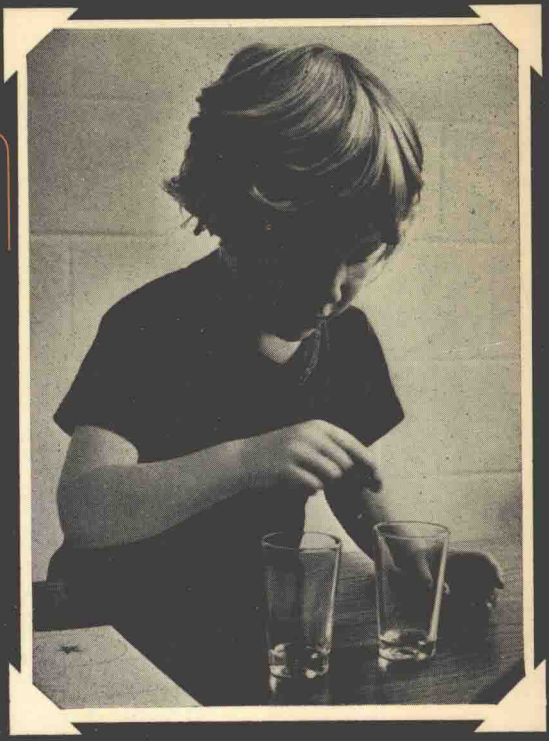
PERCEPTION & UNDERSTANDING IN YOUNG CHILDREN



An Experimental Approach

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Methuen & Co Ltd

First published in 1974 by
Methuen & Co Ltd, 11 New Fetter Lane, London EC4P 4EE
First published as a University Paperback in 1975

Printed in Great Britain by
Whitstable Litho Ltd, Whitstable, Kent

ISBN 0 416 79440 8 (hardbound edition)
ISBN 0 416 70390 9 (paperback edition)

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Foreword and Acknowledgements

Nowadays most books on psychology start with a *caveat* or two. I have a particularly pressing obligation to do so. The reader should be warned that this book is *not* a review. Although the book is based around the implications of some extremely well known developmental experiments, such as the conservation, the transposition and the transitivity experiments, I have not tried to cover the vast literature which exists on these different ways of looking at children's behaviour. Instead I have concentrated on the logic behind the design of these and other developmental experiments and have illustrated my argument with only a few key studies.

Inevitably some of my conclusions will be controversial, but perhaps this is not a bad thing. Fifteen years or so ago child psychology used to be a tranquil and also a relatively undervalued branch of psychology. Now the tranquillity has gone completely and at the same time the interest in children's behaviour has grown enormously. I think that these two changes go hand in hand. Having something to argue about is usually a sign of health in psychology.

Most of the argument which this book puts forward is the product of the research in which I have been involved over the past six years in Oxford. Very little of this research would have been possible without the help of my colleagues and friends, Jane Weightman, Pauline Jones, Vicky Claxton, Wendy Lawrensen, Cherie Bettison and Susan Martin. We had generous support from the Mental Health Research Fund, the Social Sciences Research Council and the Medical Research Council.

I was also extremely fortunate to have friends in the Department of Experimental Psychology at Oxford whose advice and criticisms were always acute and interesting. I am particularly grateful to Dick Passingham, Paul Harris and Jerome Bruner for having taken my ideas seriously, whether they agreed with me or not.

Then there is a former colleague of mine, Ati Hermelin, to whom I am indeed indebted. She read the manuscript of this book carefully and critically and her comments were incisive and, as always, most refreshing.

My wife Bridget also read the manuscript and gave me valuable help with comments which were intelligent, very perceptive and full of her usual sense of humour. She also corrected my English, read the proofs with me and generally made this book possible. I am very grateful.

I should like to thank the St John's College office for typing the manuscript.

Oxford July 1973

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Introduction

Our perception and our understanding of our environment are very closely linked, and this relationship between what we perceive and what we understand is almost certainly a two-way one. The better we understand the world around us, the more effectively can we set about gathering information about a particular part of it, and similarly the better we perceive our surroundings, the more efficiently can we interpret what is going on around us.

At no time in our lives is this connexion between perception and understanding more important than during childhood, because it is then that both undergo the most radical changes. Certainly it is during childhood that we lay the basis of our understanding of the rules which govern our environment. However imperfect our grasp of these rules as adults is, it is nonetheless the product of a very lengthy development. It is also fairly certain that there are greater changes in our perception during childhood than at any other time. Recent research, it is true, has established that even very young babies possess an impressive range of perceptual abilities (Kessen, Haith, and Salapatek, 1970). Nevertheless, it is still certain that these capacities alter, and generally become more effective, as children grow older.

