

The effect of make-believe play on deductive reasoning

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Under certain circumstances, a deductive or 'theoretical' mode of reasoning is revealed among young children, as well as among illiterate adults. In four experiments we asked whether 4-, 5- and 6-year-old children can extend their deductive abilities to syllogisms whose content runs counter to their practical world knowledge. In Experiment 1, premises were presented within the context of play, using suitable toys and props, or in the ordinary verbal mode. Syllogisms with known, unknown as well as contrary facts were included. Children's performance following presentation in the verbal mode was less accurate than with presentation in the context of play, particularly when syllogisms with contrary facts were included in the premises. Experiments 2, 3 and 4 showed that it is the make-believe context of play rather than the visible presence of toys during play that facilitates children's reasoning when the premises of the problems run counter to their experience.

Cross-cultural research has suggested that subjects vary in the extent to which they approach syllogisms in a deductive or 'theoretical' mode rather than attempting to draw conclusions based on empirical knowledge. The cross-cultural work of Luria (1976) and Scribner (1975) is particularly important in this respect.

Scribner (1975) tested (a) illiterate adults from a West African tribe, the Kpelle, who live on rice plantations in isolated regions, (b) young Kpelle who had secondary education and (c) North-American University students. Each subject received eight classic syllogisms whose contents varied. Some contained veridical premises and others included non-veridical premises.

The illiterate Kpelle solved 53 per cent of the problems, Kpelle students 80 per cent, and the North-American University students 90 per cent. Scribner went on to analyse the type of justification that subjects gave for their responses. She identified three types of justification: *theoretical*, in which the conclusion was explicitly related to information contained in the premises as given by the experimenter; *empirical*, in which the conclusion was explicitly related to what the subject knew or believed to be true; and *arbitrary*, which covered idiosyncratic and arbitrary answers as well as 'don't know responses'.

Illiterate subjects gave far more empirical justifications than literate subjects who used more theoretical justifications. To explain these results Scribner (1977) intro-

duced the concept of 'empirical bias', which corresponds to the tendency of subjects, among some traditional groups, to appeal to personal knowledge and experience in order to draw conclusions.

To what extent do young children adopt an empirical rather than a theoretical bias? To answer this question, Hawkins, Pea, Glick & Scribner (1984), presented 4- and 5-year-old-children with verbal syllogisms containing three different types of content: fantasy (F); incongruent (I) and congruent (C) with at least one negative and one affirmative problem, for example:

Pogs wear blue boots.
Tom is a pog.
Does Tom wear blue boots?

Rabbits never bite.
Cuddly is a rabbit.
Does Cuddly bite?

The order of the three different types of content was systematically varied across four groups: (F/I/C), (I/F/C), (C/I/F) and jumbled. Like Scribner (1975), Hawkins *et al.* (1984) examined justifications to determine whether the reasoning of the child was 'theoretical' or 'empirical'. They found that the children performed well on categorical syllogisms with unknown (fantasy) content or with content that was congruent with their experience. However, when the content of the syllogisms was incongruent with their experience, children performed below chance. Task order also affected the use of deductive reasoning. Children who received fantasy problems first gave a significantly higher number of theoretical justifications particularly for the fantasy problems and also produced significantly more correct responses than the children belonging to the other three groups who did not receive fantasy problems first. Thus, children could use unfamiliar information in the premises in a deductively correct manner, but this was only likely to happen (a) when practical world knowledge was irrelevant as in fantasy problems, and (b) when such fantasy problems were presented at the outset, i.e. prior to problems which might engage the subject's real world knowledge.

These results are exciting and important because they show that under certain circumstances, children with limited exposure to either schooling or literacy (the subjects ranged from 4.2–5.1 years) can reason in a logically correct 'theoretical' manner.

In the present study, we tried to find out whether children can extend their deductive abilities to syllogisms in which the content of the premises runs counter to the subjects' experience. Although subjects in the study carried out by Hawkins *et al.* (1984) performed well below chance on such incongruent problems and rarely offered theoretical justifications, irrespective of the order of problem presentation, we predicted that young children could be prompted to apply their deductive capacity to such incongruent material. Our prediction was based on the assumption that children's success with fantasy material, particularly when it is presented at the beginning of a testing session, is not due to the fantasy content of that material.

