DOCUMENT RESUME

ED 115 462 SE 018 728

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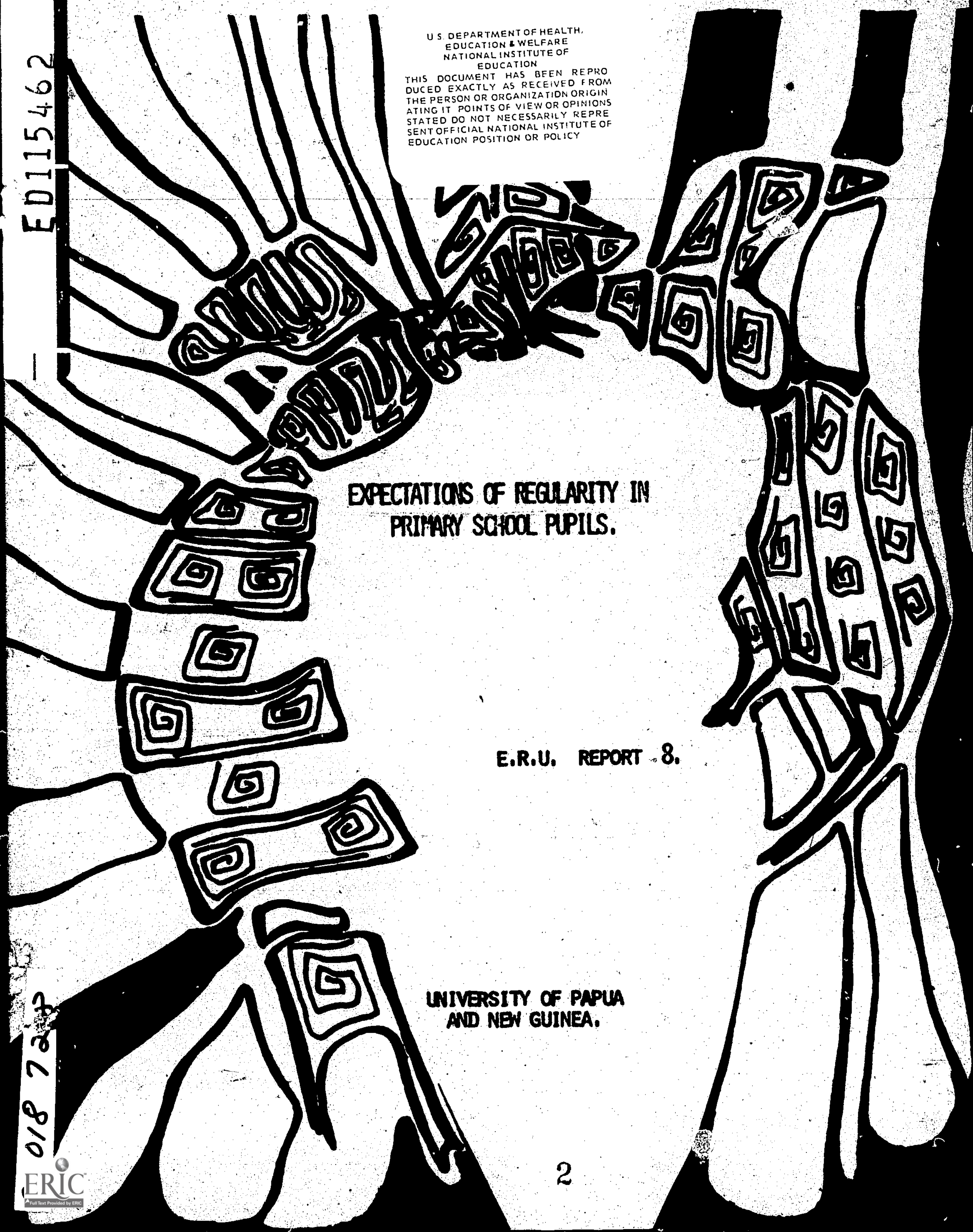
TITLE	Expectations of Regularity in Primary School Pupils. E.R.U. Report 8.
INSTITUTION	Papua and New Guinea Univ., Port Moresby. Educational Research Unit.
PUB DATE	Jun 73
NOTE	37p.; Occasional Marginal Legibility
EDRS PRICE	MF-$0.76 HC-$1.95 Plus Postage
DESCRIPTORS	Educational Research; *Elementary Education; Elementary School Science; *Environmental Influences; *Instruction; Mathematics; *Prediction; *Ratios (Mathematics); Science Education
IDENTIFIERS	*Papua New Guinea; Research Reports

ABSTRACT

There is much concern at present among those engaged in science education in Papua New Guinea over the difficulties which students have with basic concepts and manipulations in science and mathematics--especially with ratio and proportion. Papua New Guinean students may have difficulty in science because the basic assumption that the world is regular, which is so striking in Western man's environment, is less easy to make for someone from a natural environment. To test the hypothesis that students from a traditional environment show a lower expectation of regularity, a series of principal situations from each of which a pattern of events emerged were set up. The five situations or tests are explained in detail. The regularity tests were carried out using primary school children from three distinct populations: (1) coastal children who were familiar with an urban environment, (2) highlands children from a remote area, and (3) Australian children who were born and raised in a Western environment. The results indicated there were no significant overall differences between the three groups. (LS)



EXPECTATIONS OF REGULARITY IN PRIMARY SCHOOL PUPILS.

