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Linear organization of spatial instructions: development of comprehension and production*

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ABSTRACT

Spatial instructions can be linearly ordered so that the sequence in which landmarks are mentioned corresponds to the spatial ordering of those landmarks en route. Two experiments were performed to investigate the ability of children to utilize and to produce such linearity in receiving and giving spatial instructions. Children were shown to be able to use highly linear instructions by four years, but were able to reorganize less orderly input only by seven years. It was suggested that this ability might be related to the ability to identify relevant locative prepositions. There was also a development in the ability to 'make allowances' for the ability of the listener, with older children (eight years) producing instructions that were suited to the skills of the other child. It is suggested that this demonstrates a development of comprehension of the cognitive and linguistic skills of others.

Children communicate about their spatial environment from an early age, giving descriptions of their own whereabouts as well as those of other objects. There has been little research into this use of spatial reference, partly because of the difficulties in classifying language used in a 'natural' setting. These experiments examine two linked issues. Firstly, whether the format of an instruction affects its usefulness to the listener, and secondly, whether the language used in giving spatial instructions changes not only as a function of the speaker's age, but also as a function of the age of the listener. This might suggest that the speaker is developing skills of modifying linguistic structure specifically for the listener's benefit. An important aspect of any communication is that the speaker should be able to judge its potential effect upon the listener. In these two studies, the effectiveness of

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different instruction formats will be compared, and children's spontaneous use of these formats will be examined for evidence that the speaker develops understanding of the listener's capacities.

EXPERIMENT I

DEVELOPMENTAL DIFFERENCES IN THE ABILITY TO FOLLOW SPATIAL INSTRUCTIONS

An adequate response to instructions depends on the capacity to identify, recall and implement the information received. This skill will be affected not only by the child's level of interest and knowledge, but also by the structure of the message. Studies on 'story schemata' suggest that the optimum story structure for young children is a linear one, where events maintain temporal order and do not diverge into sub-plots during the main sequence. For example, Brown & Murphy (1975) have shown that 4-year-olds are poor at reproducing random or scrambled series, but that they tend to reproduce sequential input fairly well. Nelson & Gruendel (1981) have found that preschool children will tend to impose sequence upon recalled stories by omission or repositioning of an event which is presented out of temporal order. There is some disagreement about the age at which the child imposes such linear organization upon scrambled input (Buss, Yussen, Mathews II, Miller & Rembold 1983, Poulsen, Kintsch, Kintsch & Premack 1979), but there is general agreement that the developmental trend is towards linear reproduction of incoming information, provided that sequencing is relevant. The nature of the material used seems to be crucial. Even 3-year-olds are able to organize disorganized input of high familiarity and simplicity (Faulkner 1983), but children of 6 years have been shown to omit some specific types of complex information (e.g. moral-oriented endings) when retelling stories which were presented in a linear format (Geva & Olson 1983).

Sequencing is obviously relevant to the test materials in the studies cited above, which examine recall for stories. A similar benefit of sequential input might be shown where the recall task does not involve verbal reproduction of a story. In this experiment, the ability of children to respond appropriately to instructions about the environment is examined, with particular reference to the value of linearity. Siegel, Allen & Kirasic (1979) use multi-dimensional scaling to suggest that a 'linear format for the cognitive construction of route representations' emerges between 7 and 10 years, though Cousins, Siegel & Maxwell (1983) found a relatively high ability to 'order' landmarks among 7-year-olds with a fairly simple reconstruction task. In line with findings on the story schema (Buss *et al.* 1983, Poulsen *et al.* 1979), one might expect a development from an early dependence upon linearity in spatial instructions to an ability to impose a linear structure on information that is presented in a less orderly fashion.

However, even if this prediction is borne out, the question remains of how this effect of linearity will be mediated. The effect of linearity upon storage and recall may be due to the primacy and recency of pertinent information, with end-point information highlighted for the child. Alternatively, there may be a more complex mechanism, whereby the child uses the order of the landmarks to construct a linear cognitive representation which terminates in the end-point of the route. This experiment will attempt to differentiate these two mechanisms. If the more complex mechanism is present, there may be something about linearity (other than simple temporal order) that helps the child to differentiate the end-point from any other landmark. A possible explanation is that the linearity is assisting the child to identify the end-point of the search by directing the child's attention to the relevant locative preposition. A set of route instructions will generally contain a number of transient locative prepositions (e.g. past, through) and only one unequivocal static locative (e.g. next to, under). If there is a development in the ability to differentiate static locatives from transients, without (or in spite of) the surrounding context, then there should be a development in the ability to use disorganized instructions.

