conceptual skill, and some years before one would otherwise expect an equivalent level of skill to emerge.

2.28 Training to deal with specific situations

An approach to the problem of road safety that is both different yet in many ways complementary to the one proposed here, has been developed in the Netherlands where a systematic, long-term programme of road safety training has been in place for a number of years (van der Molen, 1989).

Their approach, like the one advocated here, starts with a systematic analysis of the tasks that the pedestrian faces in traffic. The strategies that experienced pedestrians adopt in order to accomplish these tasks are then examined, with a view to defining what the inexperienced road user needs to learn. A difference between their approach and the one advocated here, however, is that instead of attempting to develop the skills directly, they adapt the adult strategies to a level considered to be more appropriate to the skills of young children. These simplified strategies are then introduced at the age when children first start to confront the road situations to which they refer (Vinje, 1981; Rothengatter, 1981a).

Four main strategies have been identified to date. Firstly, there is a Basic Strategy (not unlike the Green Cross Code) which is regarded as suitable for introducing to children as young as 4 years. This is regarded as useful for children in dealing with quiet streets such as are found in residential neighbourhoods and is sufficiently simple for children to comprehend at an early age. However, unlike the Green Cross Code, it is recognised that as children grow older they come in contact with an increasingly complex environment in which the Basic Strategy will frequently be inadequate. Accordingly, children around 5 years of age are introduced to techniques for crossing at parked cars and, at around 6 years, are taught how to cross at intersections. These techniques are elaborations of the basic method, so that previous strategies are not undermined by later ones. A fourth strategy which has been developed more recently (van Schagen and Rothengatter, 1986), is to teach children how to deal with intersections where there is also a parked vehicle - situations which are amongst the most dangerous of all (Howarth *et al*., 1974; Howarth and Repetto-Wright, 1978). This strategy is taught to children from around age 7.

The Dutch approach, then, involves a number of stages. Firstly, those road-crossing situations that seem to give rise to accidents (and which, it can be assumed, tax the child's road-crossing skills), are identified. These are then considered in relation to the ages at which children are likely to start coming across them. This helps determine when training of the different strategies should begin. The strategy is then designed taking into account the skills that can be expected in children of that age. The approach is essentially hierarchical, with each stage building on experience gained during a previous one. The programme as a whole has coherence because it is based on a relatively clear theoretical and empirical foundation. Finally, the most fundamental aspect of the Dutch approach is that it is *practical*, using modelling and reinforcement methods based on Bandura's (1977) social learning theory to induce the desired changes in children's behaviour.

Detailed evaluations of the training have been made in a number of studies (e.g., Rothengatter 1981a,b, 1984). The extent to which children's behaviour generalises to the roadside has also been assessed using unobtrusive observation techniques (van der Molen, 1983). The programme was designed for use by parents working in co-operation with kindergarten schools and substantial improvements in children's behaviour were observed following training, together with some evidence of generalisation to the real traffic environment. The findings were regarded as sufficiently impressive for extensive materials to be produced and the methods have been widely adopted in Dutch schools. A similar approach to road safety education has been taken in Germany (DVR, 1990).

This approach has many admirable features, as well as several points in common with the overall view advocated here. However, in one or two respects it remains susceptible to some of the criticisms we have made of other approaches. For example the Basic Strategy, like the Green Cross Code, does not teach

children how to recognise a dangerous place or find a safe one. To some extent, this problem is tackled in later parts of the programme where the dangers of parked vehicles and intersections are implicit. However, we have already noted that the ability to find a safe place logically precedes the need for a crossing strategy and this does not seem to be fully appreciated in the Dutch system any more than in the British.

A second issue arising from this work concerns the teaching of children how to cross at parked cars or intersections. Many authorities are extremely uneasy about training children to cross at such sites: indeed, the advice often offered in the UK is to avoid such situations and cross elsewhere. This would apply particularly to the car/junction combination which clearly taxes the abilities of 7 year-olds (van Schagen, 1985). The Dutch approach, on the other hand, is to teach children specifically how to cross at such locations rather than how to avoid them. There is thus a controversial aspect to this approach.

Our own feeling is that the child must, at some point, learn to cross in the vicinity of parked vehicles because, in many cases, there is simply nowhere else to cross. Having a safe and effective strategy for dealing with such situations is therefore essential to all pedestrians. However, it is vital that children learn to appreciate the intrinsic danger in such situations *in advance* of being offered a strategy to deal with them. Indeed, unless the child appreciates this, there is the very real risk that they might fail to see the point of the strategy at all, with the risk that it will be applied blindly or, at best, with only partial comprehension. This is, of course, a criticism we have already levelled at the Green Cross Code. Thus, training in the recognition of safe and dangerous sites should either precede or accompany training of such strategies.

Nevertheless, a combination of approaches emphasising, on the one hand, the strategies that children need at different ages and, on the other, the skills that will enable them to adopt increasingly efficient strategies in a logical and systematic way, seems by far the most sensible way for road safety education to proceed. Programmes should be developed so that children of different ages receive meaningful training that is appropriate to their abilities and level of experience.

2.3 Conclusions

In summary, problems exist with many widely used traditional methods of road safety. Doubts must also be expressed with regard to the content of much education, which concentrates on knowledge rather than behaviour. Since the aim of road safety education is to enable children to behave safely in traffic, a shift of emphasis is needed with regard to fundamental aims and objectives. It can no longer be assumed that knowledge translates into behaviour at the roadside. The evidence shows that this simply does not happen.

The studies reviewed in this chapter clearly point to the benefits of a behavioural approach. The fact is, many of the skills that young children need simply cannot be taught by other means. For instance, it is hard to see how timing skills could possibly be taught by verbal means. In many ways road crossing is similar to any other skill involving perceptuo-motor judgements. Skiing or swimming, driving or learning to ride a bike all require practical experience: no one ever learned to do any of these things just sitting at a desk. Yet this is precisely how we expect young children to learn to cross the road. Meanwhile, the practical experience that does eventually turn children into skilled pedestrians is picked up on real roads and under the supervision of no-one. Little wonder that so many fail to reach adulthood without mishap.

The advantage of practical training is not just that it exercises particular skills such as visual timing, but that it educates other skills as well. In the case of the pretend road, for instance, the children do not just learn to make timing judgements. By becoming tuned to the 'affordances' of traffic (Gibson, 1979; Lee *et al*., 1984), they learn about many other aspects of the traffic environment as well. They also learn how to deploy the basic skills in appropriate strategic form. Roadside training can also be expected to educate the child's attention and visual search, making them more attuned to relevant information and less attuned to what is irrelevant. Inexperienced children simply cannot be expected to know what to look for on the road, any more than the novice skier can be expected to know what terrain features are important in skiing down a mountainside (Lee et al, 1984). Giving children the opportunity to behave meaningfully in traffic improves this attentional tuning in a natural manner as they gradually focus in on what it is they need to attend to. This also helps undermine the rigidity problem discussed earlier. The trouble with simply telling children to 'look around' before crossing is that, when these instructions are divorced from the reality to which they refer, they end up going through a ritual whose function they scarcely understand. However, children trained in making

timing judgements are much more likely to look before crossing because they *can't make timing judgements without doing so*. They are no longer going through a series of head movements because someone told them to: they are picking up information and are making whatever movements are necessary to accomplish this. It is the picking up of information that is crucial, not the executing of abstract movements. The difference between the two is fundamental.

Finally, when a behavioural approach is taken, it is possible for training to be undertaken much earlier than with other methods. For example, we have seen that the Green Cross Code is generally regarded as unsuitable until the child has reached 7 years of age. This is primarily due to the limited verbal skills of younger children and to their extremely limited ability to generalise from verbal rules to behaviour. By contrast, when the Code is taught behaviourally, children can be taught to successfully follow the precepts as young as 4 years of age (Rothengatter, 1981a). All this points to the conclusion that practical training should receive far greater weighting than it does at present. However, this would require a major shift in what are currently perceived to be the aims and objectives in road safety education.

Chapter 3
Theories of Development

3.1 Why is practical training effective?

The review of current practice in road safety education presented in Chapter 2 strongly suggests that practical methods of instruction in pedestrian skills are the most likely to be effective. Programmes based on roadside training or using realistic simulations have been found to lead to improvements in visual timing and gap selection, to increased ability to identify safe and dangerous crossing locations, and to enhanced learning of appropriate strategies for crossing at parked cars and junctions. Moreover, such training has produced positive results with children as young as five years, making them behave like older, more experienced pedestrians. Finally, and perhaps most importantly of all, unobtrusive observation has provided evidence of generalisation to everyday traffic behaviour. Such behavioural changes have seldom, if ever, been reported following traditional road safety education. However, these results in themselves tell us little about which aspects of such training are important and thus worth further refinement. For example, the behavioural programmes implemented in Holland (e.g. Rothengatter, 1984) were deliberately designed to employ the principles of Social Learning Theory, which emphasises the acquisition of new behaviours via the imitation of actions modelled by others (see e.g. Bandura and Walters, 1963). This might seem to provide a clue to the source of these programmes' effectiveness, except that it is hard to explain the improvements in safe crossing location produced by Thomson et al. (1992) in these terms: their method only presented ostensible opportunities for modelling and imitation as a last resort. If the intention is to design more global programmes of training it would seem desirable, then, to consider what, if anything, the relatively different methods of practical instruction might have in common at a more fundamental level; i.e. to attempt to establish some more overarching account of *why* the practical approach works, so that we can capitalise on the processes involved. The purpose of this chapter is to examine some aspects of the major theories of child development and learning, to see what light they shed.

3.2 Theories of the process of development

There are four main bodies of theory which have a bearing on road safety education, and taken together these may in fact be argued to represent the primary orientations within contemporary developmental psychology, outside of work on language acquisition. The potential contribution of each to our understanding of how pedestrian skills are learnt is examined in turn below.

3.21 J.J. Gibson

The first corpus to be considered here is that which has grown up around the work of J.J. Gibson, who, whilst not a developmental psychologist per se, was a major contributor to understanding of the acquisition and development of perceptual-motor skills. It has already been argued in Chapter 1 that such skills constitute a considerable part of what the novice pedestrian has to acquire, and indeed, in Gibsonian terms, the road crossing task is at root a perceptual-motor problem rather than one of higher-order interpretation and cognitive construction.

There are two main strands to Gibson's theory (Gibson, 1979) which are of particular relevance here. The first is the notion that organisms, in order to survive, need rapid access to information about their own movements and the movements of others within the environment. As a result of this evolutionary pressure, the visual system of human beings (and many other species) has become capable of extracting salient temporal information directly from the visual field. We have already seen in Chapter 1 that the optical variable t (corresponding to the rate of dilation of an object or surface on the retina) is inversely proportional to the time-to-contact of the object with the eye. Thus the information required to judge the time-to-arrival of an approaching object is *directly* specified in the optic array and does not need to be cognitively constructed via extrapolation from data about distance and rate of change of position. Thus, the notion that such judgements require integration of several variables and therefore cannot be made by children below the stage of concrete operations is seriously questioned by this research.

The second strand is that, for Gibson, perception is ultimately bound to action, and environmental events are perceived in terms of the actions which they afford. Therefore, the perception of time-to-contact is a perception of the potential for action within that time. In these terms the developmental task, then, is one of refinement through experience of the direct perception of specific temporal information and the calibration of this with the requirements of different kinds of action.