E.R.U. REPORT 8.

UNIVERSITY OF PAPUA AND NEW GUINEA.

EXPECTATIONS OF REGULARITY IN PRIMARY SCHOOL PUPILS

ERU REPORT 8

JUNE 1973

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ACKNOWLEDGEMENTS

We would like to thank the staff of the schools where this work was carried out for their cooperation and hospitality. Also, thanks to Simon Passingan and Ann Jones who helped with sections of the testing programme; and finally, thanks to Pru Dixon who typed the report.

INTRODUCTION

There is much concern at present among those engaged in education in the sciences in Papua New Guinea over the difficulties which students have with basic concepts and manipulations in science and mathematics. At an informal meeting of science educators last year at Goroka Teachers' College the discussion centred upon 'ratio and proportion' -- a subject which frequently crops up among teachers at the University also.

> "If you say to a group of students that 4ft. of pipe weighs 2 lbs. how much will 8ft. weigh?, they can't tell you and you just don't know what to do next".

There is of course an essential assumption to be made here before the answer can be computed, an assumption which is so obvious that it is often not stated, and that is simply that the pipe is uniform. A uniform pipe is one of which it can be said that if 4ft. weigh 2 lbs., 8ft. will weigh 4 lbs. We take this for granted. Pipes are uniform - they are made in factories by machinery which can only produce uniform pipes. We are surrounded by such uniformity and regularity in our man-made world. We sit at desks with uniform surfaces, with 3 identical drawers and are surrounded by a world which is straight-edged, regular and predictable. When we press the light switch the light comes on; we turn the handle and push the door and it responds in the same way as all the other doors in the house. Our world is one of man-made regularity and uniformity.

If one considers the traditional background from which our Papua New Guinean students come, the situation appears quite different and, to return to the original question, it is difficult to think of anything to which the simple rules of ratio and proportion will apply - certainly not to the accuracy with which it applies to the pipe. The branches used to build houses or fences come close but do not conform. If 2 kau kau weigh 4 lbs. what will 4 kau kau weigh?

There is much less obvious uniformity and regularity in the natural world of traditional life than in the artificial world of Western man. But science is about regularity, about a search for regular patterns in events and in fact starts from the assumption that such regular patterns exist. Perhaps Papua New Guinean students have trouble with ratio and proportion because they do not so easily assume uniformity and regularity in the world around them; perhaps they have difficulty understanding what science is all about because the basic assumption that the world is regular, which is so striking in Western man's environment is less easy to make for someone from a natural environment.

A further example illustrates this latter point. An experienced teachers' college science lecturer once told one of the writers about a series of experiments his students had been doing using local flower colours as pH indicators. They had been doing a series of tests over a period of weeks using these agents when on one occasion, for some reason, a colour change quite different from those which they had been regularly observing occurred. The students passed on without comment. When this irregularity was drawn to their attention they failed to see that it had any particular significance! -- 'Samting nating'. Things are not expected to occur in a regular or predictable manner - sometimes things happen which we don't expect and cannot explain. 'Maski'.

From these kinds of considerations came the project described in the present paper. Our hypothesis is that some of the difficulties experienced by Papua New Guinean students in science and in particular difficulty with 'ratio and proportion' arise from a relative lack of regularity in their environment and hence they lack the degree of 'expectation of regularity' in the material world which is a pre-requisite of scientific understanding.

The Test Situation

To test the hypothesis that students from a traditional environment show a lower 'expectation of regularity' we set up a series of practical situations from each of which a pattern of events emerged. European and Papua New Guinean subjects were then asked on the basis of their observation of these events to predict a future event in the series. In each case the prediction could only be made if the subject expected, recognised and identified the pattern of regularity and then extrapolated this pattern to a future event.

The regularity tests were carried out using samples from three distinct populations. The first was a group of 21 coastal Papuan primary school children. They ranged in age from 7 to 11 with a mean of 9 years, and lived in 2 villages within easy reach of Port Moresby by road. It is safe to assume that all would be familiar with an urban environment and most of their parents would in fact work in Port Moresby. The second group consisted of 21 New Guinean Highlands primary school children from schools in and around Tambul in the Western Highlands District. In this group the age range was from 8 to 12 years with a mean of 10 years. Although the age of these children is slightly higher than that of the coastal children, they were taken from Standard 3 as were most of the coastal group. The Highlands pupils would have much less contact with urban life and with Western man and his 'regular' world, as Tambul lies in a fairly remote area.