Most studies of locative meaning have concentrated on the development of understanding of single, isolated relations such as 'A is in front of B' or 'A is on top of B' (Clark 1977, 1980, Johnston 1984, Kuczaj & Maratsos 1975). There seems to be a sequential acquisition of correct usage of different locatives, which is determined in part by the child's conceptual preferences (Clark 1973), by the child's knowledge of the body's frame of reference (Kuczaj & Maratsos 1975) and by situational variables, such as the specific task employed (Durkin 1981). These factors mean that one cannot assume that the child who responds correctly to a locative (e.g. 'in') actually understands its meaning. Furthermore, Johnston (1984) has shown that children's responses to locatives reveal that the child acquires different meanings at different times for the same locative.

A criticism of this work is that it concentrates on limited situations, where an individual static locative is presented to the child. This procedure ignores the question of how children develop skills of extracting the relevant information from more complex, natural speech. In this study, a series of instructions for finding a prize will be given to children in order to find out if the linearity of instruction format assists them. The first condition will simply use a linear set of instructions to specify the goal. This should be easy for all children, as the structure will be similar to that of a simple story. In the second condition, the end-point (goal) will be presented before the main body of the instructions, which will remain linear. If the child simply fixes on the terminal item of a set (Brown & French 1976), performance should be poorer than in the first condition, but if it is the linear organization of part of the route instructions which is relevant, then the child should be capable of using the instructions effectively. However, a good performance on the second condition might be due to a primacy effect in memory. To check that it is linearity of the main body of the instructions rather than primacy or recency of the end-point information which is crucial to the young child's understanding, a third condition will be used, in which the linear order is reversed. A 'primacy/recency' hypothesis would predict that this condition should be no harder than the end-point + linear condition, and so should not become significantly easier (across a particular age range) if that condition does not. A 'linearity' hypothesis predicts that the ability to use reversed instructions should develop later than the ability to use the end-point + linear format. The final comparison will be with a condition where the instructions are scrambled, which both hypotheses would predict to be the most difficult format for young children.

The literature on spatial reference suggests a wide age range for the acquisition of different locatives (e.g. Johnston 1984). However, the present study is concerned more with the effects of linear organization of a set of instructions, and will concentrate on children of between 4 and 9 years, presuming that the wide range of locatives used will be understood by the children. If there is no such understanding, then this can only work against the hypothesis of more linear formats producing better comprehension in younger children. This age range was chosen because it seems to encompass the period during which reorganization of scrambled stories becomes easier, and so should highlight the value of linearity to the younger children.

METHOD

Subjects

64 children from an Oxfordshire First School served as subjects, divided into 4 age groups of 16 children each. Mean ages of the groups were 4;2 years (range 3;10–4;6), 5;5 years (range 5;2–5;9), 7;1 years (range 6;10–7;3) and 9;5 years (range 9;3–9;9). All children were fluent English speakers.

Materials

Each child selected a piece of fruit ('prize') as the object to be hidden. There were four possible hiding places – small white pots, in full view, under which the prize could be hidden. Basic instructions were generated by an adult who was familiar with the room but not with the purposes of the experiment. Two sets of instructions were made for each of the four hiding places, and were constructed in the form: (1) Start Point; (2) Landmark; (3) Landmark; (4)

End Point. No connectives were used. This format was defined as Linear. Each of the 8 sets of Linear instructions was then transformed into three different formats. Thus, each instruction was presented in a total of four different formats, as follows:

Linear	– (1) (2) (3) (4)
End-Point + Linear	– (4) (1) (2) (3)
Reversed	– (4) (3) (2) (1)
Pseudorandom	– (3) (1) (4) (2)

Since there were two sets of instructions for each hiding place, four hiding places and four different formats for each instruction, a total of 32 sets of instructions were created. (See Table 1 for originals and transformations.)