Instead, it is attributable to the fact that children are prompted by such material to enter into a semi-autonomous, pretend world. They appreciate that within this possible world, their normal empirical knowledge does not apply. Hence, they have recourse to their deductive abilities in order to reason from the premises, as stated by the experimenter. If this interpretation is correct, it predicts that children should also be able to extend their deductive abilities to incongruent premises, providing these premises are offered to the children in such a way that they treat them as part of a pretend world that is separate from reality.

To encourage young children to treat incongruent premises in this way, we presented them within the context of play, using suitable toys and props. For comparison purposes, children were also presented with the same premises in the ordinary verbal mode. Finally, in order to compare performance with that obtained in earlier studies, children were given three types of premise content: unknown (i.e. fantasy), known, and contrary to their practical world knowledge (i.e. incongruent). Every problem consisted of two premises and a conclusion in the form of a question. The rule of inference *Modus Ponens* (p implies q , p , therefore q) was represented by items which employed class statements instead of conditional statement (if p then q). In this affirming-the-antecedent form of syllogism, the subject was told all p are q and x is p and asked whether x was or was not q as used in Kuhn (1977). For example:

All people in Tudor are happy.
Jean lives in Tudor.
Is Jean happy?

Children were asked to justify their answers, and their justifications were classified as theoretical, empirical or arbitrary.

Experiment 1

Method

Subjects. Subjects were 48 children equally subdivided into a young group, average age 5 years 6 months (range 5 years 2 months to 5 years 10 months) and an older group, average age 6 years 6 months (range 6 years 2 months to 6 years 10 months), from a primary school in Oxford. There were 24 girls and 24 boys. There were six boys and six girls from each age group assigned to the verbal group (VG) and six boys and six girls to the play group (PG).

Material. The test materials consisted of 24 classical syllogisms. The content of the syllogisms varied: eight included known facts that agreed with the subject's experience, eight included unknown facts and eight included known facts contrary to the subject's experience. Within each group of eight syllogistic problems, four required 'Yes' as the correct answer, and four required 'No'.

Every problem consisted of two premises and a conclusion in the form of a question (see Appendix 1). Appendix 1 also illustrates how the premise (e.g. that a given animal makes a particular sound) was presented in three different ways: so as to restate known facts ('All cats miaow'); so as to introduce unknown facts ('All hyenas laugh'); and so as to run contrary to known facts ('All cats bark'). Probe questions (see Appendix 1) which were posed before the syllogisms were used to establish what facts subjects did know.

Toys and dolls were used to represent the contents of the syllogisms for the play group.

Procedure. There were 24 children in each age group: half of them were allocated to the verbal group and half to the play group. Each group of 12 children was randomly divided into three subgroups: each subgroup of four subjects was presented with a set of eight problems that were either known, or unknown or contrary to the subject's experience. Of these eight syllogisms, four had as the correct answer 'Yes' and four had as the correct answer 'No', with each of the eight syllogisms falling in the same category, i.e. known or unknown or contrary. The order of the eight syllogisms was randomly varied across subjects.

Before the experiment began, subjects were asked the probe questions to determine whether they were familiar with the facts stated in the initial premise of each problem.

For the verbal group, the experimental instructions were as follows: 'I am going to read you some little stories about things that: (a) you will know about (for the known facts subgroup), (b) you will not know about (for the unknown fact subgroup), (c) will sound funny (for the contrary facts subgroup). But let's pretend that everything in the stories is true'. Then, the experimenter read each syllogism.

For the play group the instructions were as follows: 'I am going to show you some toys and at the same time read you a little story about the toys. These stories are about things that: (a) you will know about, or (b) you will not know about, or (c) will sound funny. But let's pretend that everything in the stories is true'.

The experimenter read each problem. For the children in the play group this included playing out the problem, i.e. as the experimenter read the syllogisms, she showed the toys which represented the content of each premise. For example, she introduced some toys and made them miaow or bark depending on the initial premise of the syllogism.

Both groups had to repeat the syllogisms, i.e. the children had to mention the first and the second premise in order to ensure that they had encoded the problem. If they could not do this, the syllogism was repeated. Then they answered the question contained in the conclusion of the syllogism. Finally, they were asked to justify their response: 'Why did you say yes?' or 'Why did you say no?'. Depending on the response, children were asked 'How do you know that?' This last question was posed only when the child's response was not clear, i.e. when the response did not specify where the child's knowledge came from. If, for example, the child answered that he or she said yes or no because 'all birds fly', the question 'How do you know that?' was necessary to clarify whether the subject was referring to his or her own knowledge (empirical justification) or to some other criteria. Thus, this last question helped the classification of type of justifications (see Results).

