Conservation accidents

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Abstract

Eighty children aged between 4 years 2 months and 6 years 3 months were tested on length and number conservation, both when the transformation occurred because of a direct action by the experimenter and when it happened 'accidentally' as the by-product of an activity directed towards a different goal. Fifty children conserved when the transformation was 'accidental', whereas only 13 were successful when it was intentional. These results are interpreted as evidence that characteristics of the experimenter's behaviour, in particular his actions towards the task materials, can influence children's interpretation of utterances by suggesting the experimenter is thinking about a different attribute from that specified linguistically. It is suggested that traditional procedures may underestimate children's cognitive abilities.

Introduction

A substantial body of research has grown up around Piaget's conservation tasks (Piaget, 1952; Piaget and Inhelder, 1969). Piaget's findings have been replicated by many investigators using standardized procedures based on Piaget's original method (Elkind, 1961; Dodwell, 1960; Hood, 1962; Smedslund, 1964). However a considerable amount of evidence has accumulated suggesting that children may have the knowledge necessary for conservation long before they succeed in the traditional conservation task (e.g., Frank, 1964; Gelman, 1972; Rose and Blank, 1974). These studies have usually involved ingenious methods for circumventing those features of the conservation task which the authors thought were particularly problematic for the child. For example, those suggesting attentional/perceptual difficulties have used screening procedures (Frank, 1964) or trained children to attend to the relevant attributes (Gelman, 1969). Those postulating linguistic difficulties have used pretraining in the use of the relational terms of the task (Gruen, 1965) or developed conservation games not involving the relational terms (Gelman, 1972). Each of these diverse procedures gave indications that children can conserve at an earlier age than is suggested by traditional methods.

This paper is addressed to the paradox presented by these conflicting results – results which show that the child can, in some contexts, demonstrate his knowledge about the invariance of certain attributes of objects while at the same time he fails to exhibit such knowledge in the typical Piagetian situation. The traditional method of assessing conservation is scrutinized and one potentially important feature of the situation is identified. It is suggested that this feature, which is irrelevant to the logical requirements of the conservation task, contributes substantially to the child's difficulty in the classic situation.

Consider the usual procedure for assessing conservation of number. Two lines of counters, equal in number, are arranged in one-to-one correspondence in front of the child, and a question about their relative numerosity is presented (Q1, e.g., are there more counters here or more counters here or are they both the same number?). The child makes the judgement (J1) that they are the same and the experimenter then rearranges one of the rows and repeats the original question (Q2). The nonconserving child typically changes his judgement in favour of the longer row (J2). It is customary to associate the child's changing choice from J1 to J2 with what appears to be the only other feature of the situation that has changed – the perceptual configuration of the row of counters – so that the explanation of the child's behaviour focusses on his susceptibility to perceptual influences.

Suppose however that, despite their formal or surface identity, Q1 and Q2 are given differing interpretations by the child. This is not as unlikely as it seems on first reflection, and it is not difficult to imagine how two identical questions might be used to interrogate different aspects of a static array. For example, some of the counters might be covered in spots. In this situation the original conservation question (Q1 and Q2) could be used to enquire about the relative numerosity of just the counters with spots, provided that preceding contextual information, either linguistic or non-linguistic, made it clear that the questioner was now interested in this aspect of the array. The point of this unlikely-sounding example is that we do not know the sources of 'contextual information' which could lead the child to vary his interpretation of an unchanging question.

One conspicuous event that intervenes between J1 and the presentation of Q2 is the experimenter's simple action of changing the length of one of the rows of counters. Could this provide the contextual information which leads the child to misinterpret Q2? Recent theoretical proposals in the area of language acquisition indicate the paramount importance, for the development of language, of the actions of the participants in early interactions. These suggestions draw upon the communication of intent model proposed by philosophers of language in which an important distinction is made between speaker's meaning and utterance meaning (Grice, 1968). Macnamara (1972) has suggested that children learn language on the basis of their independent hypotheses about speaker's meaning, derived from their intercourse with the world. Ryan (1973) and Bruner (1975) have argued that mother–child interactions provide contexts of mutual action in which intentions, initially communicated non-linguistically, come to be mapped on to their linguistic means of expression. They suggest a central role for non-linguistic means of

collaboratively directing attention as a basis for the referential function of language. Although the detail of these processes remains to be specified, this approach clearly indicates the importance of the intentional structure of the speaker's non-linguistic behaviour for the child's interpretation of utterances. Since language acquisition continues at least until the period of concrete operations (Palermo and Molfese, 1973) then it is important to consider the possible effect of the intentional activity of the experimenter on the child's interpretation of the language of the conservation task.