TABLE 1. *Basic instructions and modifications given by the experimenter to describe the location of the prize to the children in Experiment I*

(1) LINEAR. You go in the door . . . past some tables . . . past the toy library . . . the pot by the painting board.
END POINT + LINEAR. The pot by the painting board . . . you go in the door . . . past some tables . . . past the toy library.
REVERSED. The pot by the painting board . . . past the toy library . . . past some tables . . . you go in the door.
PSEUDORANDOM. Past the toy library . . . you go in the door . . . the pot by the painting board . . . past some tables.

(2) LINEAR. You go in . . . across the room . . . past the toys . . . under the paintboard.

(3) LINEAR. Starting from over there . . . go out of the door . . . walk to the carpet . . . it's near the bookshelf.

(4) LINEAR. You go in the door . . . you go over to the rug . . . way over to the end of the rug . . . it's under the books.

(5) LINEAR. You go in there . . . there's a table . . . past some shelves . . . it's by the television set.

(6) LINEAR. Through the door . . . walk straight ahead . . . past some tables . . . it's by the telly.

(7) LINEAR. Through the door . . . you have to turn right . . . you go past a blackboard . . . it's under a radiator.

(8) LINEAR. You go out the door . . . you go right . . . you go past the other end of the table . . . it's by that radiator.

Procedure

The testing area was the school's Television Room, which all the children used at least once a week for other activities. Each child heard 8 sets of instructions from the 32 available. These 8 were selected so that no child ever heard the same set twice (even in a different order) and so that each child heard two of each of the four Instruction Formats. The order of these 8 sets was randomized differently for each child.

The experimenter first toured the room with the child, pointing out the pots and ensuring that the child could name the adjacent objects (used as end-points in the instructions). The child then waited in the hallway while the experimenter hid the prize under one of the four pots. The experimenter then returned to the hallway, asked the child to try to find the prize first time if possible, and then read the relevant transcript. The child then went back into the room and looked for the prize, while the experimenter unobtrusively noted the number of pots searched. This was repeated until the child had searched for the prize in response to each of the eight sets of instructions.

Scoring

Each child's responses were scored as the mean number of pots (ranging from 1 to 4) that had been searched (over two trials) to find the prize for each of the four different Instruction Formats. Hence, each child yielded four scores.

RESULTS

Subjects' mean scores are presented in Table 2, as a function of Age and Instruction Format. Inspection of the means suggests that fewer searches are required by older children. Instruction Format also has a marked effect, with more searches needed with the Reversed and Pseudorandom Formats

TABLE 2. *Mean number of searches taken by children of different ages to find the prize in Experiment I, given instructions in different formats*

Instruction format	Age 4	5	7	9	Mean
Linear	1.500	1.313	1.156	1.188	1.289
s.d.	0.658	0.544	0.437	0.403	
End-Point + Linear	1.563	1.563	1.313	1.250	1.422
s.d.	0.730	0.750	0.577	0.483	
Reversed	1.938	1.594	1.219	1.219	1.492
s.d.	0.704	0.841	0.407	0.413	
Pseudorandom	2.313	2.000	1.250	1.156	1.680
s.d.	0.750	0.775	0.387	0.515	
Mean	1.828	1.617	1.234	1.203	1.471

and fewer required with the Linear Format. However, this effect of Instruction Format appears to be present for the younger children only. Older children require relatively few searches regardless of the type of format. To confirm these conclusions, an Age (4 levels) × Instruction Format (Linear, End-Point + Linear, Reversed, Pseudorandom) ANOVA with repeated measures on the second factor was carried out, using the mean number of searches taken by each child over two trials as the dependent variable. This shows significant main effects of Age [$F(3,60)=7.87$, $P<0.001$] and of Instruction Format [$F(3,180)=8.58$, $P<0.001$]. There is also a significant interaction of Age × Instruction Format [$F(9,180)=2.11$, $P<0.05$].