Results

All responses were coded in two ways: (a) for response correctness and (b) for the type of justification given for the response independent of whether the response in question was correct or not. The justifications were assigned to one of three categories: theoretical, empirical or arbitrary.

Theoretical justifications were responses which only referred to information presented in the problem in the first, second or both premises, in a valid deductive manner. Empirical justifications were responses that were justified by reference to practical world knowledge. Arbitrary justifications were responses where the subject offered no justification or an irrelevant justification.

For example in the syllogisms 'All cats miaow; Rex is a cat; Does Rex miaow?' if the children said 'Because you told me that all cats miaow', this justification was classified as theoretical, but if he or she said 'Because I know that cats miaow', it was classified as empirical. And when the child said 'I don't know' or 'Because I like cats' or 'Because he is happy', they were classified as arbitrary.

Probe questions. Each child answered eight probe questions prior to the experiment proper. Children belonging to the contrary facts subgroup answered the same probe

questions as those belonging to the known facts subgroup. The results showed that both age groups were familiar with the general principles stated in the known syllogisms (mean for both groups = 8.00); unfamiliar with the principles stated in the unknown syllogisms (mean for both groups < 1.0); and held beliefs contrary to those asserted in the contrary facts syllogisms (mean for both groups > 7.0).

Response correctness. Inspection of the overall means (bottom row, Table 1) shows that children made fewer mistakes in the play group as compared to the verbal group. This holds true for unknown and contrary facts but there is only a slight difference between the groups for known facts. There is no obvious effect of age or type of answer expected.

To check these conclusions a four-way analysis of age (2) \times group (2) \times type of fact (3) \times type of answer expected (2) was carried out. This produced a main effect for group ($F = 22.69$, d.f. = 1,36, $P < 0.001$) and type of fact ($F = 4.44$, d.f. = 2,36, $P < 0.019$). However interpretation of these two main effects must be qualified by the only other significant result, the interaction of group \times type of fact ($F = 4.04$, d.f. = 2,36, $P < 0.026$). Further analysis of this interaction showed that the two groups did not differ in their performance on known facts ($F = 0.45$, d.f. = 1,36, P n.s.). However, the play group produced more correct replies than the verbal group for unknown facts ($F = 8.40$, d.f. = 1,36, $P < 0.006$) and for contrary facts ($F = 21.93$, d.f. = 1,36, $P < 0.001$).

Type of justification. Two independent and trained judges classified the justifications employing the same criteria as Scribner (1975). Inter-judge reliability for the two

Table 1. Mean correct responses (out of a total of 4) as a function of age, type of group, type of fact, type of answer expected (Expt 1)

		Verbal group			Play group		
		Known	Unknown	Contrary	Known	Unknown	Contrary
Age	Type of answer expected						
Younger	Yes	4.00	2.75	2.25	4.00	3.50	4.00
	No	4.00	3.25	2.50	4.00	4.00	4.00
Older	Yes	3.50	3.25	2.25	4.00	4.00	4.00
	No	3.75	3.00	3.75	4.00	4.00	4.00
Means		3.80	3.10	2.70	4.00	3.90	4.00

judges was 91.7 per cent. Discrepant judgements were presented to a third judge who worked on 32 justifications. This third evaluation in all cases coincided with one of the first two judges. The third judgement was taken as final.

Table 2 indicates that children from the play group gave more theoretical justifications for all types of fact than children from the verbal group. To check this conclusion, a three-way analysis of age (2) \times group (2) \times type of fact (3) was carried out. The only significant main effect was for group ($F = 29.16$, d.f. = 1,36, $P < 0.001$), confirming that children belonging to the play group, gave far more theoretical justifications for all types of fact than children belonging to the verbal group.

Table 2 also shows that children in both groups gave more empirical justifications for known facts. The three-way analysis of age \times group \times type of fact confirmed that there was a significant main effect for fact ($F = 3.87$, d.f. = 2,36, $P < 0.03$).