One major implication of this is that perceptual judgements and motor responses can only be learned in the contexts in which they occur, or close analogues thereof. Although human beings are from infancy well-attuned to aspects of visual information, they still need to differentiate the specific perceptual regularities to attend to in a given situation, and to link these with the behavioural opportunities afforded by that specific configuration. In the pedestrian context the principal instance of this would be refinement of the perception of temporal information about traffic gaps vis à vis opportunities to cross (cf. Demetre *et al*., 1992): i.e. learning to differentiate time-to-contact intervals which provide a safe opportunity to cross from those which do not. Such differentiations can only be made in the first instance in terms of situation-specific information about the range of gaps available, the individual's own rate of movement and the width of road to be covered. Although with experience grasp of the relationship between these parameters may become more generalised (one might draw an analogy with an algebraic equation), it cannot in any functional sense be learnt from scratch at this level. In Gibsonian terms, then, perceptual-motor learning is necessarily a process of bottom-up development of skills within the context of their application. From this standpoint, practical training works because it provides an opportunity for this to happen.

Admittedly, Gibson's perspective may seem to some extent restricted when viewed against our earlier characterisation of the knowledge held by expert pedestrians. In Chapter 1, for instance, road-crossing skills of the kind outlined above were not seen as being self-contained, but instead as part of a broader conceptualisation of the traffic environment that determines how and when they would be used. However, Gibsonian theory is significant because of the emphasis that it places on the idea that learning occurs through the acquisition and refinement of specific actions in specific contexts and subsequent generalisation from these. This is, in fact, a theme common among many developmental theorists, and the same kind of sequence has been used by two major figures in particular, Piaget and Vygotsky, to account for the development not just of perceptual-motor skills, but of the conceptual underpinnings which might affect their deployment.

3.22 Jean Piaget

Any outline of Piagetian theory must necessarily be prefaced by an acknowledgement of the fact that this framework was developed over half a century of work and has many complexities that cannot be dealt with in the space of a brief report such as this. What follows is an account of some of the basic principles that are of relevance for the road crossing task (for more detailed summaries see e.g. Piaget, 1985; Flavell, 1963; Vuyk, 1981).

For Piaget, all knowledge was the result of a process of internal construction directed towards ever better (i.e. more accurate and more parsimonious) representations of the world in terms of the activities that could be carried out within it and the objects to which those activities applied. The basic building block of this process of construction was what Piaget termed a *scheme*, a cognitive unit which defines the sequence of action to be performed towards an object in a particular context (i.e. a form of "action plan").

In early infancy, schemes are identical with reflexes: i.e. simple structures which instigate specific actions when a particular kind of stimulus is present (e.g. raising an arm defensively against a looming object). However, activation of a reflex provides the infant with experience of performing the relevant action in different contexts, with all their concomitant variations. In other words, the potential of the reflex becomes translated into separate experiences. As a result, over time single reflexes become differentiated into a series of more specific schemes.

Subsequent learning occurs through the operation of three interrelated processes*, assimilation, accommodation and equilibration*. Assimilation is the process of matching up on-going experience of the world with existing knowledge: i.e. identifying (unconsciously, at least at first) which scheme best fits the circumstances in hand. Accommodation is the process of attempting to fit that scheme to current experience,

altering it in minor ways, if necessary, to provide a better fit (e.g. modifying the angle of the defensively raised arm to take into account the trajectory of the approaching object). Assimilation and accommodation can be regarded as complementary, since together they provide the means by which existing schemes are modified to take into account new information about the action-object relationship with which they deal. At root, these processes constitute a simple feedback system: failure to apply an identified scheme successfully results in the modification of action towards its object until success is achieved and the scheme is redefined (i.e. assimilation and accommodation have been brought into line with each other).

The successive calibration or "balancing" of assimilation and accommodation which this implies, together with its impact on schemes, serves to define the basic operation of the process of equilibration. This can be regarded as a pressure towards the maintenance of a correspondence between the world as cognised and the world as experienced. However, the mechanisms of equilibration go beyond the kind of adjustment described thus far. On occasion it will happen that the scheme to which some aspect of the world has been assimilated has so poor a fit to circumstances that it cannot be applied without considerably more than minor modification (i.e. accommodation has failed). Under these conditions equilibration acts to restore balance by instigating two types of more far-reaching cognitive change. The first is further *differentiation* of an existing scheme into new schemes which highlight the distinctive properties of actions and objects previously treated as being identical. The second is *coordination* of separate schemes into structures which highlight previously unperceived regularities of objects or actions across different contexts. The latter process is of particular interest for present purposes since it is through coordination that the child constructs on the one hand concepts of objects which are independent of specific actions, and on the other, courses of action which are independent of specific objects. It should also be noted that the principles of assimilation, accommodation and equilibration apply to structures in the same way as they do to schemes, since they *are functional invariants* which operate at all levels of development, despite increases in the complexity of the content being dealt with.

To summarise, then, for Piaget learning basically occurs via the accommodation, differentiation and coordination of schemes which detail specific actions towards specific objects; and it constitutes a direct response to perceived discrepancies or conflicts between those schemes and experience. Putting this into the context of the road-crossing task, one (admittedly rather artificial) example of accommodation might be the learning that would occur when a previously familiar stretch of road was encountered under unusual circumstances, such as a strong headwind. Although all other parameters of the situation (e.g. traffic flow, road width) might remain as expected, and it would therefore be assimilated to the existing scheme, the weather conditions would make a significant difference to the rate of the child's movement across the road. As a result, the action of beginning to cross would need to be adjusted so that it took place during a longer than normal traffic gap. Successful achievement of this objective would lead to modification of the scheme to include information about the variation in behaviour that should accompany those conditions (i.e. effectively weather would now be included as a specific parameter of the scheme which would, as a result, become more generalised in its applicability).

Similarly, it is possible to identify plausible (if again somewhat simplistic) examples of the occurrence of learning through differentiation and coordination in the context of road-crossing. One instance might be where a child used to dealing with roads of a certain width became exposed to conditions where this varied more dramatically (say by moving from a rural to an urban environment). Corresponding, but unanticipated variations in the time taken to cross different roads might result first of all in the differentiation of a single, previously adequate, scheme into a limited series of new schemes, each implicitly relating crossing time (and hence traffic gap selection) to a specific road width. Continued conflicts between expectation and experience might then be resolved by coordination of these schemes into a unified structure which highlighted the underlying regularity of relationship between road width and crossing time. This structure would provide a more general basis for the selection of the minimum appropriate size of traffic gap necessary for safe crossing (cf. the earlier analogy with an algebraic equation).

Taking the idea a step further, related, albeit more complex kinds of coordinations might also be made under circumstances where a child encounters non-uniform vehicle motion (i.e. there is variation in speed, deceleration or acceleration) or non-uniform vehicle direction (e.g. where a car is turning a corner at a junction). If these conditions occur relatively frequently they may promote the development of structures

which permit anticipation of the overall pattern of the vehicle's movement, via the coordination of schemes or simpler structures which detail its various component parts.

These examples are intended more as illustrations of the ways in which the processes of learning detailed by Piaget might apply to pedestrian activity than as substantive predictions about what learning does actually take place. However, they do help to draw out two particular issues of importance. The first is that although all aspects of knowledge display a tendency towards generalisation, there is a qualitative difference between the effects of accommodation within a scheme and coordination between schemes. The range of applicability of individual schemes is broadened by accommodation, but these are still essentially tied to specific contexts and the process itself may require little conscious effort. In contrast, coordination produces more general constructs (i.e. those which provide information relevant *across* contexts), and this requires explicit connections to be made between different schemes. A central element of Piaget's characterisation of this process is the notion of *decentration*. In order to make a connection between schemes it is necessary for the child to attend to an experience not just in terms of the scheme to which it has been assimilated (i.e. in terms of one single perspective), but to be aware of at least some of the range of other relevant schemes which might be applied to it, and to note the correspondences between these. Piaget suggests that such connections are in fact most likely to be made for the first time as a result of reflection *after* the event, in an attempt to resolve perceived conflicts, although they may then be recalled and utilised during an on-going experience.

Whenever it occurs, though, the point is that coordination is intimately bound up with a decentring of attention. As will be seen subsequently, this is an idea with profound educational implications. For the moment it is sufficient to note the potential role of decentration in, for example, systematising visual search (cf. Chapter 1). Attention to a range of related experiences should in itself point up the features which are both stable across specific contexts and most consistently relevant to action (i.e. what to look for and where to look for it); conversely it should also shift the child's focus away from features which are distinctive but transient. Effectively, then, decentration could serve as the primary means by which the child's perceptions of what is salient are changed.

The second issue concerns the role of action within learning. Piagetian theory suggests that learning results in a gradual shift of cognition away from a dominant focus on context-bound action, towards broader, more context-independent understanding i.e. towards more general conceptualisation. It is important to note, however, that this does not imply any downgrading of the status of action within the learning process. Since schemes constitute the building blocks of learning, a basic framework of these must be in place before more generalised understanding can be constructed in any new area of experience. This in itself provides a powerful explanation of why practical, "walk-through" approaches to road safety education tend to be successful, irrespective of the precise form that these take. More fundamentally, though, as Smith (1993) points out, Piagetian theory accords action a primacy at all levels of development: knowledge is always directed at action, whether this is in the form of overt behaviour or corresponding mental operations, and construction always occurs as a result of action in this same broad sense. In other words, then, learning is always dependent upon active engagement with some task.

The Piagetian emphasis on learning as a bottom-up process of construction from specific actions in specific contexts has obvious correspondences with the account of skill acquisition provided by Gibsonian theory. There are also parallels between the two schools of thought in terms of at least some of the kinds of mechanisms envisaged as operating within this process (e.g. the differentiation of perceptual invariants and the behaviour they afford on the one hand, and the differentiation of schemes on the other). It is possible, additionally, to perceive similarities at the level of some basic theoretical tenets. For Piaget as well as Gibson, for instance, there is a fundamental relationship between perception and action, which is captured by the complementarity of assimilation and accommodation: both theories could be argued to rest on the notion of some form of afferent-efferent (i.e. input-output) loop.

Where Piagetian theory departs is over the idea of the coordination of related instances of these "loops". This dimension is of particular importance for present purposes, though, since it means that the theory is capable of providing a framework for understanding the development of both skill (i.e. the differentiation of specific actions in specific contexts) and its strategic deployment (i.e. the moderation of action according to the constraints suggested by more global conceptualisations). Within this framework, skills, strategies, and even

abstract concepts are not to be seen as separate types of knowledge acquired in distinct ways, but instead as parts of a structural hierarchy that emerges over time as the scope of coordination successively increases.

3.23 L.S. Vygotsky

The idea of learning as a bottom-up process which begins with contextualised action was identified as common to both Gibson and Piaget, but also provides a link through to the work of L.S. Vygotsky, acknowledged alongside Piaget as the other great theorist of developmental psychology. Superficially, Piaget and Vygotsky appear to have diametrically opposed viewpoints, and they have often been presented in this light. In fact, though, closer inspection reveals that the correspondences outweigh the differences in many respects. The main point of departure between the two is that whilst Piaget regarded learning as a process of internal construction, for Vygotsky learning takes place via the internalisation of *socially* constructed or guided behaviour. Thus in a famous statement of principle, he writes:

"Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first *between* people *(interpsychological*), and then inside the child (*intrapsychological*)...All the higher functions originate as actual relations between human individuals." (Vygotsky, 1978, p. 57, italics in original).

Two key points follow from this basic position. Firstly, all organised thought is the mental equivalent of action and has its origins within action. To take a simple example, the activity of counting out within one's mind the number of e.g. books on a shelf is an internalised application of the developmentally earlier activity of physically moving a set of objects into a row whilst counting out "one", "two", "three", "four" and so on. Secondly, all organised action is constructed in the first instance in conjunction with those who have already mastered its characteristics. To extend the example of counting, the child's first attempts at physically seriating and numbering objects would not take place in social isolation, but would instead form part of a joint activity directed by a more advanced other (e.g. an adult caretaker) who was already adept at counting.