How are these two types of development related? This is the question which prompts this book. The book's main aim is to present a theory about the way young children perceive their environment, and about how the perceptual information which they have to deal with affects their comprehension of the rules governing this environment. The theory itself is a limited one. It does not deal with all aspects of the young child's perception, but concentrates instead on the way children deal with recognizable perceptual continua, such as size, orientation, and position, and on the effects which their perception of

these continua has on their understanding of such central notions as size, space and number.

The book then is not in any way a review. It concentrates on only some aspects of perceptual development, and on only one theoretical approach to a subject in which there have been many theories. The theory itself is based on the idea that an extremely important factor in the young child's perception of his world is his use of logical inferences to help him make perceptual judgements. The main argument will be that young children depend very heavily on inferences in making most of their important perceptual judgements, and that finding out about the reasons for this dependence and about the effects of these inferences can throw a great deal of light on the question of how children learn about their environment.

The theory is in some ways a novel one. Yet several of its ingredients are extremely familiar. Many of the ideas which are central to it were also discussed at length in some of the earliest and most important accounts of perceptual development. In particular, the perceptual theories of Helmholtz and of Piaget use the idea of perceptual inferences extensively, and the Gestalt theory of perception, although not directly concerned with the issue, did, it can be argued, establish one very good reason why inferences are necessary.

Perhaps the best way to approach the theory set forth in this book is to deal first with these more familiar accounts of perception, and to show how many of the ideas which occur in these can be incorporated, sometimes in a slightly altered form, in a new theory about perceptual development which can be used to explain a surprisingly wide range of recent experimental data on the behaviour of young children.

Perceptual inferences—the influence of Helmholtz

One of the earliest and also most influential theories about perception and perceptual development used as its central theme the suggestion that a great deal of what we perceive depends on our being able to make rapid and automatic inferences. This was the theory of H. von Helmholtz, the nineteenth-century German physicist and physiologist, who through his work on the sensory systems also became interested in the psychology of perception.

Helmholtz was impressed with the possibility that what a person perceives may be considerably affected by his past experiences. He argued that the sensory systems on their own are not versatile enough

to account for the richness of perception, particularly of visual perception, and he suggested that people attain their perceptual sophistication by learning the meaning of particular cues in their environment. For example, the retina is two-dimensional, and yet we see things in three dimensions. Helmholtz put forward the idea that we are able to recognize the third dimension because we have learned to associate certain two-dimensional cues with depth. He further suggested that we use this learning inferentially. When we perceive cues which, for example, have in the past been associated with depth, we immediately infer that they signify depth once again.

These are 'unconscious inferences', which means that they are automatic, not expressed in words, and that the individual is not on the whole aware of making them. Yet they are nonetheless logical inferences. In one of his lectures Helmholtz described their logical status in the following way: 'There appears to me to be in reality only a superficial difference between the conclusions of logicians and those inductive conclusions of which we recognize the result in the conceptions we gain of the outer world through our sensations. The difference chiefly depends upon the former conclusions being capable of expression in words, while the latter are not: because instead of words they only deal with sensations and the memory of sensations' (Helmholtz, 1873).

Helmholtz even argued that in some ways these unconscious inferences are more powerful than inferences of which one is aware and which one can express in words. 'Just because they are not free acts of conscious thought these unconscious conclusions from analogy are irresistible, and the effects of them cannot be overcome by a better understanding of the real relations. It may be ever so clear how we get an idea of the luminous phenomena in the field of vision when pressure is exerted on the eye, and yet we cannot get rid of the conviction that this appearance of light is actually there at a given place in the visual field: and we cannot seem to comprehend that this is a luminous phenomenon at the place where the retina is stimulated' (Helmholtz, 1866). In his view, however conscious we might have been of the learning which established them, we are not aware of the perceptual inferences when we actually make them.

There are two main points which can be made about this theory. The first, and most frequently made, concerns his ideas about the role of experience in perceptual development. The second, which is far less commonly discussed, involves his notion of logical mechanisms in perception. Of these two points the first has very little bearing on the

argument to be developed in this book, while the second is crucial to its hypothesis about perceptual development.