The main effect of Age is due to a general decrease with age in the number of searches required. The main effect of Instruction Format is due to the Linear, End-Point + Linear and Reversed Formats all being easier than the Pseudorandom Format. However, these conclusions must be qualified by the two-way interaction of Age × Instruction Format. Further analysis of the simple main effects of Age of child for the different Instruction Formats showed that whereas Age has a marked effect for the Reversed Format [$F(3,240)=5.22$, $P<0.01$] and for the Pseudorandom Format [$F(3,240)=11.65$, $P<0.001$], there is very little effect for the Linear Format and the End-Point + Linear Format [$F(3,240)<1.2$, both cases]. Tukey's test [$q(4,240)=4.40$, HSD($p=0.05$)$=0.549$] confirmed that the effect for Reversed Format is due to the 4-year-olds requiring more searches than 7-year-olds ($P<0.01$) and 9-year-olds ($P<0.01$). The effect for Pseudorandom Format is due to 4-year-olds requiring more searches than 7-year-olds ($P<0.01$) and 9-year-olds ($P<0.01$), and 5-year-olds requiring more searches than 7-year-olds ($P<0.05$) and 9-year-olds ($P<0.01$). The simple main effects of Instruction Format for different ages of child showed that there is an effect for 4-year-olds [$F(3,180)=9.39$, $P<0.001$] and 5-year-olds [$F(3,180)=4.95$, $P<0.01$], but not for 7- or 9-year-olds [$F(3,180)<1$, both cases]. Tukey's test [$q(4,180)=4.40$, HSD($P=0.01$)$=0.563$] confirmed that the effect for 4-year-olds is due to the children requiring more searches for Pseudorandom instructions than for Linear ($P<0.01$) or End-Point + Linear ($P<0.01$). The effect for 5-year-olds is due to the children requiring more searches for Pseudorandom than for Linear instructions ($P<0.01$).

To summarize this interaction, 7- and 9-year-olds are equally capable of using all of the formats. However, 4-year-olds are hampered by both Reversed and Pseudorandom instructions, and 5-year-olds are hampered by the Pseudorandom Format.

DISCUSSION

These results strongly support the predictions that the Linear and End-Point + Linear Formats would be comparatively easy at all ages. There was also support for the prediction that younger children would find it more difficult to cope with the Pseudorandom and Reversed Formats. There was some indication that young children find it especially difficult to cope with the Pseudorandom Format as compared to the Reversed Format, as the 5-year-olds were only hampered (relative to the Linear Format) by the scrambled instructions. The lack of any difference between the Linear and End-Point + Linear conditions shows that children are not being hampered by remembering only the terminal item of the instructions, even at 4 years. This suggests that the temporal order of landmarks and locatives is not sufficient to explain the effects of linearity upon recall. This probably differs from Brown & French's (1976) findings because the children here were not asked to reconstruct an entire sequence, but could complete the task if they only identified the end-point of the sequence from the whole description.

Some general conclusions can now be drawn regarding children's reception and use of spatial instructions. It seems that there is an early ability to take advantage of the linearity of incoming information, which is present for the Linear and End-Point + Linear Formats. This is probably not a simple ability to use primacy and recency effects to identify the end-point information, which is equivalently placed in the End-Point + Linear and Reversed Formats, since there was a significant development with age in the ability to use Reversed instructions, but not End-Point + Linear instructions. Between 4 and 7 years, the child seems to learn how to 'manipulate' instructions, either through a 'screening' of the information or through a 'mental rearrangement'. This means that the identification of end-points and static locatives is better, so that the resultant search pattern is more efficient.

This effect of linear presentation on young children is compatible with the results of other research. The ability to use linear organization of cognitive maps for routes seems to be present earlier than was predicted by Siegel *et al.*'s (1979) study, but it is possible that Siegel *et al.*'s use of MDS may have led to a less realistic reflection of the cognitive representation. Baird, Merrill & Tannenbaum (1979) showed that adults find that MDS, derived from their own paired-distance estimates, gives an 'unsatisfactory' representation of the environment.

The present results are most congruent with those of Poulsen *et al.* (1979), who showed a development between 4 and 6 years in the ability to recall scrambled input. Of course, the results of this study are based on relatively short descriptions, and it might not be until a later age that children would be able to utilize longer scrambled descriptions (cf. Buss *et al.*, 1983). While this study has not explicitly tested the way in which linearity has helped the child to understand spatial reference, it seems likely that it has been effective by highlighting (for the young children, at least) either the end-point or the static locative which uniquely marks the end-point from the other instructions. The notion that the value of linearity may lie in its ability to highlight the static locative, and hence teach the child the locative's meaning, will be taken up in the General Discussion.