The final group was made up of 19 expatriate (mainly Australian) children from a Port Moresby Australian curriculum school. They were also all from Standard 3 but had a more restricted age range, all of them being either 8 or 9 with a mean of $8\frac{1}{2}$ years. These children were of course born and raised in a Western environment. In each of the Papua New Guinea groups there was a small number of girls and in the Australian sample a rather larger number. In view of the relatively small numbers involved differences in age and sex have been ignored in the description and analysis which follows.

Each of the 61 children from the 3 groups described above undertook the tests individually either in an empty classroom or an office at their school with only the experimenter and a recorder present. The authors acted alternately as experimenter and recorder for the coastal Papuan group after which one author (M.W.) acted as experimenter with a student recorder for the Highland group while the other (J.J.) was the experimenter with a research assistant as recorder for the expatriate group. Thus it was ensured that all groups underwent as near as possible identical test procedures.

The Tests

Five regularity tests were devised and used and these are described, in the order they were presented to the subjects, in the following section. To facilitate comprehension, the results of each test are recorded and discussed immediately after the description of the test. A somewhat different test, designed to measure subjects' comprehension of a "distribution" of events is described and discussed in a separate section. This test was administered immediately following the "regularity" tests described below.

1. Floating Blocks

This first test situation involved a number of different sized cubes some of which were painted black and some white. These cubes were dropped one by one into a plastic container of water by the experimenter. The first, a white cube of medium size, was seen to sink, the second, a black cube of the same size, floated. The subject was then asked to say whether he thought that the next cube (small white) would float or sink (or equivalent words as used by the subject to describe the behaviour of the first 2 blocks). This continued with blocks of differing sizes, both black and white until the subject had predicted the behaviour of 3 successive blocks correctly. In every case the subject was asked to give a reason for his prediction. In fact all the white blocks had been weighted by inserting a piece of iron, although this was of course quite undetectable on the outside. So the regularity was "All white blocks sink, all black blocks float". To arrive at this generalisation in order to predict the behaviour of the third and subsequent blocks the subject must (1) have an expectation that there is some discernable regularity in the situation; (2) search for possible factors related to the regularity (e.g. size or colour); (3) identify the factor which determines the regularity (size can in fact be eliminated after the first 2 blocks).

The number of blocks placed in the water before the beginning of a sequence of 3 correct predictions was recorded for each subject. The minimum score was therefore 2 and the maximum was 9 (the total number of blocks). A subject who never achieved 3 correct predictions was scored 9. There could be no scores of 7 or 8.

TABLE 1

Floating Blocks

	Mean score	No. of Subjects score = 2	No. of Subjects score = 9	% 'Colour' Response	Total Subjects
Highlands	4.7	6	6	24%	21
Expatriate	4.4	5	4	63%	19
Coastal	2.7	13	1	29%	21

Table 1 shows that the Coastal Papuan children were outstanding in predicting whether the blocks would sink or float. More than half of them were consistently correct after seeing only 2 blocks placed in the water. The fact that the coastal groups did better than the Highland group would be predicted by our hypothesis on the basis of the coastals' greater experience of a regular urban environment. However the expatriate results are quite unexpected. In order to preserve the hypothesis we could postulate that some of the expatriate group were suspicious and expected a more complex situation than that presented ("It can't be as simple as that"); however, there is no real evidence, subjective or objective, to support this conjecture.

The reasons given for the prediction are of considerable interest and here the expatriate group are markedly different from the Papua New Guinean group. Reasons given by the expatriates were overwhelmingly of the type "It will sink because it is white - (like those other white ones)". However this kind of reason was much more rarely given by the Papua New Guinean subjects - even by the Coastal group whose predictions were extremely accurate. Sometimes these subjects would give reasons for correct predictions which were manifestly wrong in the sense that they contradicted what had happened before, e.g. "Because it is big". But more often they said something like "It sinks because it is heavy". If this is taken to mean 'because it is more dense' this is of course the correct explanation. But even when pressed "But how did you know it was heavy?" a response in terms of colour was very rarely given.

It was clear to the experimenters in the test situation, and is confirmed by the figures, that the Coastal sample predicted confidently and well but they largely failed to mention colour when asked to explain their predictions. One could perhaps sum up the results by saying that the Coastal group was best at recognising the regularity in the situation and making accurate predictions while the expatriate group was best at describing or verbalising the regularity when they recognised it.