The basis for the first point is that these inferences are plainly inductive, and Helmholtz himself went to great lengths to emphasize this. An inductive inference is based on the assumption that a relationship which has existed in the past will continue to apply in the present. Thus one infers that a particular cue signals something because it has always signalled it in the past. Each inference then depends on the 'association of ideas going on in the dark background of our memory' (Helmholtz, 1894). Past experience is, therefore, crucially important, and if it affects perceptual inferences in this radical way, it must, if Helmoltz was right, also influence the way a person perceives.

This inductive aspect of Helmholtz's theory has attracted most attention, because it places him clearly in the familiar debate about whether perceptual abilities are innate or acquired. He is now chiefly remembered as an extreme empiricist by those who are interested in perceptual development, because the nativist–empiricist question, more than any other, has dominated this field of study throughout this century. It is true that he regarded very little in perception as innate, except, interestingly enough, the mechanism for making inferences. However, one's view of this side of Helmholtz's theory is bound to be coloured by one's opinion of the value of the nativist–empiricist debate. It could reasonably be argued that it is unfortunate that so much energy has been spent on the question of whether perceptual capacities have to be acquired, rather than on the equally interesting question of how children use them. And it is regrettable that the emphasis on Helmholtz's empiricism has been allowed to obscure the importance of the other side of his contribution – his interesting notion of logical mechanisms actively affecting what children and adults perceive. One particularly attractive feature of this idea is that it suggests a connexion between the way our immediate perception is organized and the way we organize our understanding of our world. What Helmholtz is saying is that we go through much the same processes when we judge, for example, the distance of an object as when we have to solve a logical problem. If this is so, then we should be able to use the results of perceptual experiments to help us understand something of the difficulties which people, and particularly children, have in logical problems, and vice versa. We should then be able to cross the divide usually found between experiments on perceptual development and experiments on cognitive development.

We are faced, then, with the conclusion that Helmholtz's general idea of logical mechanisms affecting perception and perceptual development was an important one, but that his particular emphasis on inductive inferences was probably unfortunate. This, of course, is no reason why the general idea should be abandoned. One perfectly valid way of pursuing his approach is to look for other logical manœuvres which might affect the young child's perception of his environment, and which might also be, in the Helmholtz manner, automatic and not expressed in words. Such logical mechanisms, as we shall see, are not hard to find. However, before going into the form they might take, we need to look at some aspects of another theory about perceptual development, which is also concerned with the possibility of logical manœuvres in perception. This is the theory of Jean Piaget.

Deductive inferences – the influence of Piaget

Not everyone ignored the logical side of Helmholtz's theory. The major exception was Jean Piaget, a Swiss psychologist, whose massive body of work on children is very well known. Piaget also recognized the importance of the idea that logical mechanisms might affect perception, and actually suggested new possibilities. One particular innovation in his theory of perceptual development, clearly described in his book *The Mechanisms of Perception* (1969), was the suggestion that at some stage in his life the child begins to use deductive inferences in order to make many of his perceptual judgements.

As is well known, Piaget's main interest in children has been their logical abilities; his general theory is that children only very gradually acquire the ability to be logical, and that logical development proceeds in several well-defined and ordered stages. A good example of his thought, and a pertinent one here, concerns the ability to make deductive inferences. These differ from the inductive inferences described by Helmholtz in that while the latter depend largely on experience with material at hand and on the assumption that past relationships will continue in the future, deductive inferences are quite independent of these conditions, and involve the use of a rule which can be applied to the familiar and to the unfamiliar equally conveniently.

A pertinent example, since it is an inference about a perceptual continuum, is the transitive deductive inference with which Piaget is most concerned. Suppose that we are shown first that A $>$ B, and then quite separately that B $>$ C. We can combine these two direct comparisons

to make a third, indirect and therefore inferential judgement that A > C. Adults can make this transitive inference, but Piaget, on the basis of experiments involving logical problems very like the one described, argues that young children of less than eight years old cannot (Piaget and Inhelder, 1941; Piaget, Inhelder, and Szeminska, 1960). He holds that below eight years children tend to be dominated by their immediate perceptual input, and are quite unable to reorganize it once it arrives. Their failure to produce the A > C inference is cited as an example of how perceptual domination and logical ineptitude go hand in hand in young children.