The following study will examine the development of children's ability to provide linear instructions when appropriate.

EXPERIMENT II

DEVELOPMENT OF THE USE OF LINEARITY IN GIVING SPATIAL INSTRUCTIONS

Having shown that the format of spatial instructions influences the comprehension of the listener, it is now relevant to ask whether children have any insight into this influence. This might suggest a development in the ability to use more linear forms appropriately (i.e. for younger listeners).

Of course, this is related to the classic problem of the child's ability to take alternative perspectives in communication, which has been examined using two types of task: the 'referential communication' task and the more naturalistic studies of sensitivity to listener status. The referential communication paradigm (see Glucksberg, Krauss & Higgins 1975) shows a development in the ability to select and transmit critical aspects of a display, with development complete by 11 years. However, Flavell, Botkin, Fry, Wright & Jarvis (1968) have shown that the ability to take the role of another and to select appropriate information may be present at 3 to 4 years if the task is sufficiently simple. The tasks chosen by Glucksberg and his colleagues were rather complex and unusual for the child, since they involved highly artificial referents and deprived the child of some of the normal mechanisms of communication (e.g. gestures). A better study is that of Greenberg, Kuczaj II & Suppiger (1983), who have shown that children of 2 to 6 years attempt to communicate more information about a more complex referent, regardless of the status of the listener. Five- and six-year-olds were shown to make spontaneous allowance for the listener's characteristics (lack of visual knowledge) by using a greater number of informative modifiers. However, even children of 3 to 4 years were capable of making such allowances if they were made aware of the listener's characteristics by a questioning session. It may be that young children can discern and transmit sufficient necessary information in more realistic settings and given adequate prompting.

Turning to the second type of task, there is a large number of naturalistic studies showing that young children can make sophisticated stylistic changes in their speech, according to the perceived status of the other person (see Shatz 1983). A problem with such studies is that they tend to lack any measurable outcome by which the effectiveness of such stylistic changes can be tested. Thus the finding that 4-year-olds can use 'baby talk' to 2-year-olds, for example (Shatz & Gelman 1973), does not mean that the 'baby talk' is necessarily an improved form of communication in that setting. However, since it has now been established that a linear account is highly informative to a younger child, it is possible to ask whether older children have developed the skill of using this format in spatial reference. This would be signalled by use of more linear descriptions by older children addressing 4- and 5-year-olds, but not necessarily towards their peers.

In this study, children were asked to describe the location of an object which they had just hidden (in the same setting as the previous study). It was predicted that only the oldest group would be able to make adjustments to the linearity of their descriptions (as rated by adults) according to the age of the listener, and that these adjustments would be in the direction of greater effectiveness.

METHOD

Subjects

A different group of 72 pupils from the same Oxfordshire Nursery and First School served as subjects. There were three age groups of 24 children each, with mean ages of 4;6 years (range 4;1 to 4;9), 5;9 years (range 5;6 to 5;11) and 8;9 years (range 8;5 to 8;11). The single group of 8-year-olds was used due to the apparent lack of differences between the 7- and 9-year-olds in Experiment I.

Materials

The same four hiding places were used as in the previous study, and pieces of fruit were again used as prizes. No predetermined instructions were used in this study. The only additional equipment was a cassette recorder, used to record the children's descriptions. These were then transcribed for adult rating.

Procedure

The same testing area was used, with no changes in the layout of the room. Each child participated twice, once as a 'Speaker' and once as a 'Listener'. Children were paired so that each age group communicated to each of the three age groups. Thus there were nine groups for comparison (4–4, 4–5, 4–8, 5–4, 5–5, 5–8, 8–4, 8–5, 8–8), each with 8 pairs of children. No child ever gave and received information from children in the same age pairing (so that a child who told a 5-year-old where the prize was hidden would never be told by a 5-year-old, for example). Each pair performed two trials.