This points to another central idea within Vygotskian theory, that of the *zone of proximal development*. This zone, which constitutes a psychological rather than a physical space, is defined in terms of the difference between what an individual child can achieve unaided (i.e. what activity they are capable of carrying through on their own), and what they can achieve whilst working in conjunction with a more knowledgeable other. This idea carries with it a number of important and related implications.

Firstly, the zone of proximal development is the space within which learning takes place. As Vygotsky puts it: "What the child can do in cooperation today he can do alone tomorrow" (Vygotsky, 1962, p.104). Secondly, given an initial level of capability on the part of the child, there is an upper boundary to what more they can achieve in cooperation with the more advanced other. Not only will no learning occur if the joint activity is pitched at a level at or below what the child is already capable of unaided, but it will also not occur if it is pitched too far *above* that level. The greatest learning will occur when the joint activity is at a level towards the upper boundary of the zone of proximal development. Thirdly, despite Vygotsky's emphasis on the socially directed nature of learning, in common with Piaget he characterises it as a bottom-up, constructive process. More complex activities or functions build upon simpler, and the range encompassed by the zone of proximal development moves forward as learning progresses.

The key to developmental progression within Vygotskian theory is *mastery*. Whilst the child may be capable of more advanced activity when working under the direction of another person, learning will not occur until they begin to take upon themselves the responsibility for directing their own behaviour along the lines indicated. Initially, this might mean nothing more than adopting as a kind of habit the external form of behaviours constructed during interaction. Over time, however, many of these behaviours (Vygotsky stresses that it does not happen in all cases) will become internalised as covert mental operations: the process of thought which was formerly used solely to direct external activity becomes separated from action and turned inwards to form part of a more integrated system of psychological functioning. As this happens new insights become possible and generalised understanding begins to emerge. This is the basis of true mastery.

In order to understand how internalisation and learning at this higher level occurs, it is necessary to consider the remaining central element in Vygotskian theory, the role played by language. During the course of

interaction between a more and a less able individual (i.e. within the zone of proximal development) the activity of both participants is embedded in a sequence of dialogue. Whilst on occasion the more able partner may demonstrate the form of some key element of behaviour, more usually they will use language to guide and structure the behaviour of the less able, by, for instance issuing corrective feedback, or using the deictic functions of language (i.e. its capacity for directing attention) to draw the less able's attention to key features of the situation that he/she needs to take into account. (We might note in passing that this use of language could equally well serve as a mechanism for promoting Piagetian decentration; this is a point we will return to in Chapter 4).

The direction of the less able partner's activity via language opens up a range of new possibilities. Firstly, this language provides a mnemonic for the sequence of actions to be carried out: in the absence of the more able partner, the less able can recover that sequence by repeating *for him/herself* the directions which had previously formed part of the interaction. In other words, therefore, it is language that acts as the mechanism for transfer of the control of behaviour. Secondly, because of the deictic function of language, what is transferred is not a mechanical series of associative prompts but instead the encapsulation of a conscious sequence of thought. Thus the transfer of control creates ordered awareness and hence true psychological functioning.

Finally, the language used by the more able partner is an external expression of the thought processes he/she is using to guide activity, and stands in the same relation to other aspects of his/her psychological functioning as the thoughts themselves. What is transferred therefore is not just conscious control, but part of a wider system of understanding which carries with it implicit traces of other relationships. Transfer of control, then, is a partial induction into an overarching conceptual framework. By dint of this, the internalisation of language (what Vygotsky calls the development of "inner speech") is not simply the basis for individual psychological functions, but ultimately for their integration into a coherent system convergent with that already developed in other members of the same community.

Focusing for the moment on the initial, interactive phase of the learning process described by Vygotskian theory, the potential applicability of this to an account of at least one way in which children might acquire some of the basic skills required by pedestrians is clear-cut. Indeed, there are sufficiently strong parallels between the instructional sequence envisaged by Vygotsky and the training method employed by Thomson et al. (1992) to suggest that this might explain the latter team's success. Taking this further, we might also note that it is possible to see the efficacy of the social learning theory framework employed in the Dutch training programmes (e.g. Rothengatter, 1984) in Vygotskian terms. Whilst the explicit emphasis of these programmes is on adult modelling of correct behaviour and social reinforcement of subsequent performance by the child, it is almost inconceivable that these activities are not embedded in directive dialogue of exactly the kind portrayed as central to learning by Vygotsky.

However, it is important not to lose sight of the fact that, as in Piagetian theory, for Vygotsky the acquisition of concrete sequences of behaviour carries with it the basis for subsequent conceptual development. Again, in common with Piaget, this is not seen as being an immediate achievement. In fact considerable emphasis is laid (Vygotsky, 1978) on the existence of an intermediate stage in the transfer of behavioural control via language. Piaget (1955b) had earlier remarked on the tendency of younger children to talk out loud as they proceeded through an activity, terming this phenomenon "egocentric" speech since he held that it was a result of the child's lack of awareness that dialogue required at least two participants. Vygotsky interpreted the existence of egocentric speech quite differently, seeing it as a halfway point in the internalisation of a function, where control of behaviour had passed to the child but thought was still tied to external expression.

There are other points of greater correspondence between Piaget and Vygotsky as regards conceptual development. For example, whilst Vygotsky is to a large extent silent on the precise causes of the subsequent advent of full internalisation of functions, he does link it quite explicitly to a change in the temporal relationship between thought and action: i.e. thought shifts from accompanying action as a direct correlate, to *preceding* action as a form of planning activity. This formulation contains distinct echoes of Piaget on the acquisition of what he terms the *symbolic* function: i.e., the emergence of schemes as more conscious representations of the relationship between actions and objects (as opposed to automatically instigated action plans). This allows actions to be represented or thought about rather than performed: as a result, thought (in the sense of manipulating representations or symbols), becomes separated from overt

action. Piaget sees this as the beginning of true representation and the genesis of mental operations. Finally, there are also parallels with Piaget in Vygotsky's account of concept formation, in which he describes a shift in children's understanding from a focus on external, concrete referents for words to abstract, categorical relationships *between* words (Vygotsky, 1962; see also Luria, 1971). The potential significance of these parallels between Vygotskian and Piagetian theory is a point we will return to shortly.

3.24 Information processing approaches

Despite varying degrees of difference in their characterisation of the mechanisms involved, there is, then, considerable convergence between Gibson, Piaget and Vygotsky in terms of the emphasis they place on learning as a bottom-up process which takes as its point of departure the acquisition of context-specific actions. The convergence between Piaget and Vygotsky is even closer with regard to what they see as being the key features in the growth of more general conceptions. This emerging unanimity about the nature of learning does not stop here, however, since there is, in addition, a fourth, looser body of theory derived from contemporary information processing approaches to development, which provides a further echo.

In contrast to the perspectives considered so far, there is no single overarching information processing theory of development. Instead, a series of related strands of research can be identified, which share a common focus on the development of basic capacities such as the representation and retrieval of information, the organisation of the knowledge base, and strategies for problem-solving. In other words, these different strands are all concerned at root with what mental processes are used to deal with information, how these are organised, and how they change during development. In addition, the main constructs employed by different information processing approaches are usually strongly related to those used in adult cognitive psychology and cognitive science; there is a similar reliance on the computational metaphor, where people are seen as limited capacity manipulators of symbols (Siegler, 1983).

For present purposes it would be somewhat redundant to pursue any detailed outline of these various strands, but one in particular is of central relevance viz. work on the development of scripts (Schank and Abelson, 1977). Scripts are representations encoding knowledge of recurring events in schematic form. Any single instance takes the form of a set of expectations about the relationship between different activities (i.e., how they are organised with respect to each other over time), which has been derived from the individual's previous experience. In other words, scripts define a likely sequence of actions-on-objects within a unitary event.

A much-cited example of a script, originally given by Schank and Abelson, is that of "going to a restaurant". We enter a restaurant with an expectation that a waiter will come and show us to a table, and provide us with a menu; that we will then choose what we want to eat, and the waiter will take our order; that shortly thereafter our food will arrive, and we will begin to eat it; and so on. One particular point which this illustrates is that the content of a script is more general than that of the memory of a specific episode, and conversely that any given instance of the type of event that it deals with will inevitably contain minor variations or deviations from this schematic outline. At the same time, though, the detail contained in a script is sufficiently concrete for it to refer to a definable class of event. In fact, its functional value would be much restricted if this were not the case: as it stands a script allows both inference about the course of the event ("what is likely to happen next is that...") and guidance of one's own activity within that context. It also provides a focal point for the organisation and storage of information from subsequent experiences.

The available evidence all tends to suggest that scripts are natural and powerful mechanisms for organising experience. For instance, Nelson, Fivush, Hudson and Lucariello (1983) asked children to describe different types of events such as "what happens when you go shopping". They found that children as young as 3 years were able to provide coherent, sequentially organised reports which were general in form (signalled in English by use of the present tense: e.g. "you drive to the supermarket, you get a basket" etc.). Nelson and Gruendel (1986) asked children about less frequent events (e.g. "What happens when you go to Disneyland?"), and found that reports were given in script form after a single experience, implying the existence of strong underlying assumptions about the consistency of future occurrences. Fivush (1984) followed 5 year olds starting school over a ten-week period, and found a rapid increase in the complexity of scripts, including the introduction of conditional elements within the overall sequential structure (e.g. "if it's raining we stay in").

What is perhaps most striking about this body of research, however, are the manifold parallels between scripts on the one hand and particular aspects of schemes or structures in Piagetian theory on the other. These parallels extend both to focal content (i.e. a sequence of context-specific actions), and to the processes by which further learning occurs. The inclusion of conditional elements, for instance, has echoes of accommodation, and holds out the possibility of a form of differentiation or splitting up of scripts as experience dictates (e.g. going to a friend's house might initially be seen in terms of a conditional branch within the script for going to visit relatives, but a separate script would be likely to develop as key differences between the two types of event emerge).

There is, moreover, a further parallel in the idea that concepts are derived from scripts via the abstraction of relations across events (Nelson, 1983; Lucariello and Rifkin, 1986): e.g. the occurrence of the same object in different scripts is held to yield a more general object concept, and, similarly, the occurrence of the same action performed by different individuals towards different objects is held to yield a more general concept of action. Clearly this has a strong resemblance to the coordination of schemes in Piagetian theory to yield object and action concepts. In one sense, then, this suggests that script theory could be seen as a restatement of Piagetian theory in contemporary terms. The main point, though, is that this convergence of different theoretical frameworks on the same structures and processes provides powerful cross-validation for both.

3.25 Implications

There are two principal implications that can be drawn from the accounts of learning detailed above, one general and one more specific. The general point relates to what we might call the minimum conditions for learning. Developmental theory, almost with one voice, argues for the natural progression of understanding from action to concept. Given that the knowledge held by the sophisticated pedestrian consists of both elements (i.e. a set of perceptual-motor skills, together with broader-based concepts of the traffic environment which guide the deployment of these skills), the implication is that methods of instruction will be effective when they work consistently with this progression from action to concept rather than when they work against it or when they only address limited elements of the process. In these terms, practical training methods are successful because they start at the right point in the developmental sequence.

The more specific point relates to the complementary nature of the accounts provided by Piagetian and Vygotskian theory. It is worth noting that Piaget provides rather less detail on the process of acquisition of the vast range of actions available even to relatively young children, but Vygotsky provides a well-defined mechanism for this. Conversely, Vygotsky is weaker on the process of generalisation from action to concept, but this is precisely the strength of Piagetian theory. Given the other correspondences between the two which were noted earlier, this suggests they might be seen as providing conjointly a single well-defined account of the learning process.