After this very brief account of Piaget's notions of children's inability to make deductive inferences about continua, we can consider how he relates it to the way in which they perceive. He makes two points: first, that deductive inferences could be employed with great effect in perceptual judgements about continua such as size and orientation, and secondly, that young children do not employ them simply because they cannot make this sort of inference before the age of about eight years.

Piaget argues that deductive inferences affect our perception primarily through the use of external frames of reference to connect and to categorize separate perceptual experiences. For example, one way of judging that the level of liquid in a glass always retains the same orientation even though the glass itself is tilted from side to side, is by noting that, whatever happens to the glass, the liquid's level always parallels some external feature, like a table top. If A is the orientation of the liquid at one time, and A_1 at another, and B is the table top, it can be seen that A parallels B, that A_1 parallels B, and therefore A and A_1 are in the same orientation. This is a deductive inference. In fact Piaget argues that it is through making this kind of inference via an external framework feature that children eventually come to understand that liquid levels stay horizontal (Piaget and Inhelder, 1956: Piaget, 1969). However, his point here is a developmental one. Young children cannot, he argues, use external reference frames in this inferential way until they are able to make deductive inferences.

One piece of evidence offered by Piaget for this developmental change is drawn from an experiment in which he and his colleagues gave young children an outline drawing of a bottle and a table top, and asked them to draw a line to depict the level of the liquid in a real bottle placed in front of them. Sometimes this bottle was upright, and at other times tilted. It was found that five- and six-year-old children tended to

draw in the line in the right orientation when the bottle was upright, but as still perpendicular to its sides when it was tilted. This is a striking result, because the child is actually misrepresenting something which is there before him. Piaget concludes that these children did not yet know how to use the external reference system, and therefore did not understand that the level of liquid rests constantly horizontal. 'At the outset the child is not even aware of physical or physiological notions of vertical and horizontal, and for a very simple reason as these results show. The reason is that a perception only covers a very limited field, whereas a system of reference presumes operational co-ordination of several fields, one with another. Far from constituting the starting point of spatial awareness the frame of reference is the culminating point of the entire psychological development of Euclidean space . . .' (Piaget and Inhelder, 1956, p. 416).

Piaget later made a similar point about judgements of size (Piaget, 1969). If children are shown two sticks whose height is equal, but of which one is further away than the other, they typically judge the further one as smaller, an error sometimes referred to as a failure in size constancy. Piaget asked if they would stop making this error if the two stimuli were both compared to some common reference point. He and his colleague, Lambercier, showed children a nearer rod, A, and one farther away, C, whose size was the same, and compared each of them successively to another, moveable rod, B, again of the same size. They asked children general questions about the transitivity principle, and they also asked them to compare A and C after both had been shown B. They found that children in the five- to seven-year-old range did not seem to understand transitivity, and that showing them that both A and C equalled B did not reduce the extent to which they underestimated C. In the seven- to nine-year-old range they understood the transitivity principle, yet still continued to underestimate C. It was not until the age of nine to eleven years, which is quite old in developmental terms, that children appeared to begin to use the common reference point B to help them make the perceptual comparison between A and C at all systematically.

Piaget's conclusion from this result is that children have to grasp the logical principle first, which they do between seven and nine years, and then have to be thoroughly familiar with it before they allow it to influence their perceptual judgements. 'It must therefore be acknowledged that transitivity derives from sensory motor processes which are more general than the perceptual processes . . . and that it has repercussions

upon perception instead of being derived from it' (Piaget, 1969, p. 336).

This is an important experiment because it illustrates extremely clearly Piaget's views on deductive inferences, use of external frameworks and perceptual development. If a child cannot make transitive deductive inferences, he cannot use external frames of reference, and he cannot therefore bring together and co-ordinate separate perceptual experiences in an effective and systematic way.

Later in this book it will be argued that children can actually make transitive inferences while still very young, and that they depend on external frameworks to a far greater extent than do older children and adults. Such a view is, of course, the direct inverse of Piaget's. However, notwithstanding this kind of disagreement, Piaget's idea of linking inferences and external frameworks as a vehicle for perceptual judgements is an important one, for several reasons. One is that it develops the most interesting part of Helmholtz's approach to perception and perceptual development by suggesting another way in which logical mechanisms can be used in perception. Another is that the inference with which we are now concerned, the deductive inference, has the advantage of being neutral as far as the innate-acquired hypothesis is concerned. To make a deductive inference properly the child does not have to be at all familiar with the specific material at hand. The actual ability to make deductive inferences may itself have to be acquired, but this is a separate question. A third reason is that Piaget's idea introduces the notion of the external framework as an important reference point through which separate perceptual experiences can be categorized. Finally the theory raises the possibility of developmental changes in the way logical mechanisms influence perception whereas Helmholtz assumed that children make their unconscious inferences in much the same way as adults.