The two children were shown around the classroom in the same way as in the previous study. Then one child (the listener) waited in the hallway while the other child (the speaker) hid the prize under a pot designated by the experimenter. Then the experimenter and the speaker returned to the hallway, and the experimenter asked the speaker to tell the listener how to find the pot where the prize was hidden, so that it could be found first time if possible. The ensuing description was recorded, and then the listener went to look for the prize. The procedure was then repeated, with the two children in the same roles.

TABLE 3. *Examples from Experiment II of children's descriptions of how to find the prize, and adults' ratings of linearity of the descriptions*

(i) 4 yr old to 4 yr old. Mean Linearity Rating = 1.6
'In there (points), isn't it? In there somewhere (points) . . . isn't it . . . it's over there somewhere (points).'

(ii) 5 yr old to 4 yr old. Mean Linearity Rating = 3.6
'Well . . . you go across the floor (points) then go . . . this way (points).'

(iii) 8 yr old to 4 yr old. Mean Linearity Rating = 3.6
'Well, erm, it's next to a paint stand . . . far away from this door . . . and there's (points) a door up there . . . it's easiest if you go up and walk straight up . . . it's under the pot.'

(iv) 8 yr old to 5 yr old. Mean Linearity Rating = 6.2
'You go out the door (points) then you go right (points) then you go past the other end of the table, it's under that pot.'

(v) 8 yr old to 8 yr old. Mean Linearity Rating = 3.0
'Well, there's a heater in the room (points) . . . over that way (points) . . . there's a pot by the heater (points) . . . down there . . . it's right by the heater.'

Each of the 144 descriptions was transcribed (see Table 3 for examples). These transcripts were given to five judges, who each rated the transcripts for Linearity on a scale of 1 (Least Linear) to 7 (Most Linear). The judges were blind to the children's ages and to the layout of the classroom, so that their ratings would reflect the structural organization of the communication rather than its reference to particular locations in the classroom. The exact question asked was: 'To what extent does the child's description appear to follow a linear, unidirectional sequence?'.

Scoring

The adult's ratings were used as the dependent variable of Linearity, and were entered into the ANOVA outlined below.

RESULTS

The mean adult ratings of linearity are presented in Table 4. The results suggest that there is a general increase with Age of Speaker in the linearity of children's instructions. The low linearity rating for 8-year-old speakers addressing 8-year-old listeners suggests that there may be a tendency for older children to use less linear instructions for their peers. In confirmation of these findings, an Age of Speaker (3 levels) × Age of Listener (3 levels) ANOVA was carried out on the adults' mean ratings of Linearity of each transcript. The ANOVA shows a significant main effect of Age of Speaker [$F(2,63)=21.33$, $P<0.001$] and a significant interaction of Age of Speaker × Age of Listener [$F(4,63)=3.00$, $P<0.025$].

TABLE 4. *Mean adult ratings of linearity of speakers' descriptions for different ages of listener in Experiment II*

		Age of speaker			
		4	5	8	Mean
Age of listener	4	1.975	2.088	3.738	2.600
	s.d.	0.492	0.871	0.793	
	5	1.863	2.400	4.238	2.834
	s.d.	0.450	0.940	1.139	
	8	1.938	2.563	2.625	2.375
	s.d.	0.863	1.411	0.623	
	Mean	1.925	2.350	3.534	2.603

The main effect of Age of Speaker is due to a continuous development in the tendency to produce linear instructions, over the age range which was identified as important in the previous study. However, this effect must be qualified by reference to the interaction of Age of Speaker × Age of Listener. Further analysis of the simple main effects of Age of Speaker for different ages of listener show that there is a significant effect of Age of Speaker for 4-year-old listeners [$F(2,63)=9.97$, $P<0.001$] and for 5-year-olds [$F(2,63)=15.88$, $P<0.001$], but not for 8-year-olds [$F(2,63)<1.5$]. Tukey's test [$q(3,63)=3.40$, $HSD(P=0.05)=1.06$] shows that the effect for 4-year-old listeners is due to 8-year-olds giving more linear instructions than 4- or 5-year-old speakers ($P<0.01$, both cases). The effect for 5-year-old listeners is also due to 8-year-old speakers giving more linear instructions than 4- or 5-year-old speakers ($P<0.01$, both cases). Further analysis of the simple main effects of the Age of Listener for the different ages of speaker shows that although there is no significant effect of Age of Listener for 4-year-old speakers [$F(2,63)=0.03$] or for 5-year-old speakers [$F(2,63)=0.60$], there is a marked effect of Age of Listener upon 8-year-old speakers [$F(2,63)=6.98$, $P<0.01$]. Tukey's test [$q(3,63)=3.40$, $HSD(P=0.05)=1.06$] confirmed that 8-year-olds give less linear descriptions to 8-year-old listeners than they give to 5-year-olds ($P<0.01$) or to 4-year-olds ($P<0.05$).