2. Breaking Thread

The materials for this test included a simple wooden frame from which a tin lid could be hung. A piece of thread (sewing cotton) was taken from a reel and used to suspend the tin lid from the frame. A piece of metal was placed on the pan, then a second piece. When the second piece was added the thread broke. The same procedure was then repeated using thread from a different reel and of a different colour but not obviously thicker or stronger than the first type of thread. The experimenter stressed that he was now using a different kind of thread. However in the second case the thread did not break when the second piece of metal was added. The experimenter then returned to the original reel and thread to repeat the first part of the experiment, this time asking the subject to say whether he thought the thread would break before each piece of metal was added. If the subject predicted correctly the test was terminated. If not it continued with the second thread and then alternate threads for a further 2 trials if necessary. In each case the subject was asked to give a reason for his prediction. Here the regularity is 'The first kind of thread does not break with one piece of metal but does break with two'; 'the second kind of thread does not break with either one or two pieces of metal'.

TABLE 2

Breaking Thread

	Correct 1st Trial	Correct 2nd Trial	Correct 3rd Trial	Never Correct	Total
Coastal	16	2	3	0	21
Expatriate	9	7	3	0	19
Highland	18	2	1	0	21

Table 2 shows that this test provided little difficulty for any of the groups. It also shows that the Highland group did best followed by the Coastal group with the Expatriate sample trailing behind. Again there is the possibility of expatriate children being overwhelmed by the simplicity of the situation and there is no significant difference between the two Papua New Guinean groups. However the results certainly do not provide any evidence in support of the original hypothesis.

The reasons given for their predictions by all three groups were largely in terms of a repeated pattern of events as one might expect. e.g. "Before when you put one it didn't break, but when you put two it did". The responses of the Coastal group were less solidly of this kind than the other two.

3. Ordered Rods

The third test used a number of rods of different lengths but uniform cross section. These were taken, unseen, from a box one by one and placed alongside one another in front of the subject. The rods selected by the experimenter were such that a regular pattern was gradually formed. In the first trial the pattern was one of regular increase in length and in the second alternate long and short rods were used. After 3 rods had been placed in front of the subject and the experimenter had pointed out where each one came to, the subject was asked where he thought the fourth (unseen) rod would come to. After two correct predictions from each pattern the test was terminated. Again subjects were asked to give reasons for their predictions.

TABLE 3

Ordered Rods

(Number of Mistakes)

	Increasing				Alternating				Total
	0	1	2	2+	0	1	2	2+	
Highlands	21	0	0	0	20	1	0	0	21
Expatriate	19	0	0	0	17	2	0	0	19
Coastal	14	6	1	0	10	8	3	0	21

Table 3 shows that this test caused no difficulty to either the Highlands or the Expatriate children. On the other hand it caused the Coastal group a certain amount of difficulty. With the increasing rods they made various mistakes - sometimes expecting it to be shorter, sometimes much longer. On the alternating rods they tended to stick with the previous situation and expected them to increase (despite the alternating pattern of the first 3 rods) or to predict a long rod after a long, or a short after a short.

Many of the reasons offered by the Papua New Guinean children were vague. e.g. 'Because it will be long' but a minority were of the type 'It is like a ladder' or even 'The tops will be in a straight line'.

Again the results provide little support for our hypothesis.

4. Stretching Rubber Bands

In this test the wooden frame and tin lid were again used but this time the lid was suspended by a rubber band. To check that all the children knew something about the behaviour of rubber bands they were first asked what would happen if an object was placed on the tin lid. Two responded in terms of breaking (no doubt thinking back to the thread situation) but all the rest gave answers in terms of 'going down a bit' or 'stretching'. Beside the pan was an apparently random pile of different wooden and metal objects and one of them (metal) was then placed on the pan. The place to which the pan descended as the rubber stretched was marked on a piece of paper attached to the frame. Next the first object was removed and a different object (wooden this time) selected from the pile and placed on the pan. The pan descended to the same place as it had with the first object. This wooden object was then removed and the subject asked to predict where the pan would go to with a third object selected from the pile. This was repeated with further objects from the pile until the subject was able to predict that each would stretch the rubber to the same place. Again reasons for predictions were requested. In fact although the objects looked quite different and varied considerably in size and shape all had been carefully adjusted to the same weight. The number of objects placed on the pan before the subject predicted correctly was recorded (minimum 2, maximum 5). The means are shown in the first column of the Table 4.

TABLE 4

Rubber-Band Tests

	Number of Objects (Mean)	Black Block Right	Black Block Wrong	Total
Highlands	3.5	20	1	21
Expatriate	3.2	18	1	19
Coastal	3.0	18	3	21

Here the Coastal group performed best and the Highlands worst although the differences between the means are small. Once more the reasons given by the Papua New Guinea children for their predictions were often vague, e.g. 'It is a bit heavy' but six of the Highlands group said that the objects were all the same in some way, 'They all come to the mark'.