The structure of the conservation task seems to involve a significant deviation from normal adult–child interactions. In the conservation task the adult's non-linguistic behaviour is uncoupled from the linguistic element, in that the non-linguistic component is irrelevant to the interpretation of the utterance. Moreover the non-linguistic behaviour is highly relevant for an utterance of a different type – one concerned with the length of the row rather than number. It could be that the experimenter's simple direct action of changing the length of the row leads the child to infer an intention on the experimenter's part to talk about what he has just been doing. It is as if the experimenter refers behaviourally to length although he continues to talk about number. If the young child's procedures for interpreting language initially depend heavily on the non-linguistic component of the interaction, it would not be surprising if he ignored normal word-referent relationships and interpreted the question on the basis of the experimenter's intentions as evidenced in his behaviour.

If this proposal is correct, it follows that it should be possible to vary the incidence of conservation success by manipulating the intentional structure of the circumstances leading to the transformation. One way to do this is to make the transformation appear accidental. It cannot of course be genuinely accidental. The notion of 'deliberate accident' is self-contradictory, so one cannot build true accident into an experimental design. However one can attempt to ensure that an event will not appear to the subject to have been produced with calculated intent by the experimenter. One can make it seem to be a by-product of some other activity and to that extent fortuitous. The method employed here exploits the child's willingness to attribute agency to inanimate objects. A small teddy bear with malicious intentions towards the task materials is operated by the experimenter to effect the transformation. The child makes his judgements before and after the transformation. In one condition, the transformation results from a direct intentional action of the experimenter like that used in the classic method. In the other condition the same transformation happens 'accidentally' in the course of the teddy bear's activity which is directed towards the goal of 'spoiling the game'. Since in both conditions the child is faced with the usual misleading perceptual array then, if orthodox accounts of conservation performance are correct, both methods of assessment should yield similar results. If, on the other hand, the intentional character of the experimenter's actions can govern the child's interpretation of the question, then better performance is predicted where the transformation occurs without this intentional background.

Method

Subjects: Eighty children, of mean age 5 years and 4 months (range 4 years 2 months to 6 years 3 months) took part in the study. Forty of these were attending Edinburgh nursery schools and their mean age was 4 years 10 months (range 4 years 2 months to 5 years 4 months). The other 40 were attending a local State primary school and their mean age was 5 years 10 months (range 5 years 3 months to 6 years 3 months). There was an equal number of boys and girls in each of the samples.

Design: Each child received number and length conservation problems under conditions in which the transformation was effected intentionally (Intentional Transformation, IT), and under conditions in which it occurred accidentally (Accidental Transformation, AT). There were two situations involving the conservation of number (equal and unequal) and two involving length conservation (equal and unequal). Children were assigned to one of two groups, with care taken to balance the sex and age composition of the groups. Group I completed all the judgements involving AT before encountering any in the IT condition; Group II received the IT condition first. Within these groups, one half of the children received the number situations first and the other half received the length situations first. The equal and unequal situations appeared first equally often. The order of presentation of situations was held constant across the IT and AT conditions.

Materials and Situations: The task materials were counters of 1½″ diameter, some lengths of string, and a small teddy bear (height 3″) with a box large enough to conceal him.

In the *number equal* situation, four red and four white counters were arranged in one-to-one correspondence into two rows of equal length. The transformation, for both IT and AT conditions, involved moving the counters of one row until they were touching each other, thereby shortening that row. Before and after the transformation the child was asked:

"Is there more here or more here or are they both the same number?"

while the experimenter pointed along each of the rows at the appropriate points in the utterance. For the *number unequal* situation, rows of four and five counters were used, and the question was:

"Which is the one with more – this one or this one?"

For the *length equal* situation, two 10″ lengths of red and black string were used. These were placed beside each other, with their end-points coinciding, and the child was asked:

"Is this one longer than this one or are they both the same length?"

while the experimenter touched each of the pieces of string in turn.* One piece of string

*It has been objected, perhaps with some reason, that it was unwise to touch the string, since the children might regard even this act as somehow transforming the material. It seems unlikely that they did so, however, in view of the large differences between the IT and AT conditions which were nonetheless obtained.

was then transformed by bending it into a crescent shape, and the question was repeated. For the *length unequal* situation one of the 10″ strings and an 8″ length of white string were used and the question was:

"Which is the long one – this one or this one?"

Procedure

At the beginning of the session only the cardboard box containing teddy was present on the table. E lifted teddy out of the box, and showed him to the child, explaining that teddy was very naughty and that he was liable to escape from his box from time to time and try to 'mess up the toys' and 'spoil the game'.

E then arranged the materials for the child's first situation. During the IT condition, the teddy bear did not appear. The IT procedure was modelled on the traditional method used in conservation studies. After the child's first judgement, E said "Now watch..." and rearranged the materials with a single direct action, and then repeated the question.