The verbal group produced more arbitrary justifications than the play group, and this type of justification was more frequent when the type of fact was contrary and unknown as opposed to known (see Table 2). A three-way analysis of age \times group \times type of fact for arbitrary justifications confirmed that there was a significant main effect of group ($F = 31.93$, d.f. = 1,36, $P < 0.001$) and of fact ($F = 5.13$, d.f. = 2,36, $P < 0.011$).

In summary, the two groups exhibited a different pattern of justification. The play group gave many theoretical justifications and rarely offered arbitrary justifications. By contrast, the verbal group gave fewer theoretical justifications, and fell back more often on arbitrary justifications. The frequency of a particular category of justification also depended on the type of fact. Known facts elicited more empirical justifications and few arbitrary justifications.

Table 2. Mean number of theoretical, empirical and arbitrary justifications as a function of group and type of fact (Expt 7).

	Verbal group			Play group		
	Known	Unknown	Contrary	Known	Unknown	Contrary
Theoretical						
Younger	4.75	2.75	2.00	6.25	6.25	6.25
Older	2.50	3.25	3.50	6.25	7.75	6.25
Empirical						
Younger	2.75	0.50	1.00	1.75	1.25	0.74
Older	3.00	2.75	0.75	1.75	0.25	1.00
Arbitrary						
Younger	0.50	4.75	5.00	0.00	0.50	1.00
Older	2.50	2.00	3.75	0.00	0.00	0.75

Discussion

The most striking result of the study is the excellent performance of the children from the play group on syllogisms with contrary facts. Recall that in the verbal group, and indeed in earlier studies (Hawkins *et al.*, 1984), children given this type of content achieved low scores. How should this excellent performance be explained? In the introduction, we proposed that presentation of premise information in the context of play would promote children to treat the premises as temporarily true or at least to regard them as true of the make-believe play world. Thus, the experimenter made some cats bark, or showed the children some fishes apparently living in trees. It seems likely the presentation of such premises in this make-believe play mode enabled them to more readily accept that the contrary premises were true, than simply hearing the contrary premises asserted verbally.

However, before this interpretation is accepted there is an alternative explanation of the results that must be ruled out. Subjects had to remember the previously stated information at the same time as they tried to work out the answer to the syllogism. For the play group this memory load was reduced because the objects mentioned in the premises were continuously in the subject's presence. Indeed, in some cases the entire premise was visible. Toy fishes, for example, remained perched in the trees. The verbal group, however, had to rely on recall of the verbally presented premises. No prompts remained visible to aid their recall of those premises. Such memory problems might be especially acute for novel premises (i.e. unknown and contrary facts) compared with familiar premises (i.e. known facts).

If the visibility of the toys, when the final question is asked, is a critical factor insofar as it helps children in the play group to remember the premises, then they will perform worse if the toys are removed from sight. Expt 2 tested whether this is true or not. Contrary facts were used since they had provoked the most clear-cut difference between the play group and the verbal group.

Experiment 2

Method

Subjects. Subjects were 20 children whose average age was 6 years (range 5 years 6 months to 6 years 6 months), from two primary schools in Oxford. There were 10 boys and 10 girls.

Material. The test materials consisted of the same eight classical syllogisms with contrary facts used in Expt 1 and the same eight probe questions which were used for the known and contrary facts subgroups in Expt 1 (see Appendix 1). In addition, the toys and dolls used in Expt 1 were used to represent the contents of the syllogisms.

Procedure. The 20 children were presented with eight syllogisms in two conditions: half of the subjects (five girls and five boys) were first presented with four syllogisms in the visible condition followed by four syllogisms in the invisible condition. For the other half (five boys and five girls), this order was reversed. The procedure for the visible condition was the same as for the play group with contrary facts in Expt 1. For the invisible condition, the following modification was introduced: after the experimenter had read and played out the second premise of each syllogism, she removed the toys from sight and then she asked the test questions. Thus, the children saw the toys only as long as the two premises were being read. For each condition there were four syllogisms: two of them had as the correct answer 'Yes' and two had as the correct answer 'No'. The order of the syllogisms was randomly varied across subjects.

Results

Probe questions. There were no errors on the probe questions.

Response correctness. The mean number of correct replies was 3.75 (out of 4) for the visible condition and 3.80 (out of 4) for the invisible condition. Thus, performance was equally good in the two conditions. A three-way analysis of variance of condition (2) \times order (2) \times type of answer expected (2) produced no significant effects.