In a second part of the rubber band test which followed that described above, a black block was first placed on the pan and the point reached by the pan marked with a paper strip. The black block was then put aside and several other objects of different weights placed one by one on the pan. Finally the black block was picked up again and the subject asked to predict where the pan would come to. The second column of Table 4 shows that almost all subjects were able to predict that it would go back to the same marked place as it had previously.

Expatriates' reasons for giving this prediction were invariably of the form 'Because that's what happened before'. Papua New Guinean children's reasons however were divided between this reason and others of the type 'Because it is not heavy'. This latter was predominant among the Coastal sample. It arose because the black block was in fact lighter than most of the other objects used and the mark was near the top of the scale. Again the Papua New Guinean answer made sense but was not what the experimenters expected or what the expatriates said.

5. Hidden Circuits

The final test used a wooden box on the top of which were 2 toggle switches, a push button and a red light. The experimenter pressed both switches down, pushed the button and the light came on. The switches were then returned to their original position. Next only one of the switches was pressed down, the button pushed and nothing happened. After returning the switch to its original position the sequence was repeated with the other switch and the push button. Again nothing happened. The experimenter then repeated the operation with the two switches but before pushing the button asked the subject whether he thought the light would come on. This was repeated with each button individually. As usual a reason for each prediction was requested. Finally the subject was asked to make the light come on for himself. (This gave many of the subjects, particularly in the Highlands, considerable pleasure - they were obviously very pleased with themselves when the light came on! It is perhaps worth noting here that the whole procedure was enjoyed by most of the subjects - again particularly in the Highlands. Interestingly enough, although we did not mention the word science to the subjects some of the Coastal children told their teachers that they had been taking part in a 'science game').

TABLE 5

Hidden Circuits

	Prediction		Operation of Switches		Total
	Correct	Incorrect	Correct	Incorrect	
Highlands	21	0	21	0	21
Expatriate	19	0	19	0	19
Coastal	19	2	17	4	21

Only the coastal group had any difficulty with either part of this test as Table 5 shows. The difficulties with the subjects' operation of the switches arose from forgetting to carry out one of the operations, e.g. only one switch pressed or the button not pushed.

In this case the reasons given by the Papua New Guinean (and Australian) subjects were overwhelmingly as we had expected them to be. The light was predicted to come on because 'You pressed two switches' or because 'It happened before'. Similarly when only one switch was pressed the light would not come on because 'You only pressed one switch'. Here the situation is perhaps less ambiguous than any of the others - the light is clearly controlled by the switches - there is less room for alternative explanations or unexpected interpretations of the questions.

Summary and Conclusions

In these tests of pupils' expectation of and ability to discern regular patterns in a practical situation there are no significant overall differences between the three groups, Highland Papua New Guinean, Coastal Papua New Guinean and Expatriates (except the type of reasons given). In one test one group is slightly better, in a different test another. The original hypothesis that there would be a greater expectation of regularity and more ability to discern regularity among children from 'regular and uniform' environments is not supported. However, there is the possibility that all the tests were rather too simple, and that more complex tests would show up differences. But it would be difficult to design more complex situations in which previous knowledge was not a help, i.e. to produce complex situations where all subjects started 'cold' and had to deal with the pattern from scratch. In other words one could argue that the simpler the situation the more likely are we to be testing the expectations and abilities which we set out to test.

Another aspect of the hypothesis which became clearer to one of the authors when he visited the Highlands to carry out the tests is that there is more regularity in the traditional Papua New Guinean environment than might be supposed. Living in a traditional house one is impressed by the uniformity of the wood used for the walls and struck by the radial symmetry of the roof. One wonders where people get so many straight branches. Kau kau mounds also come to mind; not only is each one uniform and remarkably similar to the one next to it but they are arranged regularly in the garden. Perhaps the best example of something to which the laws of ratio and proportion must apply very closely is the bamboo used, among other things, for carrying water. Not only is it beautifully uniform but it is marked off in equal lengths!

So the conclusion must be that stated in the first sentence of this section; there is not much difference between the groups.

However, perhaps a more important result arises from the differences in the type of explanation given by the expatriate children on the one hand and the Papua New Guinean on the other. The explanations given by the expatriates were usually straight forward and just what we expected (i.e. the 'right' answer). The Papua New Guinean subjects' explanations were more often confused and even more often unexpected, but, if considered carefully, sensible; e.g. the block sinks because it is heavy, the thread breaks because it is not strong etc. At the same time as they were giving these explanations, which avoided references to previous cases and gave no indication of an expectation or recognition of regularity, the Papua New Guinean subjects were dealing with the practical situation (i.e. making correct predictions), as well as or better than the expatriates. It was only when we asked them to talk about what they were doing that they appeared weaker. Perhaps there is a very important lesson here for science (and other) educators. We judge our students' ability in science most frequently (almost invariably in fact) by what they write or say about science. Perhaps if we asked them to deal with a practical situation in a practical way we would get more encouraging results and a truer indication and understanding of their real abilities.