If so, it implies that any serious attempt to promote the development of appropriate pedestrian behaviour ought to begin by explicitly training children in particular actions, within (at least) close analogues of the situations in which those behaviours will have to be used; this would provide the necessary basic information about the relationship between action and environment in a form which children will adopt and use for themselves. Once these patterns of action begin to be established, they can be used as basic experiences from which to build a more articulated understanding of the behaviours to be used in different contexts, as well as more general concepts about the traffic environment. The precise form that Vygotskian and Piagetian theory suggest these two elements of intervention ought to take, together with empirical evidence for their effectiveness, is considered in detail in Chapter 4.

3.3 The issue of rate of development

Identifying an appropriate sequence that ought to be followed by instruction in pedestrian skills is not, however, sufficient. There is also a need to establish the appropriate timing for the application of such instruction, whilst bearing in mind the practical reasons for holding to the broad principle of the earlier the better (cf. Introduction). The underlying question here is whether there are general constraints on the rate of individual development which indicate that training before a certain age would be likely to be a wasted effort.

As noted in Chapter 1, there has in fact been a tendency in the past to assume that there are indeed such constraints on what can be achieved with what age of child. From a current standpoint, however, these assumptions (at least as usually expressed) are inappropriate and, moreover, ill-founded. Rate of development appears to be less constrained than has often been thought, and empirical work suggests that it can be accelerated if approached correctly.

The main reason for these earlier assumptions about rate of development is that as far as educational practice is concerned (and this applies to road safety education in particular), calls upon developmental theory have primarily been restricted to Piagetian stage theory (see e.g. Piaget, 1955a). According to received wisdom, this holds that there are four distinct stages of development which occur at roughly defined ages: the sensori-motor stage (0-2 years), the pre-operational stage (2-7 years), the concrete operational stage (7-11 years), and the formal operational stage (11 years on). These stages are typically regarded as some kind of biological constraint, and since the shift into each new stage signals the emergence of new capabilities, it is held that tasks which require some particular instance of these cannot be successfully completed until the relevant stage has been reached. From this has come the idea that children can only be taught certain things "when they are ready". Sandels (1975), for instance, argues that children below the age of 7 or 8 (i.e. pre-operational children in stage theory terms) are unsafe pedestrians because they lack the necessary cognitive abilities to be able to perform the tasks involved (e.g. they tend to fixate on single elements of the traffic environment rather than being aware of the complex interaction of different factors).

One response to this might be to point out that there is good reason to suppose that some of the cognitive requirements of being a pedestrian are less than previously thought (see Chapter 1), and that the basic perceptual-motor skills involved ought theoretically to be well within the scope of the pre-operational child. However, this whole notion is in any case based on a misconception, resulting from the removal of the concept of stages from the broader context of Piagetian theory. For Piaget, development proceeded in a fixed order (i.e. certain things built on others), but not to a fixed timescale, nor necessarily at a fixed rate across all different areas of functioning. As Smith (1993) points out: "The process of construction is time-related, because new constructions occur as time passes. But it does not follow from this definition that any such construction occurs at a specifiable point in time. Thus it does not follow that it is age related" (p. 39).

In fact, Piaget explicitly addresses the occurrence of cross-task variability in the child's level of functioning, referring to instances of this as décalages. In the context of conservation for example (i.e. grasp of the fact that certain properties of objects remain invariant in the face of superficial transformations), Piaget reported, and subsequent studies have tended to confirm, that conservation of mass (how much of a substance there is) appears before conservation of weight. One possible reason for this is that there are differences in the complexity of the structures to be acquired: it could be that conservation of weight appears later simply because it requires the additional inference that a given amount of substance has a fixed weight, and hence that if substance remains constant then so must weight (note the implication here that conservation of weight depends on prior conservation of mass). However, implicit within Piagetian theory is the possibility that the frequency of a particular type of experience could also be influential: earlier and more frequent experience of the conflict produced by a failure to conserve a given property ought, in principle, to produce earlier coordination of the kind required for understanding the notion of conservation in a particular context. Consistent with this, Price-Williams, Gordon and Ramirez (1969) found that the children of Mexican potters, used to working with clay from an early age, showed precocious ability to conserve mass, although they were no better than other children at conserving, for example, weight.

The wider issue is the question of what precisely it is that brings about a particular decentration (e.g. in conservation, noticing that if you roll a ball of plasticene into a sausage shape, as length increases so width decreases, in a manner consistent with overall constancy of the amount of plasticene), and whether there is any kind of structural limitation on its occurrence. However, given the prerequisite experiences, Piagetian theory does not really suggest any inherent constraint on decentration (beyond a certain interdependency of ideas) after the symbolic function has been acquired and thought has become to some extent separated from action (this being a basic requirement for the ability to shift attention). It just seems to take some time, which again holds out the possibility that it is weight of experience (and the conflicts this throws up) that matters. This in turn suggests that desired decentrations could be promoted by appropriate interventions.

One implication of this is that the sensori-motor, pre-operational, concrete operational and formal operational stages are best seen as a convenient shorthand for the kind of development that might typically be going on in an average child of a given age, as like as not without specific educational intervention. This last point is of particular relevance when it comes to any assessment of the validity of the age range usually associated with the different stages: given the period and context of the bulk of Piaget's research, it is necessary to bear in mind that his subjects may well have been exposed to educational techniques which were, relatively speaking, lacking in sophistication. There is in fact good evidence for an impact on development of shifts in educational and cultural practice. Research by Flynn (1987), Lynn, Hampson and Mullineux (1987), and Fuggle, Tokar, Grant and Smith (1992) all points to the existence of systematic cross-generational increases in IQ scores on standardised measures which are hard to account for in any other way. A further point to note is that even Piaget himself often used the terms for the different stages as broad descriptions with rather hazy boundaries. Karmiloff-Smith (1978) takes this as an indication that the number of stages was actually dictated by heuristic rather than substantive considerations. This certainly fits in with Piaget's tendency, when dealing with different well-defined domains of knowledge, such as velocity and flotation, to specify somewhat different patterns of stages and sub-stages.

Finally, given the bottom-up nature of the process of construction described in section 3.2, to the extent that stages exist, it is more appropriate to regard them as emergent characteristics, rather than overarching constraints. It is in fact implicit in the notion of décalages that a child can perform at, say, the concrete operational level in one context and at the pre-operational in another. With one possible caveat, which will be dealt with in the next section, the whole question of stages is really an issue of less theoretical moment than it has often been accorded. Certainly, as far as contemporary developmental psychology is concerned, the value of Piaget's theory lies in its account of the process of development, not in any indication of the absolute timing of specific developmental changes.

It is possible to discern similar implications about the variability of the rate and timing of learning in more recent work such as that of Case (1984, 1985), who adopts an information processing or "neo-Piagetian" approach to development. Without going into detail, Case proposes a maturational constraint on the rate of development which stems from the size of what he terms the Short Term Storage Space (STSS) available for information processing. The underlying idea here is that there are limited attentional resources which have to be divided between carrying out operations and storing or retrieving the results of those operations (cf. the problems of complexity, capacity, and divided attention mentioned in Chapter 1). Case argues that the *effective* size of the STSS gradually increases, since as operations become more practiced, they require less resources, leaving more available for their products within the STSS.

Whilst Case's account seems, if taken at face value, to suggest that there are global constraints on development, the point is that it actually implies a direct effect of training (in the sense of structured and targetted experience), albeit one which is restricted to a specific context or domain. As the child practices and becomes more adept at carrying out operations in a given domain, they will have greater capacity to make more complex coordinations i.e. both to notice more about what is going on and to integrate that information as it becomes available, and also to gain greater conceptual insight by making stable connections between different aspects of the experience (e.g. noticing the sequence of traffic light changes at a complex junction, and gradually building up to using this information in terms of the opportunities it presents for action).

Other research provides a hint of the potential power of specific training of the kind implied. White and Horwitz (1988), for instance, report on an intervention in physics which involved children working with a computer-based simulation of the motion of objects in order to improve their ability to predict the effects of applying different forces. The structured programme surrounding this activity succeeded in raising the understanding of 10 year olds above the level of high school students.

This should not be considered an exceptional result, since there is good evidence for the occurrence of apparently precocious development in a variety of areas. For instance, Markovits (1993) reports that children as young as 7 or 8 can correctly manipulate the logical properties of conditional relationships ("if P then Q"), although this does seem to be dependent on the familiarity and concreteness of the task content (see also Markovits and Vachon, 1990). Similarly, Somerville and Wellman (1987) report that before the age of 6 children are capable of holding in mind and manipulating the set of different possible outcomes of some

event, although they are less good at judging the relative probabilities of these, and again there is a tendency towards variation in performance from one context to another. This last is not necessarily the limitation it seems, however, since the evidence for cross-task variability points back again to the possibility that the source of such differences is frequency of experience, with all that this implies for the potential effectiveness of intervention and training.

At very least, then, children's capabilities are considerably more elastic than the common interpretation of stage theory implies. Well-designed and well-founded educational interventions may achieve progress unthinkable within the confines of this narrow perspective. Moreover, whilst the age at which didactic interventions would be effective might well be constrained by the child's limited experience (and hence ability to relate language to relevant events when used out of context), if action-based training and contextualised verbal instruction were used, there seems to be no good reason why this could not begin at young age (i.e. at the start of primary school or even earlier).

3.4 The issue of domain specificity

Whilst age might not be the constraint that it has previously been thought to be, both Piaget's notion of décalages and Case's STSS theory suggest that a different kind of constraint on learning may operate: i.e. that it tends to be relatively domain-specific rather than completely generalised. In other words, whilst the scope of ideas within a particular domain may increase, cross-domain generalisation may well be more restricted. If so, this has obvious implications for the kind of training that might be effective i.e. that it will need to be fairly precisely targeted. But how specific does it have to be? How much generalisation can be expected? There are two issues here.

The first of these concerns the flexibility of transfer to varying tasks within the same basic domain. There is evidence of both individual and age differences in the extent to which this occurs. Brown and Campione (1986), for instance, found that older children were more likely to carry over strategies to successive parallel tasks, such as identifying the rule governing a series of letters and a matrix completion exercise, but noted that this also tended to vary as a function of IQ. The exact source of these differences is unclear, and this is an area where further research is definitely warranted. However, the presence of an age effect again suggests that experience and metacognition (cf. decentration) may be important parameters.

The second issue is the likely extent of cross-domain or "far" transfer. From a theoretical perspective, one construct of some relevance here is what Piaget termed structures d'ensemble. These are hypothetical global coordinations that crystallise the achievements of a particular stage and spread their effects to all areas of functioning. If structures d'ensemble do exist, this suggests that at key points of development learning does have a universal effect. However, for a variety of reasons, this notion is not unproblematic.

One difficulty is that at root the possibility of such global coordinations would seem to depend on the extent of the operation of equilibration. For structures d'ensemble to actually occur, there seems to be an implied need for the child to perceive at some level the conflicts between all existing structures and to recognise the connections between different domains. The trouble is that it is difficult to identify mechanisms which could work on such a broad scale (let alone experiences which would trigger their operation). Metacognition and decentration are obviously possible candidates, and yet for Piaget the ability to treat one's own thoughts or perceptions as objects to such an extent as to be able to make decentrations of the required breadth would be a relatively late development. This begs the question of how structures d'ensemble at, say, the pre-operational level come about, unless they are argued to be simply a cumulative product of more limited coordinations. In this respect Piagetian theory could actually be argued to be consistent with at least some tendency towards domain specificity. Similarly, whilst social cueing of the connections between different domains might conceivably have some effect, this would need to be salient (i.e. to be assimilable to child's existing structures), and perhaps also of immediate use to the child. It is hard to see how this could operate except on a piecemeal basis.