To summarize, these results show that 8-year-old speakers use more linear instructions than younger speakers when addressing 4- or 5-year-old listeners, and that the 8-year-old speaker uses more linearity in instructions to younger children than to same-age peers. This shows a degree of flexibility in the way in which the 8-year-old delivers instructions.

DISCUSSION

This experiment was primarily designed to find whether children develop an ability to use more effective means of communicating about the environment. As it had previously been shown (Experiment I) that a linear format is an effective form at all ages, then a possible outcome might have been for the older children to use a highly linear Instruction Format at all times. However, the results show that although the 8-year-olds do more frequently produce linear information than younger children, they are especially likely to do this for young listeners, who would have particular difficulties with non-linear information. This suggests that the 8-year-old is able to take the sophistication of the listener into account when formulating a spatial reference.

GENERAL DISCUSSION

These two experiments have shown that there is a development between 5 and 7 years in the ability to deal with disorganized instructions, and that children as young as 8 years are able to make adjustments to their speech which make use of this developing ability. The examples in Table 3 demonstrate this development of linearity in production. Some examples (e.g. iii) suggest that the 8-year-olds may be able to produce the End-Point + Linear format which was included in the first experiment. The studies relate findings on children's individual capacities in a more experimentally constrained setting to more natural patterns of dyadic interaction. This relationship not only gives the findings of Experiment I more relevance to children's normal behaviour, but also shows that Experiment II is addressing a pattern of interaction which is of some value to the child.

Children appear to be able to use linearity in receiving spatial instructions before tending to use linearity in giving them. However, with the development of such a style of presentation, there seems to be a development of skill in its application, so that it is heavily used when it would be particularly beneficial (i.e. for younger listeners). These studies suggest that there is development of the selective use of effective communicative styles, rather than simply in the use of syntactic styles (Shatz & Gelman 1973). A complex model of the child's cognitive and linguistic processing would be needed to account for these findings.

It seems that Siegel *et al.*'s (1979) 'linear format for cognitive construction of route representations' is less straightforward than had been envisaged. Children of a young age can benefit from a linear presentation, suggesting that it is more conducive to memory for (or identification of) relevant information. However, 7-year-olds have the ability to 'select and re-organize' input, so that linearity is no longer particularly beneficial, at least for simple instructions. It seems that the production of linear instructions (more like Siegel *et al.*'s findings) is possible by 8 years.

A more linguistic explanation may be helpful. Possibly the children in Experiment I are becoming better at identifying the static locative prepositions used in all the instructions (by, under, near) as more likely to indicate the end-point than the prepositions used in other parts of the instructions (past, across, ahead, etc.). However, this cannot be the entire case, as described earlier, because the End-Point + Linear Format was useful at an earlier age than the Reversed Format. So the structure of the whole spatial reference is affecting the value of particular linguistic forms within it. The 8-year-olds' ability to adapt instructions according to the age of listener (Experiment II) is probably the product of a skill of using static locatives and landmarks in appropriate places, rather than simply using the correct locative and landmark (see Table 4, examples iii–v). Possibly it will be necessary for young children to develop a more general cognitive skill of benefiting from linearity prior to being able to select the static locative preposition from a complex set of instructions, as linear instructions may serve to highlight and define the locative in a realistic context.

Summary

These studies have shown that children are developing skills of adapting communication in a way which will make their speech more helpful to the listener, with 8-year-olds using more linear organization of speech when addressing children who will benefit from such a structure. It seems that the ability to communicate depends not only on the amount or formatting of the children's knowledge, but also reflects the speaker's knowledge about the cognitive and linguistic skills of the listener.

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