Type of justification. Inter-judge reliability for the two judges was 100 per cent. Children frequently offered theoretical justification in both the visible (mean = 3.2) and invisible (mean = 3.3) conditions whereas empirical and arbitrary justifications were very rarely used (mean in all cases < 1.0). Three separate two-way analyses of variance of order \times condition carried out on each type of justification produced no significant effects. Indeed, in each case the main effect of condition fell well short of significance ($F < 1$, d.f. = 1,6, P n.s.).

Discussion

Children's performance in the visible and invisible conditions was equally good. Theoretical justifications predominated in both conditions. Arbitrary and empirical justifications were rarely used by any children. The order of presentation also had no effect on subjects' performance. In view of these results, we cannot attribute the children's good performance in the play group in Expt 1 to the fact that the objects remained visible when the crucial question was asked for premises with contrary facts.

These results strengthen the conclusion that the presentation of premises with contrary facts in the context of play prompts children to accept them as true, and to use them as a basis for reasoning. However, it is still possible to object that the presence of toys during the presentation of the premises helps children to encode the premises, without helping them to treat the premises as true. Recall that in the so-called invisible condition of Expt 2, the toys were removed when the trial question was posed but they had been visible during the encoding of the premises.

To choose between these two alternatives, a third experiment was carried out. The premises were presented with toys either hidden or visible holding the play environment constant in other respects. If the play condition facilitates performance by providing a make-believe environment where premises with contrary facts can be regarded as true, then children in these conditions should perform equally well. If, on the other hand, the visible presence of toys is needed to help children encode the premises, children should perform better when the toys are visible than when they are hidden.

Experiment 3

Method

Subjects. There were 20 children whose average age was 5 years and 11 months (range 5 years 8 months to 6 years 2 months), from a primary school in Oxford. There were 10 boys and 10 girls.

Material. The test materials were the same eight syllogisms with contrary facts as for Expt 1 and Expt 2 and the same eight probe questions which were used for the known and contrary fact subgroups in Expt 1 (see Appendix 1).

The same toys and dolls were used to represent the content of the syllogisms for the play group as those used in Expts 1 and 2. In addition, a box with a hole that allowed children to see the toys placed inside it was used.

Procedure. Before the experiment proper had begun, the probe questions were asked.

The 20 children were divided into two groups. Half of them (five boys and five girls) were allocated to the visible toys group and half (five boys and five girls) to the hidden toys group. For the visible toys group the instructions and the procedure were as follows: 'Here is another planet. Everything in this planet is different. Look in here'. The experimenter directed the child to look through the hole at the objects in the box which represented the content of the two premises of the syllogism that she was playing out, i.e. as the experimenter read the syllogism and the child was looking at the toys in the box, the experimenter made the toys bark or the child could see fishes 'living in trees', black snow, etc. Thereafter, the procedure was the same as for the invisible condition in Expt 2 except for the use of the box. Thus, when children had turned away from the box so that the toys were no longer visible, the test question was posed.

For the hidden toys group, the experimenter said: 'This is another planet. Everything in this planet is different. I'll see what's going on there and I'll tell you'. Then, the experimenter looked through the hole and told the child the two premises describing what she saw and then asked the question. For example: 'All cats bark. I see here that all cats are barking' or 'All fishes live in trees. I see here that all fishes are living in trees'.

In summary, the premises were presented to both groups in a make-believe mode. The two groups differed only in whether they could perceive the content of the premises, as well as hearing the premises stated.

Results

Probe questions. There were no errors on the probe questions.

Response correctness. The mean number of correct replies was 3.90 (out of 4) for the visible condition and 3.55 (out of 4) for the hidden condition. A two-way analysis of variance of group (2) \times type of answer expected (2) produced no significant effects.

Type of justification. Inter-judge reliability for the two judges was 95.6 per cent. Discrepant judgements were presented to a third judge who worked on seven justifications. This third evaluation in all cases coincided with one of the first two judges. The third judgement was taken as final.

Children frequently offered theoretical justifications in both the visible (mean = 6.20) and the hidden (mean = 5.20) conditions, whereas empirical and arbitrary justifications were rarely used in both conditions (in all cases, mean < 2.0). Three separate one-way analyses of group were carried out for each type of justification. No significant effect of group was obtained in any of these analyses.