There is, in any event, a possibility that the implications of structures d'ensemble have been misunderstood. Smith (1993) points out a little-mentioned restriction that Piaget placed upon the applicability of his theory, namely that he was talking about development in the "epistemic subject" rather than the individual person. In other words, he was claiming that his theory was restricted in its application to that aspect of the

individual which acts as a rational agent. From this perspective, Smith argues, it makes more sense to see structures d'ensemble simply as yardsticks against which to measure performance on structurally similar tasks (the ideal subject would perform consistently), and not as implying global coordinations within actual individuals. A related notion here is that put forward by Carey (1987), who argues that there are far-reaching reorganisations of knowledge that unify otherwise piecemeal developments, but that these are content-specific and so restricted to operating with certain boundaries: i.e. they relate to overarching "theories" applicable to specific domains such as biology or matter.

In fact, the available evidence tends to favour the position that cross-domain transfer is limited. For example, correlations between performance on different Piagetian tasks are frequently little better than moderate. Kuhn and Brannock (1977), for instance, compared children's solutions to two problems, one relating to the factors affecting healthy plant growth and the other to the factors affecting the motion of a pendulum. Association between level of performance on the two was no better than chance. Carraher, Carraher and Schliemann (1985) report large-scale differences between the performance of child street vendors in Brazil on money calculations on the one hand and comparable classroom mathematics problems on the other. Similarly, in one of our own studies in science education (Howe, Tolmie, Anderson and MacKenzie, 1992), we noted that although undergraduate students knew from the context of driving a car how to work out average speed from information about time and distance, they not infrequently failed to see how to use exactly the same type of information in the context of physics problems.

More generally, Light (1993) points out that contextual constraint is inherent to the idea of script knowledge. This, he suggests, accounts for the variation in children's performance on conservation tasks depending on how these are framed (see e.g. Donaldson, 1978). From this standpoint, one of the major goals of development is the recontextualisation of knowledge (Walkerdine, 1988). However, Adey and Shayer (1990), in an examination of the effects of specific training in metacognitive skills, provide evidence that when such recontextualisation occurs, it is on a time scale of years. Byrne (1993) points out that interventions designed to instill domain-general skills are typically ineffective, but that programmes intended to enhance higher-order thinking in specific domains are more usually successful. These effects are, however, restricted to the domain that was the focus of instruction.

On this evidence then, even when a well-elaborated conceptual framework has been developed, generalisation beyond the domain to which that framework applies may be a long time coming, if it comes at all: i.e. there is a considerable tendency of knowledge towards compartmentalisation. It is instructive to contrast this with road safety training materials which begin from a focus on generalisation, in the hope that children will spontaneously extend what they understand in one context to another (e.g. comparison of the boundaries of classroom furniture to the kerbside, or training in observation skills within the classroom). Even if transfer of some kind does occur under these circumstances, the potential for misunderstanding which correspondences are salient is rife. Moreover, as the research in Chapter 2 indicates, it is in fact the case that even relatively small shifts in the context of road safety instruction (e.g., from street to traffic garden) can result in measurable decrements in useful learning. This provides a timely reminder that what constitutes a unitary domain to a child may, in fact, be even more restricted than we as adults might realise.

The implication then is that it would be better to focus on promoting development from scratch in the area in hand, and aim for self-contained advance (i.e. with circumscribed calls to outside knowledge). In the context of education more generally, where it can be argued that a major aim is to draw connections between different areas of knowledge, this approach might seem less than desirable. However, in road safety education, where the priority is the promotion of necessary pedestrian skills as rapidly and effectively as possible, everything would seem to point to this being the best way to proceed.

3.5 Summary

This chapter began by posing the question of why it was that methods involving practical training appeared to be the most effective means of instructing children in pedestrian skills. The survey of the main strands of developmental theory presented in Section 3.2 suggested that answer is that it is because they adhere to and so facilitate the natural progression of learning from specific actions to more general concepts; and more specifically that they almost inevitably make use of the underlying mechanisms of learning. In a nutshell,

skills and strategies cannot be taught solely by verbal means but must be built up from their constituent behaviours.

Having established this point, we went on to consider the issue of whether there are any inherent constraints on the timing and rate of learning that might have implications for the application of a training programme based on this principle. It was noted that previous assumptions about age-related constraints are based on a misconception of Piagetian theory, and that there is good evidence that learning is much more flexible than supposed, especially when appropriate interventions are employed. Whilst it would perhaps be misleading to state that there is no bottom age at which training would be effective, there is certainly good reason to suppose that it could begin as early as 4 years of age.

Finally, it was also noted that there is on the other hand considerable evidence for a previously little-recognised constraint, namely a tendency for learning to be domain-specific or compartmentalised. This suggests that road safety education can ill afford to assume any carry over from other areas of knowledge. It is important that training takes place within circumstances closely related to the ultimate context of use. The next chapter goes on to consider in more detail what developmental research has to offer apropos the methods such training ought to espouse.

Chapter 4
Implications of developmental theory for training

4.1 Relevance of developmental theory

Developmental theory provides clear indications as to why practical training in pedestrian skills has been found to be more effective than classroom approaches. It also suggests that, provided the focus is on promoting appropriate action using close analogues of the road environment, there is no reason why effective training should not begin with children of age 5 or even younger. However, we still need information about the precise format and methods of training that would be most effective. Here again, developmental theories (particularly contemporary extensions of the work of Piaget and Vygotsky) provide a framework for addressing this issue.

On the face of it, Piagetian and Vygotskian theory suggest rather different mechanisms for promoting development. For Piaget, the most important element is the experience of conflict between ideas and experience, or between one's own ideas and those of others as revealed during dialogue, since it is such conflict which promotes coordination. In other words, progress is held to occur through the internal resolution of externally-induced conflict. Whilst its potential importance has not been widely recognised until recently, there is good reason to suppose that discussion may be of particular value here. This is because it provides a greater scope for conflict (and its resolution) as a result of the ability of language to refer to aspects of the universe beyond those immediately present. Moreover, discussion may also serve to promote specific decentrations, since dialogue has the capacity for explicitly drawing attention to different, but related structures or schemes. In fact, Piaget and Inhelder (1956) directly emphasise the central role that social interaction might play in the growth of decentration.

It is important to note, however, that there are restrictions on the conditions under which dialogue would be useful. Not only is there an implicit requirement for participants to hold differing perspectives, but it is also likely to be the case that *peer* discussion will be considerably more effective than that between, say, an adult and a child. In the first place, peers will show a greater tendency to use the same type of language to refer to the same things, and are more likely to find the same aspects of experience to be salient. In addition, there are also relevant social effects: peers are more likely to question each other and to discuss competing perspectives. Adult-child interaction is more likely to result in the adult putting forward his/her own view for the child to accept, and the child acquiescing whether they understand or not.

In contrast to this, for Vygotsky, the central mechanism of learning is the guidance of action, especially via contingent, "corrective" dialogue (cf. 3.2 above). The main constraint is that the external construction of activity should take place within the zone of proximal development of the less able, i.e. that it must build on the child's existing capabilities. Assuming that this condition is met, joint activity of this kind will eventually become internalised as the *inter*psychological operation becomes established at an *intra*psychological level.

Despite the obvious differences it is not necessary to suppose that these mechanisms are mutually exclusive, especially given the complementarity of Vygotskian and Piagetian theory identified in Section 3.2. In both cases, there is an emphasis on the importance of social interaction - on *interactive learning* - and there is evidence that the two operate as alternative processes within interaction. From one viewpoint, this leaves it simply as a matter of empirical research to identify which is more likely to occur and to be productive under what circumstances. However, a strong case can be made that the Vygotskian approach is particularly suited to the learning of actions, whereas the Piagetian approach better facilitates conceptual advance. In part, this is a reflection of differences in the natural focus of the two theories. For instance, it seems intuitively plausible that the acquisition of practical skills will occur most naturally via interpersonal guidance and transfer (i.e. some form of apprenticeship model). On the other hand, understanding the reasoning that lies behind practical action seems to emerge most naturally as a result of task-centred debate, especially where individuals have slightly different perspectives (note that this could concern both strategic knowledge and more abstract concepts).

This idea of a natural ambit for the two theories is backed up by a considerable amount of evidence since the Vygotskian and Piagetian approaches map well on to specific types of established educational activity, namely peer (or adult-led) tutoring and peer collaboration respectively. Research on these two techniques provides a sizeable body of literature on which to draw vis-à-vis the operation of training and instruction methods and the circumstances under which they are effective. This chapter examines each in turn before considering what they have to offer in the specific context of road safety education.

4.2 Peer tutoring

Peer tutoring refers to a dyadic interaction in which one partner who is the more competent, tutors the other, less competent partner. The asymmetry of this relationship meets the basic condition required by Vygotsky for establishing the zone of proximal development, although it must be acknowledged that this in itself does not guarantee that the learning process that he describes will inevitably occur. However, research addressing the processes and outcomes of peer tutoring is on the whole supportive, indicating positive effects on learning in line with what would be expected, and defining conditions which appear to be favourable for the facilitation of learning which are again consistent with Vygotskian theory.

For instance, some indication of the effectiveness of peer tutoring is provided by studies which have utilised Piagetian conservation tasks, in which a conserving child has been paired with a non-conserver. Under this arrangement, non-conservers have typically been found to progress to the level of conservation (Ames and Murray, 1982; Murray, 1972; Perret-Clermont and Schubauer-Leoni, 1981). Moreover, this does not seem to be a function simply of interaction *per se*: in a study by Tudge (1992), only those non-conservers paired with conservers advanced following interaction. This would suggest that the differing level of competence of the partners is a crucial factor in the success of the interactive session.

As far as it goes, this suggests that peer tutoring might be better understood in terms of Vygotskian than Piagetian theory. Tudge certainly interprets his findings in this way, and also suggests that pairing with a more competent partner is a necessary (though not sufficient) condition for development. The more able partner, he argues, must also introduce reasoning to the discussion at an appropriate level for the tutee to understand, and the tutee must accept this reasoning (Tudge, 1992). This is, of course, consistent with Vygotsky's requirement that the dialogue of the more advanced individual remain within the zone of proximal development of the less advanced.

Despite this evidence, it is not possible to eliminate a Piagetian account of these effects, since the more experienced partner may have induced conflict in the less experienced partner, and it may be the resolution of this that led to the cognitive advance. It is therefore important that Azmitia (1988) provides further support of the Vygotskian interpretation. This author also found that peer collaboration led to greater learning in preschool children when they were paired with a more competent partner. However, Azmitia reports that analysis of the interactive episodes revealed that the learning was mediated mainly by observation and guidance of action, and not by cognitive conflict as would be required by Piagetian theory. This is consistent with Vygotsky's idea of the importance of "corrective dialogue" in the process of interaction with a more competent other.

Research has, however, indicated other factors that may have a mediating influence on the success of peer tutoring, and any attempt to assess its usefulness as an educational strategy must take these into account. In addition to the tutor possessing greater competence in the particular domain of learning, and being able to introduce reasoning at a level suited to the understanding of the tutee, a number of authors have suggested that peer tutoring may be more suited to some tasks than to others.

Thus, in a review of peer mediated and teacher mediated learning, Greenwood, Carta and Kamps (1990) point to the limitations of peer tutoring as a method of teaching high level conceptual skills. In support of this, the authors cite evidence from Greenwood, Delaquadri and Hall (1984) to show that peer tutoring improved performance on reading comprehension, but that this improvement depended on the learning of rote skills such as oral reading, spelling and reading rate. Similarly, we might note, apropos those studies which examined the role of peer tutoring in promoting conservation, that it is to some extent unclear whether what was acquired by initial non-conservers was a genuine conceptual grasp or simply a series of appropriate responses to a specific task. Also consistent with this line of argument is the assertion of Damon

(1984) that peer tutoring is best suited to tasks which are rule-governed and which concentrate on the exchange of skills and information. Damon and Phelps (1989) conclude that peer tutoring is most effective when applied to learning a skill which has been partially acquired but not yet mastered. Again, though, these points are all consistent with the general tenor of Vygotskian theory, as outlined in earlier sections.