This account of Piaget's theory about perceptual development is a very selective one. He saw the influence of inferences on children's perception as only one of the major factors in development; at one stage in *The Mechanisms of Perception* he lists fourteen major differences between 'perception' on the one hand and 'intelligence' on the other, and only one of these concerns inferences. (To contrast two such global concepts as 'perception' and 'intelligence' may seem rather unattractively arbitrary, but Piaget's distinction is a developmental one, since he is mainly comparing the way in which children take in perceptual information about their environment before and after they have

developed some basic logical abilities.) This specific issue of perceptual inferences and external frameworks has been selected for its bearing on the theory to be outlined in this book.

This theory deals with the idea of deductive inferences and the use of perceptual frames of reference very extensively, and its major disagreement with Piaget will be about developmental changes. It will be argued that children make deductive inferences from a very early age, and that they use these deductive inferences and external frameworks very heavily. In fact it will be suggested that, where there are developmental changes, they are the opposite of those suggested by Piaget. Young children of three and four years initially rely very strongly on framework cues, and use them inferentially as an effective way of categorizing and learning from their perceptual experiences; as they grow older they begin to acquire other, more flexible, props, which I shall categorize as internal frameworks, to help them organize their perception. The strategy which Piaget saw as a culmination of perceptual development is, in this alternative view, a very basic perceptual strategy, whose effects are limited and rather haphazard, and which children already begin to abandon by the time they reach the age of about six years.

However, before describing this alternative theory and the arguments for taking the opposite point of view to Piaget's, it is necessary to examine one other major theory about perception, Gestalt theory, because some of its ideas illustrate very neatly the answer to a question not yet mentioned, that of *why* the child needs to make deductive inferences in order to make certain perceptual judgements about the world around him.

Gestalt theory and the question of absolute and relative codes

The discussion so far has been concerned mainly with the question of how children take in information about perceptual continua such as size and orientation. One question which needs to be asked about reactions to continua such as these is whether the values perceived and remembered are absolute or relative in nature. When someone takes in information about different sizes or orientations, or about different distances, numbers, brightnesses and textures, he can do so absolutely or relatively. For example, if he is shown two sticks together whose lengths are different, he can either register somehow that A is 8 inches and B 4 inches in length, or he can note that A is larger

than B, or, even more specifically, that A is twice as large as B. In the first case he is using an absolute code, in the second and third a relative one. The two codes are not necessarily mutually exclusive, but they are different.

There is a more specific reason why the absolute-relative question is important for this discussion, and this concerns the use of deductive inferences in perception. Transitive inferences about points along a continuum are not necessary if the absolute values are known. Suppose, for example, that a child is shown three sticks in two separate pairs. First he sees A which is 8 inches in length compared directly with B whose length is 4 inches. Next he sees B compared with C which is 2 inches long. Finally he is asked which is the longer, A or C, but is not allowed to compare them directly. How can he answer the AC question? One way, already described, is to make a transitive deductive inference. However, this would be entirely unnecessary if the child or adult were able to remember the absolute values of A and C. But if the child were capable of taking in only relative values, the only way he could solve the AC problem would be by making a transitive deductive inference.

Exactly the same argument can be made about perception of orientation. As Piaget has noted, one way of remembering the orientation of the level of liquid in a glass is to note that it parallels the table top. This is a relative judgement, and it can be used to make a transitive inference that the level's orientation does not change when the glass is tilted in a different direction. But this inference is not necessary if one has an internal absolute category which will tell one that the level on the first and second occasion is horizontal. One simply knows, without the help of an inference, that both times the level was horizontal, and therefore unchanged.

It follows from this analysis that the question of whether children use absolute or relative codes is crucial for any discussion of the role of inferences in perceptual development. Fortunately there is now a great deal of information about this, most of which has been assembled in a valuable book by Reese (1968). The question was originally posed by the Gestalt psychologists in the early years of this century. Their interest in it had nothing directly to do with the subject of perceptual inferences. They raised the question because they were primarily concerned with the perception of pattern, and they were impressed by the fact that people can recognize patterns even when the absolute values of their individual components change radically, provided always