In the AT condition, following the initial judgement, E pretended to experience surprise and alarm as he moved teddy towards the materials making such remarks as: "It's naughty teddy!" "Oh! look out, he's going to spoil the game." At this point E quickly moved teddy over the string or the row of counters making sure that they were appropriately disarranged in apparently haphazard fashion.

Then he allowed the child to return teddy to his box.

On four occasions during the AT procedure the child, having removed teddy, restored the string or counters to their original state before E could elicit the conservation judgement. When this happened that situation was begun again using a modified procedure.* Instead of chasing teddy back to his box, the child was asked to keep teddy prisoner – that is, to hold him in his hands. This ensured that the transformation remained unaltered until the judgement was elicited.

The transformation, for both AT and IT conditions, was always carried out on the material furthest from the child. This procedure was adopted to allow teddy more opportunity for carrying out his mischief before the child could intervene. Each child saw both red and white counters undergo transformation within any condition (i.e., in one situation the red row was transformed, in the other the white), and similarly for the red and black string. When each situation was encountered again under the second condition (IT or AT), the child witnessed the same material being transformed as on the first occasion. The order in which E pointed to the materials in conjunction with the question was varied systematically. E gave no feedback concerning the child's performance.

The method employed here for assessing conservation does not involve the eliciting of justifications. This strategy was adopted for two reasons. In the first place, Brainerd

*It might have been better simply to stop testing in these cases. But since they were so few in number, the pattern of the results is not substantially affected.

(1973) has argued that, even from the point of view of Piagetian theory, the justification criterion is too strict. More important for present purposes, the attempt to elicit justifications would have involved the child and E in further complex interaction, the characteristics of which could have influenced the child's subsequent behaviour in a number of ways.

Results

Tables 1 and 2 show that correct responses were far more frequent when the transformation occurred accidentally than when it was effected in the traditional manner. Nearly three-quarters of responses were correct in the AT condition, whereas only one-third were correct in the IT condition. If the criterion for successful conservation is set at four out of four judgements correct, then 50 of the 80 children are diagnosed as conservers under the AT method. In contrast, when these same 80 children made their judgements in the IT condition, only 13 achieved the criterion of successful conservation. This conclusion remains essentially unaltered if a laxer criterion is employed.

Table 1. *Total of correct responses given by Groups I and II for each situation under AT and IT conditions*

Situations	Group I (n = 40) AT ⟶ IT		Group II (n = 40) IT ⟶ AT	
A Number Equal	32	19	14	22
B Number Unequal	36	18	13	22
C Length Equal	34	15	8	24
D Length Unequal	37	12	9	23
Totals	139	64	44	91

Table 2. *Percentages of correct responses for Groups I and II under AT and IT conditions*

	Group I AT ⟶ IT		Group II IT ⟶ AT	
Nursery School Children	80.0	31.25	22.5	46.25
Primary School Children	93.7	48.8	32.5	67.5
Overall	86.9	40.0	27.5	56.9
Mean AT Performance		71.9		
Mean IT Performance		33.7		

The performance in the AT condition of Group II, which had received the IT condition first, was significantly poorer than that of Group I ($\chi^2 = 4.85, p < 0.05$). Hence it may be more appropriate to compare only the initial four judgements of each group. On this analysis 30 of the 40 children of Group I successfully conserved (AT condition) whereas only 5 of Group II did so (IT condition) ($\chi^2 = 29.2, p < 0.001$).

Discussion

These results give clear indications that traditional procedures for assessing conservation seriously underestimate the child's knowledge. Most of these four- and five-year olds achieved the criterion for successful conservation of length and number when the transformation was accidental, and yet most of the same children failed when the transformation was effected in the traditional manner. Indeed the results suggest that the performance in the AT condition of Group II subjects was depressed because of their prior experience with IT, so that even the AT procedure may have underestimated their knowledge of conservation. The verbalisations of those Group II subjects who were unsuccessful in the AT condition suggest they ignored the teddy's stated intentions and interpreted his activity as being directed towards changing the length of the row of counters, presumably because they had just witnessed the experimenter exhibit such activity. For example one child in the *length equal* situation chose the untransformed string as being longer after the teddy's activity "because you bent that one doing it and it's the shortest one".

The present approach differs from earlier ones which have emphasized language comprehension difficulties in that it considers the possibility that extralinguistic features of the testing situation, in particular the non-verbal behaviour of the experimenter, can influence the child's interpretation of the language. Several investigators have suggested there is a failure to understand key words in the question, and Griffiths, Shantz and Sigel (1967) have argued for the use of pretests which assess the comprehension of the relational terms in non-conservation contexts. However it is possible to understand a word in one context while failing to do so in others. The framework adopted here has allowed the identification of one feature of the testing situation which has precisely this effect – the intentional character of the experimenter's behaviour. It appears that this feature of interactions is implicated in the young child's normal procedures for interpreting language.