In the present context, however, one further issue of particular significance is highlighted by reports of apparent limitations in children's role-taking abilities, tailoring of verbal direction, and sensitivity to others. So, for example, Peterson, Danner and Flavell (1972) found that young children lack the skills of knowing what form of help is required by the other, and have trouble ascertaining the nature of the problem (see also Foot, Shute, Morgan and Barron, 1990). Furthermore, children make less use of verbal explanation in the tutoring process than do adults, with adults tending more often to give information regarding processes, rationale and purpose (Ellis and Rogoff, 1982; Mehen, 1977). Given other parallels between peer tutoring and adult-child interaction, it seems worthwhile exploring the possibility that the latter might actually be more effective.

4.3 Adult-led tutoring

Certainly, as Rogoff (1986) points out, adult-child interaction can be regarded as being as much of a step away from the traditional direct instruction model as peer tutoring. She considers the interaction to be one of "guided participation", which again has similarities to the Vygotskian notion of the corrective dialogue. As already implied, one of the potential strengths of adult-child interaction is the degree of tutoring skill that an adult may have in comparison to that of a child. For instance, adults tend to be more sensitive to the misunderstandings of the tutee, and may be better able to respond to requests for help (Foot *et al*., 1990). In their discussion of the processes of interactive learning, Tudge and Rogoff (1989) conclude that adults are particularly effective partners when promoting skills in which they are expert. So, for example, Radziswewska and Rogoff (1991) found that 9 year-old children gained more skill in errand planning through collaboration with parents than with peers.

The competence of the partner (in terms of both task-specific and more general tutoring skills), and the locating of the discourse within the less able partner's zone of proximal development appear, then, to be the crucial factors. In the context of road safety education, this would suggest that adult-child interaction has the potential to make concrete the skills involved in road crossing, and thus to provide an important element within a programme of practical training (cf. the research referred to in Chapter 2 on adult-led training of visual timing judgements and safe place finding). This might be especially so if use were made of trained adults who have sufficient understanding of the child's capabilities to pitch their behaviour so that it falls within the zone of proximal development.

In this regard, Wood (1986) not only emphasises the role played by adult tutors in "scaffolding" children's performance on concrete tasks (and hence their acquisition of relevant skills), he also identifies a general principle underlying successful tutoring, namely varying the degree of guidance that is given according to the tutee's behaviour. According to Wood, tutors have available to them five possible levels of guidance. In order of increasing specificity these are: general verbal prompts; specific verbal instructions; indication of key materials; preparation of materials ready for action; and demonstration of action. Effective tutors begin the session employing the most general level of guidance, but increase the level of specificity whenever the tutee is unsuccessful, and increase the level of generality whenever the tutee is successful. In essence, when this system is employed the tutor's input is tailored to provide support and guidance where it is most needed, and within the zone of proximal development. However, it should also be noted that Wood does report difficulties in training adults to use these techniques in a consistent fashion, indicating a need for further research.

Finally, Wood's work also has some interesting implications for resourcing issues. Superficially at least, one potential limitation on the adoption of adult-led training in this format would be the time constraints that would arise out of using it on a one-to-one basis. However, Wood's model of contingent control was derived in part from observation of expert tutors in the classroom context. This suggests that it ought to be possible to operate it in a "time-sharing" mode, at least with small groups of children, without effectiveness being greatly impeded. Whether this is in fact the case in the context of road safety education is a matter for further

research, but the work of Thomson *et al*. (1992) on small-group training in safe place location does provide some support for this notion.

4.4 Peer collaboration

Peer collaboration refers to a situation in which the interaction between peers is not as structured as in a tutoring session, but involves individuals working together to establish a joint solution to a specified problem. Furthermore, peer collaboration as a descriptive term is equally applicable both to the group situation (typically involving somewhere between three and six individuals) and to that of a dyadic interaction. Unlike peer tutoring, peer collaboration does not stress the importance of different levels of competence, although there is evidence to suggest that different *perspectives* may be important in the success of collaborative work among peers. Howe, Rodgers and Tolmie (1990), for example, found in two separate studies that conceptual advance in primary school children was increased by group interaction where group members differed in their initial viewpoints, but not where these were the same. Crucially, in half of these cases groups had been composed so that, although individuals differed in the *content* of their ideas, they were at equal levels of competence as measured against objective criteria.

Findings of this kind not only suggest that the processes mediating advancement through peer collaboration may be different from those operating in peer tutoring, but also provide specific impetus to the Piagetian account. Consistent with Piaget, Howe *et al*. placed considerable emphasis within their tasks on exchange and negotiation, and on the importance of the group trying to achieve a joint solution, because it was anticipated that this would promote dialogue about ideas and impressions, allowing differences between these to serve as fuel for individual advance. Similarly, a number of other researchers have also reported that when two novices work together under the same kind of task conditions as employed by Howe *et al*. they advance more than they do when working alone (e.g. Doise and Mugny, 1979; Emler and Valiant, 1982; Damon and Phelps, 1989; Berkowitz, Gibbs and Broughton, 1980). The one limitation to many of these studies is that they concentrated on outcome measures, and as such failed to provide adequate information to clarify the *processes* by which observed improvements were mediated.

Doise and Mugny (1984), in fact, suggest that the processes involved in collaborative learning are, at least in part, in line with Vygotsky's theoretical position. They consider conflict to be a crucial motivating factor (hence the importance of individuals bringing different perspectives to the task), but in the sense that this socio-cognitive conflict forces the participants into the formation of a joint resolution. This joint understanding, they argue, is then internalised by the learners in a manner which is consistent with Vygotsky's notion of the shift from interpsychological to intrapsychological functioning.

Howe, Tolmie and Rodgers (1992), however, provided important evidence to suggest that this is in fact not the process by which development is mediated in group collaboration, at least at primary school level. Their study examined different groups of children working together on a task relating to the motion of objects down an incline. The authors reported positive effects following collaboration, but there were two points which indicated that internalisation of jointly constructed understanding could not be the mechanism at work. The first of these was that in the group sessions there was little sign of any joint understanding being established. The second was that on an immediate post-test the performance of group members was no better than at pre-test; it was only on a delayed post-test a number of weeks later that the performance of children was found to have improved, and careful questioning revealed that this was, moreover, not attributable to them having engaged in any relevant activity in the interim.

On this evidence, then, the effects of collaborative work are indeed best interpreted in Piagetian terms, with conceptual advance being seen as a result of the private resolution of cognitive conflict generated by the airing of different ideas within the task itself. When seen in this light, the role of group discussion would be primarily to serve as a catalyst for change. Further evidence in favour of this is provided by Howe *et al*. (1992a), who found that one type of group with different perspectives did not show increased advance. It was noted afterwards that, despite their differences in understanding, these individuals would have tended nonetheless to have arrived at the same solutions to the problems the group was working on, and thus would have had no basis for realising that they did differ. In other words, dialogue will only be effective if conflicts are actually identified.

Similar support is provided by Tolmie and Howe (1993), who report on a study which examined the effects of collaborative work on secondary school pupils' understanding of the trajectories followed by falling objects. It was found in this case that measures of the degree of initial difference between participants' understanding predicted both the amount of in-group discussion of different explanations and the extent of pre- to post-test conceptual advance. Again, Tolmie, Howe, Mackenzie and Greer (1993) found that when group discussion amongst primary school children was left to follow its own course, conceptual advance was strongly predicted by the amount of in-group discussion of different ideas, but only at a delayed post-test eleven weeks later. A related effect is reported by Webb and Kenderski (1984), who found that the children who showed the greatest benefits of interaction were those who gave explanations to their peers most frequently.

Evidence for the importance of dialogue in learning is also provided by studies of the effect of friendship on the success of collaborative work. Aboud (1985) and Nelson and Aboud (1985), for instance, found that friends collaborate better than non-friends. More recently Azmitia and Montgomery (1993) found that friends benefitted more from collaboration than did acquaintances, although this effect was only evident on more challenging tasks. In particular, though, these authors noted that collaborating friends engaged in more "transactive dialogue" than acquaintances, this referring to the exchange of ideas, criticisms, explanations and elaborations. The authors concluded that this was the most important factor in determining the higher level of performance. That Kruger and Tomasello (1986) and Kruger (1993) have found that adult-child partnerships rarely produce as much transactive dialogue as peer dyads, serves once again to highlight differences in the processes implicated in peer collaboration and in tutoring sessions.

It is important to note, however, that there are reasons to suppose that the impact of dialogue within collaborative work has the potential to extend beyond that of merely generating cognitive conflict. For Piaget, connections and coordinations depended on the child having access to different possible perspectives, and this access was in turn strictly dependent on conscious thought (cf. 3.2 above). One implication of this is that the discussion of ideas might actually serve to encapsulate specific perspectives in an explicit and manipulable form (i.e. fuelling decentration). Where discussion is rather disordered, as may often happen when primary school children are left to follow their own course, this may reduce to an effect of conflict, with subsequent progress dictated by the extent to which the child is able to make productive coordinations amongst the different elements which have been thrown up. Where greater order is imposed, however, dialogue may have the capacity to signal in relatively direct fashion something of what those coordinations should be.

Consistent with this, Tolmie *et al*. (1993) found that when groups of children were required as part of their activity to generate running summaries of their conclusions, advance was no longer predicted by the amount of discussion about different ideas, but by the quality of those summaries. It should be stressed that this was not the kind of process outlined by Vygotskian theory (cf. Doise and Mugny, 1984), since the effects were still not apparent until a delayed post-test. It was not, then, that children were internalising a joint construction, but rather that they were making private constructions along lines which had been signalled by resolutions achieved in-group.

What this indicates further is that at root everything may hinge upon task construction. In general terms, Tolmie *et al*. (1993) demonstrated that by constructing tasks in a certain manner it is possible to shape dialogue to achieve specified educational goals. That this is possible is not in itself a new assertion: Webb (1989), for instance, also suggested that interaction could be structured so as to promote the giving of explanations. Again, that task format had such a profound influence on dialogue, which in turn affected learning, is in part simply more support for the notion that dialogue is a central feature in collaborative learning. However, what this study revealed in addition is that it is not necessarily the extent of dialogue that is important, but the quality of discussion of relevant factors and what use this is put to. The finding that tasks can be structured so as to yield control over *this* aspect of collaborative work is extremely important both for future research and for the implementation of these techniques.

Finally, the question remains as to whether there are particular tasks and areas of learning which are best suited to the use of peer collaboration. In the previous section, evidence was presented which suggested that tutoring procedures were better suited to the learning of skills or to enhancing performance on tasks which are essentially rule-governed and do not require the development of new conceptual understanding. In

contrast, the work of Howe and colleagues (Howe *et al*., 1990, 1992a,b; Tolmie and Howe, 1993; Tolmie *et al*., 1993) demonstrates the efficacy of peer collaboration for promoting conceptual advance.

Damon and Phelps (1988) examined this issue more directly by presenting dyads of 9 and 10 year-old children with a series of mathematical, spatial and physical tasks. They found progress following interaction, but the gains were restricted to certain tasks. Improvement was reported on ratio and proportion tasks, perspective taking tasks and problems involving ratios and equilibrium. There were no gains on addition, subtraction and model building tasks. In other words, the tasks where collaboration had produced benefits were those which required children to grasp new insights and concepts; tasks which depended more on specific instructions and accurate reproduction skills showed little effect. This finding was in line with the analysis of different interactive learning structures carried out by Damon and Phelps (1987), who concluded that peer collaboration was likely to be particularly suited to the advancing of conceptual understanding.