Discussion

Both Expts 2 and 3 produced negative results. Neither the removal of the toys after premise presentation (Expt 2) nor their invisibility throughout the experiment (Expt 3) led to any drop in the accuracy of children's reasoning or to a change in the pattern of justification. However, when considered together, the results of Expts 1–3 yield an important prediction. Children who receive premises in an ordinary verbal mode will reason less accurately than children presented with those same premises in a make-believe or pretend mode, even when there are no visible toys or props to support the pretend mode. Experiment 4 tested this prediction again using contrary facts. To make the comparison between verbal and play mode as direct as possible, no props were used in either mode.

A second goal of Expt 4 was to check for possible age changes. Thus, 4- and 6-year-old children were compared. Cross-cultural work has frequently suggested that schooling is important for the cultivation of a 'theoretical' attitude. (Scribner, 1975). The inclusion of 4-year-olds should indicate whether such an attitude is available prior to any experience of formal schooling. The 4-year-olds were attending nursery classes but had received only very elementary instruction in arithmetic and no formal instruction in reading or writing.

Experiment 4

Method

Subjects. There were 32 younger children (16 boys and 16 girls) whose average age was 4 years and 6 months (range: 4 years 0 month to 4 years 11 months) and 32 older children (16 boys and 16 girls) whose average age was 6 years and 6 months (range: 6 years 0 month to 6 years 11 months). The 4-year-olds were recruited from nurseries of two primary schools in Oxford where no formal instruction was given in reading or writing and only very elementary instruction in arithmetic.

Material. The test materials were the same eight syllogisms with contrary facts as for Expts 1–3 and the same eight probe questions which were used for the known and contrary fact subgroups in Expt 1.

Procedure. The 32 children of each age group were divided into two groups: 16 of them were allocated to the play group (invisible condition—without toys and without box) and 16 to the verbal group. The procedure for the play group was the same as in Expt 3 except that no box was used. The procedure for the verbal group was the same as for the verbal group in Expt 1.

Before the experiment began, subjects were asked the probe questions to determine whether they were familiar with the facts stated in the initial premise of each problem.

For the verbal group, the experimental instructions were as follows: 'I am going to read you some little stories about things that will sound funny. But let's pretend that everything in the stories is true'. Then, the experimenter read each syllogism, with a normal matter-of-fact intonation.

For the play group the instructions were as follows: 'Let's pretend that I am in another planet. Everything in that planet is different. I'll tell you what's going on there'. Then, the experimenter told the child the syllogism. For example: 'All cats bark. In that planet I saw that all cats bark' or 'All fishes live in trees. In that planet I saw that all fishes live in trees'. The experimenter presented each syllogism as a story, i.e. her intonation was in a make-believe mode. However, there was no attempt to act out the actions described in the syllogism. For example, the experimenter did not make barking noises. Thus, the experimenter introduced dramatic emphasis into her voice just as one might when describing an unusual or striking scene in a story.

Results

Probe questions. The 4-year-old children made few mistakes on the probe questions but they were slightly less accurate (95 per cent) than the 6-year-old children (99 per cent). In general, results showed that both age groups held beliefs contrary to the facts stated in the syllogisms.

Response correctness. Inspection of Table 3 shows that in both age groups, children in the play group were more accurate than those in the verbal group. It can also be seen that 6-year-old children produced more correct responses than 4-year-old children. To check these conclusions, a three-way analysis of variance of age \times group \times type of answer expected was carried out. The results of this analysis produced only two significant results: the main effect of group ($F = 20.02$, d.f. = 1,56, $P < 0.0001$) and the main effect of age ($F = 27.95$, d.f. = 1,56, $P < 0.0001$).

Type of justification. Inter-judge reliability for the two judges was 94.5 per cent. Discrepant judgements were presented to a third judge who worked on 28 justifications. This third evaluation in all cases coincided with one of the first two judges. The third judgement was taken as final.

Table 4 presents the mean number of theoretical, empirical and arbitrary justifications as a function of age and type of group.