Distributions of Events

Often, we are required to make decisions, during the course of our everyday lives, on the basis of incomplete information or knowledge. In many cases this entails "guessing" what is going to happen or what other people are going to do, and taking appropriate action. This means that we have to judge the probability of particular occurrences, and it is implicit in the situation that we form a frequency distribution for the possible occurrences; i.e. it is quite possible that x will occur, a bit less probable that y will occur and very unlikely that z will eventuate. The degree of understanding of the probabilistic nature of such events influences the way in which decisions will be made. Among adults in a Western situation, decisions are largely made on the basis of total past experience, with events which have occurred frequently in the past being predicted more often than events which have been observed to occur only occasionally. (See, e.g. Humphreys, 1939). An important case in which a decision has to be made when information is incomplete is the binary situation: i.e. the yes/no, I will/I won't situation. While adults normally make decisions with reference to the total observed frequency distribution of past events, the immediate past experience is also important in deciding upon the likely outcome of a particular event. This postulated influence of the immediate past on a particular event is called the "gamblers' fallacy".

The gamblers' fallacy is a false assumption of the interdependence of events, one of the simplest cases being that of tossing a "fair coin", where the chances of a head or a tail appearing are equal on any toss of the coin. Previous tosses have no effect on the outcome of a particular toss; nevertheless, the "subjective probability" of a head appearing after a run of, say, six consecutive heads is much smaller than that associated with its likely appearance after a run of six tails, and in this case, most people would guess "tails" rather than "heads". The reasoning behind this seems to be that since in a very long run of tosses an approximately equal number of heads and tails will appear, then a temporary predominance of heads must mean that a tail is about to appear in order to "balance" the distribution.

The situation is complicated when the chances of the outcomes of a binary event are not equal; a biased coin for example, which shows heads more frequently than tails; or, the chances of it raining in Port Moresby on June 30th. Experiments have shown that in such a situation adults will match their frequency of a particular prediction, usually very accurately, with the actual distribution of events. (e.g. Grant et al. 1951). At the same time that subjects predict on the basis of the observed overall distributions, there is evidence that subjects will be susceptible to the gamblers' fallacy or "maturity of the chances" effect. (Ross and Levy, 1958).

The experiments which are described below formed part of the overall investigation into the extent to which the concept of "regularity" had developed in our subjects. We were interested in assessing the extent to which children were aware of the distribution of outcomes in a random binary event system, and the extent to which they were influenced in a particular decision by the pattern of events which had immediately preceded it.

It has been suggested that the concept of the regularity of specific cause-effect relationships does not develop so readily in under-developed communities. While the rationale behind the suggestions for differences in the regularity of cause-effect relations is persuasive, the same is not true of the perceptions of the regularity of <u>distributions</u> of events. Circumstances favourable for the occurrence of readily-observed and regular cause-effect relations are more predominant in developed and carpentered environments, but this would not seem to be true of circumstances necessary for the concept of (binary at least) frequency distributions. For example, the regularity of the cause-effect relationship exemplified by the turning of a switch and the lighting of a bulb is almost certainly not approached in non-carpentered environments; at the same time, the uncertainty of outcomes, such as whether it will rain or not at a particular time, whether a baby will be a boy or a girl etc., is common to both types of environment, as are games of chance and skill which might do much to develop the concept of a regular distribution of outcomes. One could rationally hypothesise that there should not be great differences in the relative developments of the concept of frequency distributions with traditional and Westernised environments.

Test Procedure

Three packs of cards were constructed; all of the cards had yellow backs. Some had black faces and some yellow faces. The three packs contained the following proportions of the different colours.

(a)	50:50	Black : Yellow
(b)	70:30	Yellow : Black
(c)	60:40	Black : Yellow

There were sixty cards in each pack, and the sequence of the cards was decided as follows. Six blocks of ten cards were taken for each pack, so that within each block of ten the overall distribution was reflected (e.g. within each block of ten for pack (b) there were seven yellow and three black cards). The order of the cards was then randomised within each block of ten, and the six blocks placed together to form the final pack. (There was one exception to this procedure, with pack (a), which is described later). An identical sequence of cards was maintained for all packs and all subjects throughout the investigation.

Subjects were tested individually as follows. The subject was shown a sample of both kinds of cards, and told that the pack, which the experimenter held, backs up, contained the same kind of cards. The subject was told that he and the experimenter were going to play a guessing game, and that the object of the game was to guess correctly as many cards as possible. After each guess by the subject, the experimenter turned over the card so that the subject could see it, and said "Yes" or "No", depending upon whether or not the guess was correct. Experimenter and subject sat opposite each other, while an observer sat a few feet away, making a note of each guess, and whether the guess was correct or not. For each subject the three packs of cards were used in the order (a), (b), (c).