Note, however, that the focus of collaborative tasks addressed at conceptual advance is still directed towards action of some kind. It is crucial to recognise that there is no evidence that discussion in the abstract would be effective. The key elements of dialogue for collaborative learning arise not in isolation, but out of attempts to decide between conflicting proposals for the solution to a concrete problem i.e. as part of a process of justification (c.f. Howe *et al*., 1992a). Where this explication of concepts as relevant to action does occur, however, all the indications are that it has immense potential for sparking robust, useful learning. Whilst there is little evidence as yet of how this potential might translate into improved performance in the specific context of pedestrian tasks, it is worth noting that the theoretical account of peer collaboration offered above goes a long way to explain why Thomson *et al*. (1992) found group-based training that included peer commentary to produce learning which showed no decrement over time.

4.5 The practicalities of interactive learning

Overall, then, there does appear to be considerable educational benefit to be gained from careful implementation of interactive learning techniques. In theoretical terms, the available evidence suggests that both Piagetian notions of conflict and coordination and Vygotskian ideas of co-construction in the zone of proximal development are implicated in interactive learning, but that tutoring is more suited to a Vygotskian analysis whilst peer collaboration is more in line with Piagetian theory.

In more practical terms, there is also evidence that both peer tutoring and the guided participation involved in adult-child interaction are likely to be best suited to the learning of skills. However, since younger children may find peer tutoring problematic as a result of difficulties in adopting the roles required by the interaction, a programme of adult-child interaction is likely to be of more use with this age group. Although this requires a sensitive approach on the part of the adult tutor (cf. Wood's points on shifts in the level of guidance provided by tutors), together with an ability to operate within the understanding of the child, the evidence suggests that in areas of relative expertise this may be to some extent spontaneously forthcoming (cf. Thomson, 1993).

Peer collaboration, on the other hand, would appear to be more useful in the promotion of conceptual advance. In the collaborative situation, when children work together they are more likely to engage in the productive exchange of ideas detailed by Piagetian theory than when they work with adults, since they share the same language. This does not mean relinquishing control of the learning process, however, since careful task design will enable much of the character of the group's dialogue to be determined by the educator. Nor should there be any problems with regard to group composition. Admittedly, the success of peer collaboration is dependent upon participants having differing perspectives, and this might seem at first sight to present practical difficulties vis à vis deciding which children to put together. However, Tolmie *et al*., (1993) and Howe, Tolmie, Greer and Mackenzie (in press) have both shown that the necessary degree of difference can usually be achieved via random allocation. In fact, the findings of Azmitia and Montgomery (1993) point to an even more practical conclusion, namely that the most productive option is likely to be to let children work in friendship groups.

There is no doubt, however, that the structuring of the group both in terms of composition and, more importantly, task set is crucial to the effectiveness of the interactive learning approach, especially with young children. Apart from anything else, structuring is necessary to ensure that each child can make a

contribution to the group goal and, in so doing, to create conditions for children to become immersed in the group activity. Studies of children's naturalistic interaction reveal that only 13-16% of their interaction time is cooperative or helpful (Hertz-Lazarowitz, 1990; Hertz-Lazarowitz, Fuchs, Sharabany & Eisenberg, 1989). Even in cooperative work groups only 16% of all dialogue involves sharing knowledge and providing or receiving explanations (Bennett, l99l). By contrast, appropriate structuring of the group activity can serve to promote much more frequent speech in individual children - speech which involves the exchange of information, giving help, offering explanations, asking questions, seeking clarification and elaboration. All of these play an important role in children's intellectual functioning (King 1990; Sharan & Shachar, 1988; Webb, Ender & Lewis, 1986).

The effective use of peer collaboration therefore hinges upon the appropriate organisation of the group's activities. An instructional programme for road safety would need to guide the teacher clearly in how to structure the children's dialogue and debate, according to the age and level of understanding that the children have reached. The teacher would also need to be briefed in how to set up conditions and activities which are challenging and which will provoke debate, question-posing, justification, explanation and elaboration. Children may be quite astute at spotting contradictions and disagreements between each others' points of view but they are not necessarily adept at generating the kinds of discussion around such conflicts that we know to be productive.

Given this kind of resource cost, it it is perhaps important to emphasise that there are considerable practical advantages to peer-based learning methods over more traditional whole-class teacher-led instructional methods.

- Interactive learning enables class teachers to manage large numbers of pupils while ensuring that their time is spent productively in learning activities (Sharan, 1990). Children are typically assigned to dyads or small groups to work on relevant tasks while teachers move among the groups to offer assistance and monitor progress. Teachers using traditional instruction methods present information as if the class was homogeneous with respect to their skills, ability and motivation. They often have little time to interact with individual children and facilitate learning because of the need to manage behaviour and maintain discipline (Kagan, l986).

- Interactive learning methods encourage children to be fully participative members of small work groups and to work together, taking responsibility for their own learning as well as helping to move the group forward (Johnson and Johnson, l990).

- Such methods encourage children to assist, guide and support others by sharing information and ideas while working together on a group task. There is considerable evidence that group work encourages a high degree of engagement in the group task which promotes cognitive effort and social relationships within the group (Damon and Phelps, 1987; 1989; Sharan and Shaulov, 1991).

- Interactive learning has a positive effect on pupils' classroom behaviour, producing a decline in pupils' boredom and disruptive behaviour (Hertz-Lazarowitz & Shachar, l990). These changes may be attributed to the children's involvement in making decisions which affect their own work and to the shift in the teachers' role in offering guidance rather than in directing them.

These points are as yet still very general. It remains necessary to identify how adult-child interaction and peer collaboration could actually form the basis of specific educational applications in the road safety context. This task is addressed in the remainder of the chapter.

4.6 Implementing interactive training strategies in the context of road safety

The first part of this chapter established the educational potential of the class of techniques known collectively as interactive learning. More specifically we identified adult-led, guided participation as particularly appropriate to skills training whereas peer collaboration is especially appropriate to the promoting of conceptual understanding. Given the identified need for road safety education to impart both skills and the conceptual framework for deployment of those skills, the implication is that it could benefit from carefully structured implementation of some of the principles of interactive learning.

From this point of view, a complementary programme of adult-child interaction and peer collaboration would seem to be the most promising avenue to pursue. Adult-child interaction could be employed to develop practical roadside skills using a hierarchical progression from relatively simple tasks, such as crossing a quiet street, to the more complex action plans and strategies needed to interact with busier roads and more complex traffic layouts. The fact that skill development is best undertaken in the roadside context is another reason for taking an adult-led approach to such learning, since the adults are required anyway for safety reasons. On the other hand, there is no reason why group discussion and argument should not be included as part of the training procedure, with the adult taking more of a background role in order to promote group collaboration.

Such a programme of guided participation could therefore be backed up by related group work, not just at the time but also later in an appropriate classroom context, where the aim would be to broaden the children's conceptual understanding beyond the concrete situations encountered at the roadside. Two issues are critical here, however. Firstly, the roadside visits are absolutely crucial, because they provide a context which the children can 'bring back' to the classroom with them. This greatly improves the chances that when the teacher refers to road situations, traffic actions, and so on, the children will know what she and everyone else is referring to. This 'shared cognition' is indispensable because, without it, there would be little common ground and therefore insufficient focus for the classroom activities. Secondly, it is essential that the classroom activities used to develop the roadside work should also provide as meaningful a context as possible. This maximises the chances of the children generalising their experiences at the roadside to the new context. Table-top models of traffic layouts have been successfully used to do this but other materials, such as videos, might well establish a suitable classroom context for at least some activities. When used conjunctively in this way, the two strands of practical and classroom activities could be expected, over time, to promote the development of a relatively sophisticated model of traffic that could guide practical action in a wide range of situations - including many that had never been encountered in real traffic.

4.7 Examples of training

In order to lay the foundations for developing an integrated educational programme in the road safety domain, it is necessary to set out in more detail how the principles that have been described could be operationalised in practical educational ways, and how classroom and other activities could be structured accordingly. We are not attempting here to specify any kind of training package but rather to provide an example of the kinds of activities that could be developed. To do this, we will consider the case of safe place finding which seems to pose a considerable conceptual challenge to younger children but which nevertheless appears to be amenable to training. Other skills could be addressed in a similar way, with appropriate modifications to the general procedure.

4.71 Road-side activities

The rationale for teaching children at an early stage how to recognise dangerous roadside locations and how to find safer ones has already been discussed in detail in Chapters 1 and 2. Although it has generally been assumed that children can do this, recent research has shown that children under the age of about nine show little insight into what constitutes a dangerous crossing site, typically regarding such sites as perfectly safe (Ampofo-Boateng and Thomson, 1991). Thus, crossing between parked vehicles, on the brow of a hill, or at a sharp bend are regarded as safe activities by most younger children.

A strong case has already been made that dealing with these errors in abstract terms is unlikely to be effective. Road-side training programmes are therefore needed which take children through the practicalities of safe place finding, and which adopt a structured learning approach focusing on the most common errors made by young children. The aim would be to help the children discover what is dangerous about such situations through their *own* rather than through *our* reasoning. There is thus no question of simply issuing children with a 'list' of places to be avoided. There is so much variation in the form that dangerous sites can take that such an approach would be ineffective. However, by promoting conceptual understanding and appropriate reasoning strategies, children can be taught how to deal with *any* such situation, not just those figuring on the 'list'. The difference between these approaches is fundamental.

In promoting recognition of what is dangerous about some locations and safe about others, it is likely that a good deal of adult guidance would be required, at least in the early stages. However, the use of group training at the road-side would also afford opportunities for the benefits of collaborative work to play a part. It seems likely that this would be particularly useful once the children had begun to develop some rudimentary understanding of the problem. At this stage, it is likely that differences of perspective would develop among the children, the exploration of which would generate the necessary conflict for conceptual advance to emerge within the individuals in the group. This would suggest that the first sessions might be primarily adult-led, with the balance towards collaborative work increasing as the programme continues.

Translating this into action, the trainer might proceed as follows. At each location a child could be selected from the group and asked to indicate where it would be safe to cross to a specified destination. The other group members could then be asked individually to comment on the proposed route, opening up a discussion about the best route. Training would continue with the teacher/responsible adult encouraging the children to consider issues such as visibility from the chosen crossing point; whether the position permits the pedestrian to see far enough ahead; what 'far enough ahead' means in the present context; whether or not this could be improved by moving elsewhere; and so on. By judicious use of questions, prompts and praise trainers could discreetly direct the group in particular directions without imposing their own point of view too heavily and thus without undermining the group discussion. When eventually an acceptable solution were found, the group could then move to a new site: if no acceptable solution were forthcoming, the trainer would eventually have to demonstrate a good route, explain why it would be more suitable than the others, and encourage the children to make similar choices at future locations. However, in order to maximise the children's own input, it would be necessary to use such intervention only as a last resort. On the other hand, it would help define the standard which the children are expected to aim for and could be useful in this regard.

At future sites, it would be important to select a different child to make the primary judgements so that all the children would be given the opportunity both to propose routes and be discussants of other people's proposals. This would maximise their experience by forcing them to consider the problem from the various perspectives offered by other children (or the trainer). It would also help to avoid the adoption of fixed roles within the group, such as the emergence of dominant and submissive partners.

In order for all members of the group to have an equal chance of participating, whilst at the same time ensuring that there are several perspectives to debate, it would seem sensible to use group sizes of between three and five children. Larger groups should certainly be avoided in the case of roadside visits because of the safety implications, unless two or more trainers are available. Smaller groups would obviously reveal fewer perspectives (or, indeed, no difference of perspective at all). More details of how to structure group activities around these themes are given in Thomson *et al*. (1992) and Ampofo-Boateng *et al*. (1993).

This training approach is highly realistic to the children; it invokes all the desirable elements of a fully engaging debate, challenging the children's own perspectives and encouraging them to discover and learn about the difficulties associated with their own choices of action. It also provides the context for understanding that their peers may have different and perhaps better ideas and that the perspectives of other road users, like drivers, have to be taken into account. Above all, this structured approach is aimed at teaching children the *principles* underlying safe actions and procedures and actively discourages them from thinking that road safety education is about adhering to drills or sets of rigid rules.