Theoretical justifications. Inspection of Table 4 shows that theoretical justifications were more frequent among children belonging to the play group than those belonging to the verbal group. In addition, the older children produced more theoretical justifications than the younger ones. Indeed, 4-year-olds in the verbal group did not produce such justifications at all. An analysis of age \times group showed a significant main effect of group ($F = 15.17$, d.f. = 1,60, $P < 0.0001$) and a significant main effect of age ($F = 26.11$, d.f. = 1,60, $P < 0.0001$). The interaction between age \times group was not significant ($F = 3.14$, d.f. = 1,60, $P < 0.08$).

Table 3. Mean number of correct responses (out of a total of 4) as a function of age, type of group and type of answer expected

	Verbal group	Play group
4-year-old		
Yes	0.81	2.19
No	0.62	2.12
6-year-old		
Yes	2.37	3.62
No	2.43	3.81

Table 4. Mean number of theoretical, empirical and arbitrary justifications as a function of age and type of group

	Verbal group	Play group
Theoretical		
4-year-old	0.00	1.31
6-year-old	2.06	5.56
Empirical		
4-year-old	2.87	0.75
6-year-old	1.81	0.37
Arbitrary		
4-year-old	5.12	5.94
6-year-old	4.12	2.06

Empirical justifications. Empirical justifications were more frequent in the verbal group than in the play group, and the younger children tended to produce this type of justification more often than the older children. The results of the analysis of age \times group produced a significant main effect of group ($F=12.64$, d.f. = 1,60, $P<0.0001$), but the main effect of age was not significant ($F=2.06$, d.f. = 1,60, P n.s.).

Arbitrary justifications. Arbitrary justifications were quite prevalent among the younger children in both groups, and also among the older children in the verbal group. Older children in the play group, however, produced this type of justification less often. The analysis of age \times group revealed no effect of group ($F=0.79$, d.f. = 1,60, P n.s.), a significant effect of age ($F=12.05$, d.f. = 1,60, $P<0.0001$) and an interaction between age \times group ($F=4.19$, d.f. = 1,60, $P<0.045$). Further analyses of this interaction confirmed that among the 4-year-olds, the two groups did not differ in the number of arbitrary justifications ($F=0.67$, d.f. = 1,60, P n.s.). Among 6-year-olds, on the other hand, children from the verbal group produced this kind of justification more often than those from the play group ($F=4.31$, d.f. = 1,60, $P<0.042$). Moreover, in the verbal group the two age groups did not differ in the number of arbitrary justifications ($F=1.01$, d.f. = 1,60, P n.s.), but in the play group the younger children produced more arbitrary justifications than the older children ($F=15.23$, d.f. = 1,60, $P<0.0002$).

In summary, the effects of group and age were quite similar with respect to theoretical and empirical justifications. Children in the play group produced more theoretical and fewer empirical justifications than children in the verbal group. Similarly, older children produced more theoretical justifications than younger children and fewer empirical justifications, although this last effect was not signifi-

cant. Arbitrary justifications were quite prevalent except among older children in the play group.

General discussion

The results of Expt 4 show that when the verbal group and the play group are directly compared, children in the play group perform more accurately, offer more theoretical justifications and fewer empirical justifications. Experiment 4 confirms that we cannot attribute this difference to differences in memory load. Thus, there were no toys or props to serve as prompts or reminders for children in the play group. The only difference between the groups was that the experimenter in the play group presented each syllogism as a story, i.e. her intonation was in a make-believe mode, whereas in the verbal group, the experimenter read each story with a normal matter-of-fact intonation. It appears that, as in the previous experiments, the mode of presentation in the play group helped the children because it encouraged them to enter into the pretend mode and to reason with the contrary facts as if they were true. In the verbal group by contrast there was no invitation to enter the pretend mode. Instead, the experimenter may have appeared to be testing their knowledge (see Heath, 1978). In this reality-oriented mode, they did not accept the premises stated in the syllogisms as true because they were contrary to existing knowledge. Thus, the children in the verbal group of Expt 1 and Expt 4 may have construed the experimental task differently from the experimenter (see Cole, Gay, Glick & Sharp, 1971; Cole & Scribner, 1974; Donaldson, 1978). This interpretation of the difference between the two groups explains not just the greater accuracy of children in the play group but also the shift towards more theoretical and fewer empirical justifications. Finally, it is important to note that Expts 2–4 employed contrary facts only. Further experiments are needed before we can safely conclude that entry into the pretend mode helps children handle unknown as well as contrary premises.