In the early stages of language acquisition, the child interprets the meaning of behavioural events to arrive at a notion of speaker's meaning and this knowledge is utilized to make sense of the language around him. Eventually the child acquires a semblance of linguistic meaning, in that he can respect certain properties of the language where the non-linguistic components of the speaker's activities do not conflict with the utterance. During this phase the intentional nature of the speaker's activities, where this is at variance with the utterance, can govern what the child thinks is being talked about, so that his understanding of such concepts as number and length can be obscured.

Hence when the experimenter has effected an intentional action which changes the *length* of a row of counters, the child behaves as if the experimenter is asking a question about length rather than number. When the length of the row changes, but without the experimenter appearing to have intended it, the child has no conflicting behavioural evidence relevant to his interpretation of the question, and so can correctly answer the experimenter's question on the basis of number. Similarly, when the experimenter carefully arranges one of the pieces of string into a crescent shape, the child compares the length of the untransformed string with one of the properties of the new figure – usually the distance between the sides of the crescent. In contrast, when the crescent shape appears as a result of the teddy's activity, the child is able to base his comparisons on the appropriate attribute.

Issues closely related to these have recently been discussed by Donaldson and McGarrigle (1974). They presented evidence that children, in judging which of two sets of toy cars had 'more', were systematically influenced by the presence of garages around the cars. The irrelevant attribute, fullness of the garage, was used as a criterion for response by about one-third of the children when the garages were present; when they were absent a different criterion was employed. Donaldson and McGarrigle suggested that these and related findings were evidence of the operation of non-linguistic rules which function in particular contexts to provide a specific interpretation of utterances when the child's linguistic knowledge by itself cannot do so. These rules, known as local rules, specify a hierarchy of attributes of the referent which are used in interpreting utterances. The results of the present experiment indicate that characteristics of the speaker's actions can also influence the child's interpretation of utterances, suggesting the existence of a different kind of local rule, one which is sensitive to the intentions of the speaker.

It is difficult to find alternative explanations for the present findings.* It is clear that accounts which emphasize perceptual effects are inadequate by themselves, since in both IT and AT conditions the child faced the usual misleading configuration of materials. Gelman (1969) has argued that attentional deficiencies could explain conservation failure. She proposed that young children define quantity multi-dimensionally so that a variety of irrelevant attributes are attended to,and suggested that the change in value of an irrelevant attribute brought about by the transformation increased the likelihood of attention to that attribute. Gelman used discrimination learning set training to overcome this tendency, and showed that five-year olds could, after extensive training, succeed in conservation tasks. However it is not easy to reconcile the results reported here with the attentional analysis since in the AT procedure the children were able, without any training whatesoever, to continue responding on the basis of the criterial attribute even though an irrelevant attribute had changed. Nonetheless the framework adopted in the

*The interval between the first and second judgements for each situation was approximately 30 seconds in the AT condition, whereas it was only 3 - 5 seconds in the IT condition. A separate study on a small number of children found no evidence that the longer time interval between J1 and J2 could account for the improved performance in the AT procedure.

present paper does have implications for attentional processes. Rather than postulating an attentional deficit, we are suggesting that the child's normal procedures for interpreting language encourage special sensitivity to certain characteristics of the speaker's behaviour.

If the explanation of the findings reported here is correct then there are important implications for those procedures which combine questions with intentional manipulative activity by an adult as a means of examining cognitive abilities. Far greater attention must be given to the features of the interactional setting in which the child's knowledge is assessed before any conclusions about the child's competence can be drawn. Further evidence is needed concerning the precise characteristics of speaker's intentional actions and how these influence the child's interpretation of utterances. It is possible that the achievements of the concrete operational stage are as much a reflection of the child's increasing independence from features of the interactional setting as they are evidence of the development of a logical competence.

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Résumé

80 enfants de 4;2 et 6;3 ans ont été testés sur la conservation de la longueur et du nombre dans les deux conditions suivantes: Lorsque la transformation est le réultat de l'action directe de l'expérimentateur et lorsque la transformation découle, indirectement, d'une action ayant un but différent (transformation 'accidentelle'). 50 enfants conservent lors d'une transformation 'accidentelle' alors que 13 seulement, répondent correctement dans le cas d'une transformation intentionnelle. Ces résultats montrent l'influence de l'attitude de l'expérimenteur et notamment de ses actions sur le matériel, sur l'interprétation de la tâche par l'enfant. En particulier, l'attitude de l'expérimentateur peut suggérer à l'enfant que les caractéristiques pertinentes ne sont pas celles qu'il exprime linguistiquement. On peut alors penser que les procédures classiques ont tendance à sousestimer les capacités cognitives de l'enfant.