4.72 Classroom-based activities

Once children have been exposed to the practicalities of the road-side, there is much work that could be carried back into the classroom. The actual situations they have confronted could be translated into a range of classroom exercises, some addressing traffic situations similar to those that were actually experienced, others extrapolated from them. This supporting programme would be best constructed around collaborative group work aimed at further developing the children's conceptual understanding on the basis of their existing concrete experience. As already indicated, it would be necessary for these activities to take place in as meaningful a context as possible so that the children could extrapolate their road side experience to the new situations. In the case of teaching safe route finding, one possibility would be to use table-top street models with houses, vehicles, miniature doll-pedestrians, and so on that can be used to create quite a realistic (and

highly popular) traffic environment. Such contexts are visually attractive to young children, can be carefully controlled, and enable the trainer to contrive tasks around which group discussion can be structured. There is no need for the models to closely resemble the road environment that the children visited previously, except insofar as bends, obscuring obstacles, intersections and so on can be set up on it. Such models have already proved effective in improving children's safe place finding skills and appear to have validity as training devices when 'primed' by a small amount of experience at the roadside (Ampofo-Boateng & Thomson, 1991; Thomson *et al*., l992; Ampofo-Boateng *et al*., 1993).

It seems likely that interactive learning could be developed around other tasks designed for classroom use such as photographic, video or computer-based materials. These could be used to illustrate a variety of potential crossing sites such as bends, hills, parked cars and intersections of different kinds. Little evaluative work has been done on the effectiveness of such materials in the context of the skills under discussion, but it seems likely that they would have a useful role to play, if used sensibly. On the positive side, videos and slides/photographs increase the realism of the scenes relative to models. On the negative side, the children would likely be involved in a more passive role when using such materials, which could be a disadvantage of such materials relative to models. Of course, different materials could be used for different purposes - for example, videos permit children to observe dynamic events which would obviously be harder to contrive using models. With models, on the other hand, it is easier to get children to choose routes or to build a safer location by reconstructing the road layout and so on. Thus, different materials could be used to emphasise different aspects of pedestrian competence, which would seem to be important in producing the rounded experience that the child required. Research should obviously be directed at how different materials of this kind could be deployed in developing different aspects of pedestrian skill in children of different ages.

The value of classroom exercises in complementing road-side practical training is, firstly, that they can be developed to present challenges and group activities to children in many different structured ways, and, secondly, that they can encompass a much wider range of potential crossing situations than practical road-side training could possibly achieve. They can therefore help in developing more general experience and understanding as the children seek to generalise the skills they learned at the road-side. The road-side experience is paramount, however, in setting the overall context for such learning and in ensuring that the real world continues to form the framework within which children's conceptual development takes place.

4.8 Summary

In this chapter we have explored the merits of two approaches to learning which might be employed to promote pedestrian competence: those in which the child learns by working with a more experienced other (usually, though not necessarily, an adult); and those in which they learn for themselves by working with other children of similar age and experience. Both approaches promote learning, but it seems that the former is best suited to developing underlying skills and strategies whereas the latter is particularly useful in promoting conceptual understanding. Since both are necessary to the development of traffic competence, it would seem appropriate that both approaches be incorporated into any training programme. Since practical roadside training must be adult-led, if only for safety reasons, it seems sensible that roadside sessions should be devoted to the skill and strategic elements of road safety education - although there is no reason, in principle, why more conceptual issues should not be addressed there as well. However, the advantage of classroom activities is that they can complement roadside training by creating scenarios that go far beyond what the children would be able to experience directly in real traffic. They would also provide a platform for collaborative work and for the promotion of conceptual understanding for which this technique is particularly useful. We have discussed some of the ways in which roadside and classroom activities might be structured to accommodate these complementary educational approaches. However, more research should be directed at how this might best be done.

Conclusions and Recommendations

Before making specific recommendations with regard to future research, we would like to emphasise a number of more global points that cut across those recommendations and form the context for them.

1. We consider the specifying of a general theoretical framework to be an indispensable requirement in the effort to develop effective and coherent educational countermeasures. In the absence of such a framework, countermeasures are never more than *ad hoc*. The lack of a serious and explicitly-stated theoretical rationale is, we believe, at the heart of the sense of malaise that is currently detectable in the field. Our aim has been to propose a rationale which, we believe, would meet with general approval both from developmental psychology and educational science. Whether it meets with approval from within the road safety field remains to be seen.

2. It is important that far more consideration should be given to *behaviour*: that is, to what different groups of pedestrian actually *do* in traffic. Since the overall aim of road safety education is to get children to behave in a safer and more skilful way, an obvious starting point would be to examine what 'expert' road users do that is different to what 'novices' do. For example, since adults have many times fewer accidents than children in spite of massively increased exposure to risk, it would seem sensible to analyse the characteristics of their behaviour in different traffic situations. This might then provide a starting point for the formulation of educational objectives. Unfortunately, hardly any road safety programmes in this country have been developed on this basis. Instead, objectives have been set mainly on the basis of indirect criteria and on assumptions as to what children can and cannot do. This is not a strong basis from which to develop countermeasures aimed at combating what is, after all, the major problem of child health today.

3. The view that, for maturational reasons, children cannot be expected to cope with anything but very simple traffic environments and are incapable of co-ordinating several variables at once needs to be re-assessed. The evidence shows that, even at a very young age, children's actions and decision-making can be raised to a more sophisticated level, provided that appropriate training is provided. This point applies not only to the road safety field but to other fields of education as well. Whilst a good deal of progress has been made in this area, further research should be carried out to identify those skills that are trainable and the optimal conditions under which training should be conducted, taking into account the age and experience of the children involved. Further research must be conducted to inform about the types of training that are most sensitive in achieving these objectives.

4. There is strong evidence that practical training is by far the most effective means of improving children's skills and judgements, particularly among younger children. In spite of widespread use, verbal approaches that concentrate primarily on the acquisition of knowledge and attitudes have not proved to be an effective way of improving the behaviour of children in traffic. There are strong developmental reasons why this should be so and we have commented on these in depth in this report. The arguments cast considerable doubts on the efficacy of much traditional road safety education. Although practical training has been advocated in major reports for at least 15 years, they have not been widely implemented for a variety of reasons, including the perceived resource implications. There is a strong need for the problems involved in implicating practical training to be addressed, with a view to determining how best such approaches might best be made.

5. To this end, interactive learning approaches hold out considerable promise. It must be emphasised that these approaches differ fundamentally from traditional didactic teaching methods, drawing instead on the basic premise that learning takes place in a social context and that the significance and meaning of actions are shaped by the value attached to those actions by others, especially by peers. The social context of learning therefore provides opportunities for children to try out and explore the implications of their own ideas and decisions before committing themselves as individuals to the hazards of the traffic environment. Research evidence from other educational settings suggests that interactive learning would be entirely appropriate for helping children develop a deeper understanding of the principles that govern safe and dangerous traffic behaviours.

6. Finally, it should hardly need stressing that any educational method, whatever its merits, is only as good as the content it aims to teach. It remains a problem in road safety education that objectives do not adequately specify the concrete outcomes that are to be expected as a direct result of the programme. Correspondingly, outcome evaluation has not generally achieved a high priority in road safety research, although there are recent signs that this situation may be changing. The latter trend is very much to be welcomed and should be encouraged.

This review of the literature suggests the need for both basic and applied research. Among the main needs are the following:

1. To develop a more comprehensive taxonomy of the skills necessary to interact safely with traffic. A number of these has already been discussed in this report. This analysis should be extended to give a more comprehensive picture of the skills involved and the ways in which they are deployed in different traffic situations.

2. To identify a hierarchical, age-graded progression of the skills involved in traffic behaviour, from simple to complex. Any educational programme should fit into an overall plan whose aim should be to develop road skills in a systematic and hierarchical manner, taking into account the age and previous experience of the child. Each programme should thus evolve out of the achievements of previous programmes and lay foundations for the next. No comprehensive plan of this type exists at rhe moment.

3. To explore children's attentional and visual search strategies in the context of traffic behaviour. The evidence suggests that children begin to demonstrate the rudiments of a systematic search strategy around 5 years of age. However, it is apparent that children remain susceptible to the distracting effects of salient cues even once they have developed the capacity to carry out an organised search. Future research should examine what children of different ages find most salient and distracting. Laboratory studies show an early preference for colour over form and texture over shape but in the context of road behaviour what is it that children focus on? For example, one observation is that children often focus on cars whereas adults focus on gaps. This implies a shift from perception of the environment in terms of purely physical features to a perceptual strategy which is bound to action. More work is needed to clarify this shift towards an action-based framework for making perceptual judgements.

4. To examine whether improved visual search and attentional control strategies can be taught to children and, if so, at what ages. The importance of training children to improve their visual search and attentional control cannot be over-emphasised as it seems highly likely that these capacities are related to distractibility and accidents involving 'dashing out'. Already programmes have been developed in Germany that use behavioural techniques to improve this aspect of children's behaviour. Further research in this field is badly needed.

5. To further investigate the nature of cognitive failure, impulsivity and distractibility. It has already been suggested that these may be related to attention and visual search deficits. The question of individual differences in cognitive style would seem worth exploring, particularly in relation to the dimension of impulsivity-reflectivity. While this dimension has perhaps not proved as useful as had been hoped, it has not been extensively invoked in relation to road safety judgements and this seems worth investigating. For example, the dimension may formally relate to the distinction between exploration and search (see Chapter 2) and may reflect either temporary or more permanent features of an individual's cognitive style. Whether training can help reorient an 'impulsive' individual's attention and search strategies is an important area for research.

6. To ascertain whether children have an accurate assessment of their movement capabilities and can calibrate this to visual information (e.g., road width) or other sensory information (e.g., auditory information about approaching vehicles). Such perceptuo-motor calibration would seem to be particularly dependent on practical experience.

7. To explore possible behavioural differences between boys and girls that might explain the greater vulnerability of boys on the road. In view of the massive difference in vulnerability, it is surprising that we have no really convincing explanation of what gives rise to this difference. It seems likely that the effect will

be partly explained by difference in exposure, although the evidence for this is also surprisingly flimsy. Further research on these sex differences is required.

8. To explore how close an analogue to the real traffic environment is needed for classroom exercises to be effective. Whilst training at the roadside is likely to be the ideal to aim for and may be essential for some skills, it is clear that simulations using, for example, table top models can be effective in relation to others. It is possible that improvements in even basic perceptual judgements might be induced through appropriate simulations. For example, film or video might improve children's timing judgements or gap selection strategies. Computer simulations might serve a similar function. Given the practical difficulties of conducting extensive training at the kerbside, the possibility of improving judgements in this way should be given careful consideration.

9. To develop suitable methods of training for relevant road crossing skills. It has already been suggested in Chapter 5 that adult-led or peer tutoring may be appropriate for the learning of many kinds of skill, whereas peer collaboration is likely to be of more benefit in promoting conceptual advance. Research is needed to establish the validity and generality of interactive learning approaches to road safety.

10. To evaluate the efficacy of different types of guided instruction or collaborative work for the acquisition of different kinds of skill and understanding. Assuming that interactive learning is effective, research needs to identify which types of group work are most appropriate for different tasks, and what the size and composition of the groups should be.

11. To explore the effectiveness of different trainers in effecting change in children of different ages. This raises the question of who should undertake road safety training. Can parents make effective trainers or should training be left to professionals such as teachers or road safety officers? Although the involvement of parents is often advocated, few studies have explored the effectiveness of parents as trainers. Studies should be conducted to establish how effective different types of trainer are likely to be with children of different ages and whether their effectiveness varies according to the complexity of the material being taught or other factors. This could have important implications for policy.

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