Experiment 4 also revealed a clear age change between 4 and 6 years. The older children were more accurate than the younger children and offered more theoretical justifications. In order to identify the locus of this age change more precisely we may envisage the task as involving three successive stages: taking in and remembering the premises; using them as a true basis for deductions; and making a correct deduction. Thus, there are three different possible explanations for the age change. First, the 4-year-olds might be less able to take in and remember the premises; second, they might be reluctant to treat the premises as a true basis for deduction, and use their own knowledge instead. Finally, they might remember the premises, treat them as a basis for deduction, but do so erroneously.

We will examine evidence for and against each of these possibilities. The first possible explanation seems to be unlikely since the 4-year-olds, like the 6-year-olds, repeated the syllogisms before the final question was posed. Thus, the 4-year-olds appeared capable of retaining the premises. The last explanation—that the children make incorrect deductions from the premises—would predict that the 4-year-olds would sometimes offer theoretical justifications for incorrect judgements, having erroneously reached the wrong conclusion on the basis of the given premises.

However, of 21 theoretical justifications provided by the 4-year-olds, all were given after a correct judgement, and none after an incorrect judgement. Thus, it seems unlikely that the 4-year-olds were treating the premises as a basis for deduction but reasoning from those premises to the wrong conclusion.

Having ruled out the first and the third explanation, we may consider the second. If 4-year-olds were reluctant to treat false premises as a basis for deduction, they should offer few theoretical justifications. Instead, they should either use their own true knowledge and offer an empirical justification, or guess and offer arbitrary justification. Inspection of Tables 3 and 4 gives some support to these predictions. The 4-year-olds produced fewer theoretical justifications than the 6-year-olds; they also produced slightly more empirical justifications and many more arbitrary justifications, especially in the play group. In summary, Expt 4 points to two conclusions: First, the play mode encourages children to treat premises they know to be false as a true basis for deduction. Second, 4-year-olds are more reluctant to do this than 6-year-olds.

Hawkins *et al.* (1984) concluded that children can engage in deductive reasoning when two conditions are fulfilled: the problem content is isolated from practical world knowledge by the use of fantasy material; second, the task setting, particularly the task sequence, also attenuates the intrusion of practical world knowledge by presenting fantasy material first. The results of all four experiments indicate that task setting is more important than problem content. When the task setting was sufficient to isolate the child's reasoning from the intrusion of practical world knowledge, content that is quite vulnerable to such intrusion (i.e. premises with contrary facts) could still be used as a basis for reasoning by 4- to 6-year-old children. Thus, provided the experimenter can engage a make-believe attitude on the part of the child at the outset, even premises that conflict with what the child knows to be true will be accepted as a basis for reasoning.

Interpreted in this light, the results have several implications. First, the results indicate that subjects with no formal schooling (i.e. the preschoolers in Expt 4) can reach novel conclusions on the basis of premises with contrary facts. Thus, although cross-cultural work has stressed the importance of schooling in the cultivation of a theoretical attitude, the present results suggest that although formal schooling may promote such an attitude, it does not engender it in the first place. Second, given the relatively good performance by young children with premises containing contrary facts, it seems likely that cross-cultural work with adults, particularly illiterate adults with little schooling, has led to an underestimate of their ability to adopt a theoretical attitude. Provided such adults could be persuaded to regard premises with contrary facts as true of a make-believe world, they should, in principle, perform as accurately and as 'theoretically' as the children in the present studies.

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Appendix 1

 'Yes' answers

Known facts problems

All cats miaow.
 Rex is a cat.
 Does Rex miaow?
 (Probe question: What noise do cats make?)

Unknown facts problems

All hyenas laugh.
 Rex is a hyena.
 Does Rex laugh?
 (Probe question: What noise do hyenas make?)

Contrary facts problems

All cats bark.
 Rex is a cat.
 Does Rex bark?
 (Probe question: What noise do cats make?)

 'No' answers

All fishes live in water.
 Tot is a fish.
 Does Tot live in a tree?
 (Probe question: Where do fishes live?)

All molluscs live in shell.
 Tot is a mollusc.
 Does Tot live in a tree?
 (Probe question: Where do molluscs live?)

All fishes live in trees.
 Tot is a fish.
 Does Tot live in water?
 (Probe question: Where do fishes live?)