The same samples described above were used for the investigations, i.e. :

(a) Twenty one standard three Papuan school children from two schools on the south Papuan coast; the schools were situated about fifteen and thirty miles respectively from Port Moresby.
Average age for sample 9.0 years.

(b) Twenty one standard three school children from three schools in the Western Highlands of New Guinea.
Average age for sample 10.0 years.

(c) Nineteen standard three Australian school children from an urban school in Port Moresby.
Average age for sample $8\frac{1}{2}$ years.

Results and Discussion

1. Proportion of Different Outcomes Chosen

Figures 1, 2, 3 show the results, for each pack, for the three groups, the average proportion of black to yellow cards chosen is plotted against the order of presentation of successive blocks of ten cards. For example, the proportions of black to yellow cards chosen with pack (a) was 0.95 : 1 for the Highlands sample on cards 1 - 10; it was 1.10 : 1 for the Australian sample on cards 11 - 20 etc. The discussion of the results is taken separately for each of the packs.

For pack (a), the results for the Highlands and Australian samples are very similar, and tend to fluctuate around the 1 : 1 ratio which represents the actual distribution of cards. The graph for the coastal group is rather different, the biggest discrepancy occurring for the 4th block of ten cards. This is interesting, since this is the exception to the normal pattern of pack construction which was referred to above. In this block of ten cards there were eight black and two yellow cards, instead of the normal five black and five yellow; this was an attempt to determine the extent to which extinction of the acquired pattern of the frequency distribution occurred over a run of ten cards. There is an extreme difference between the Australian/Highlands group as compared with the Coastal.

(i) The Australian and Highlands groups guess their lowest proportion of black:yellow cards in the face of a preponderance of black cards, then switch back to their highest proportion of black:yellow guesses on groups 5 and 6.

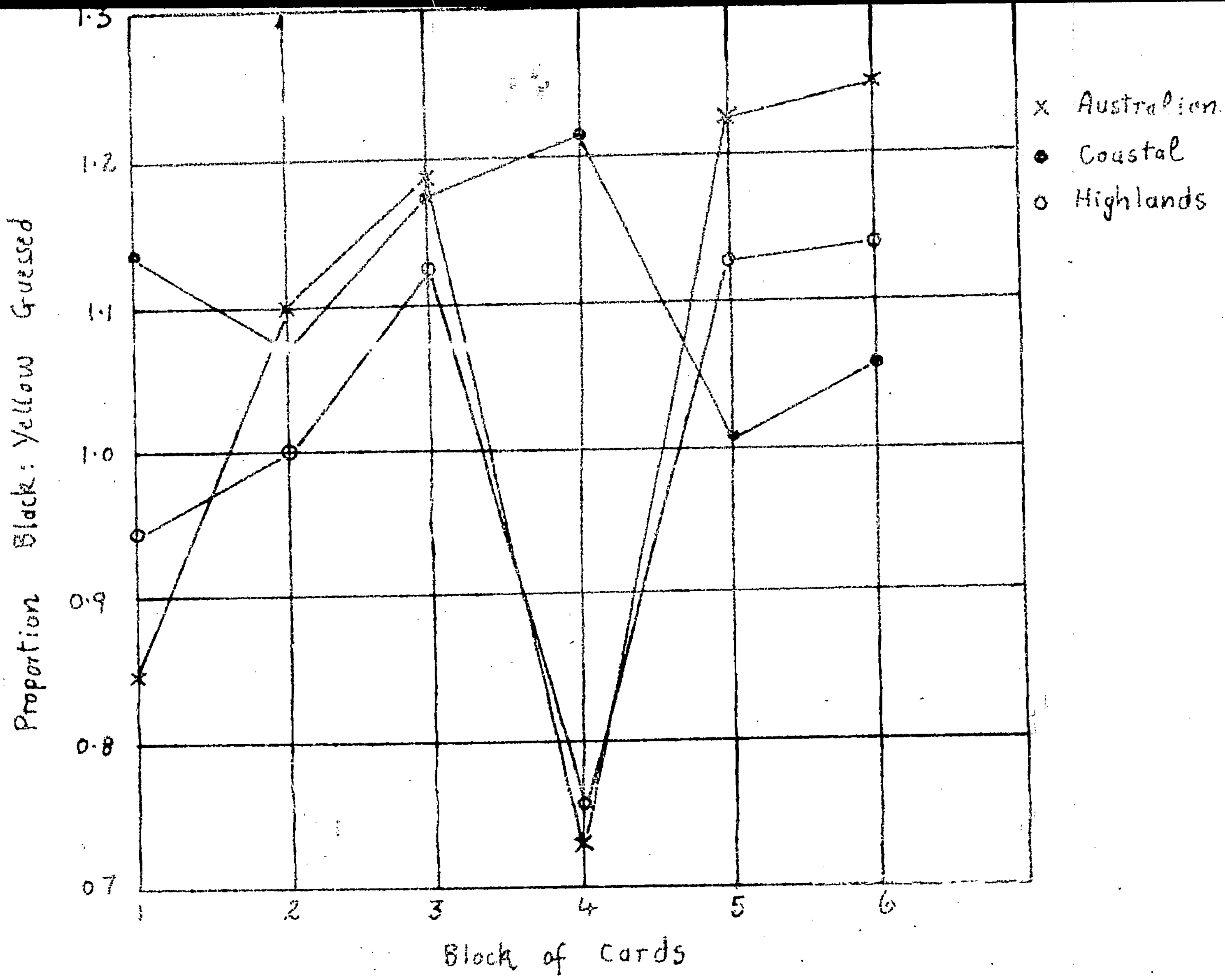

Fig. 1. 50:50, Black:Yellow

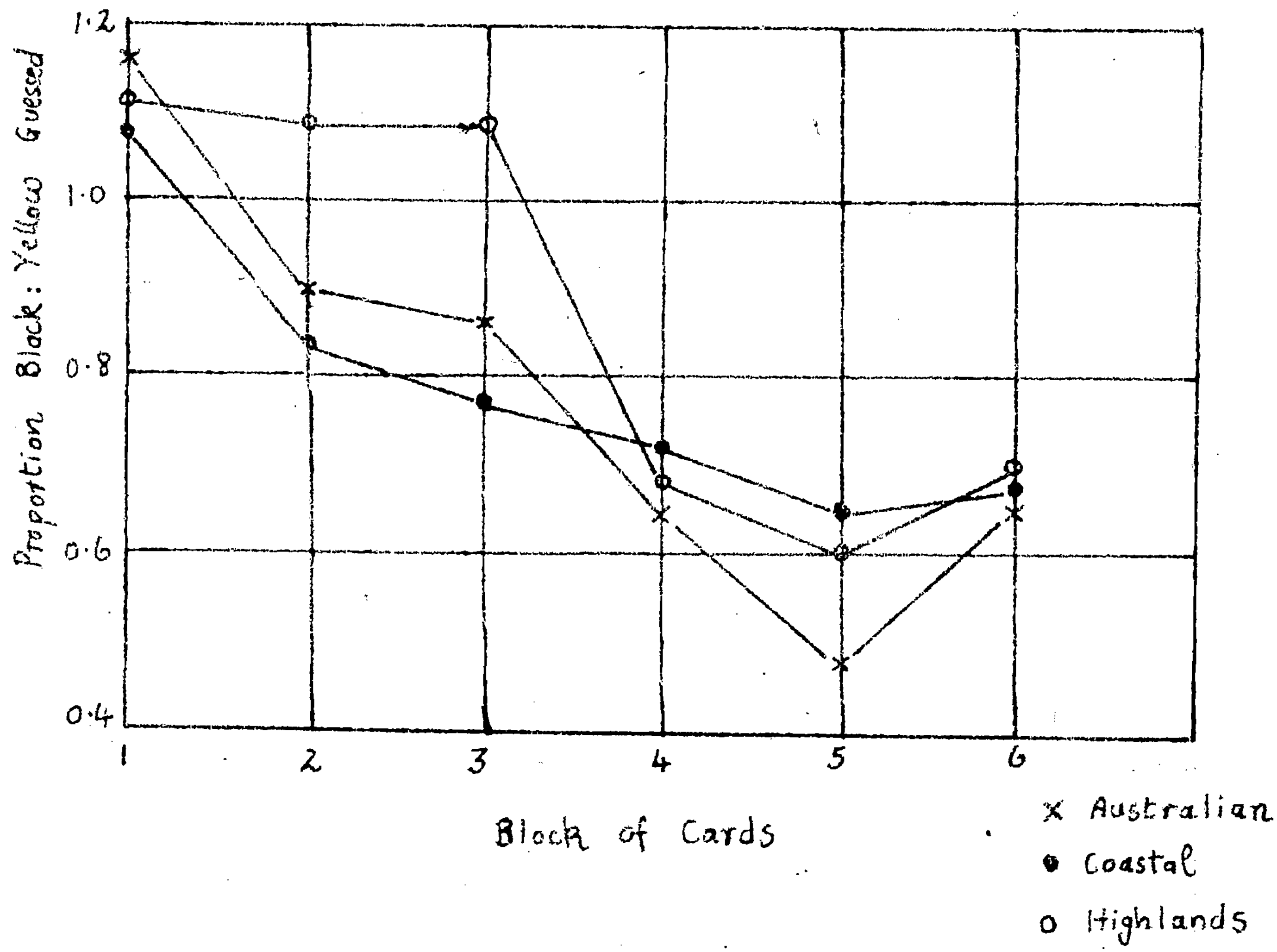

Fig. 2. 30:70, Black:Yellow.

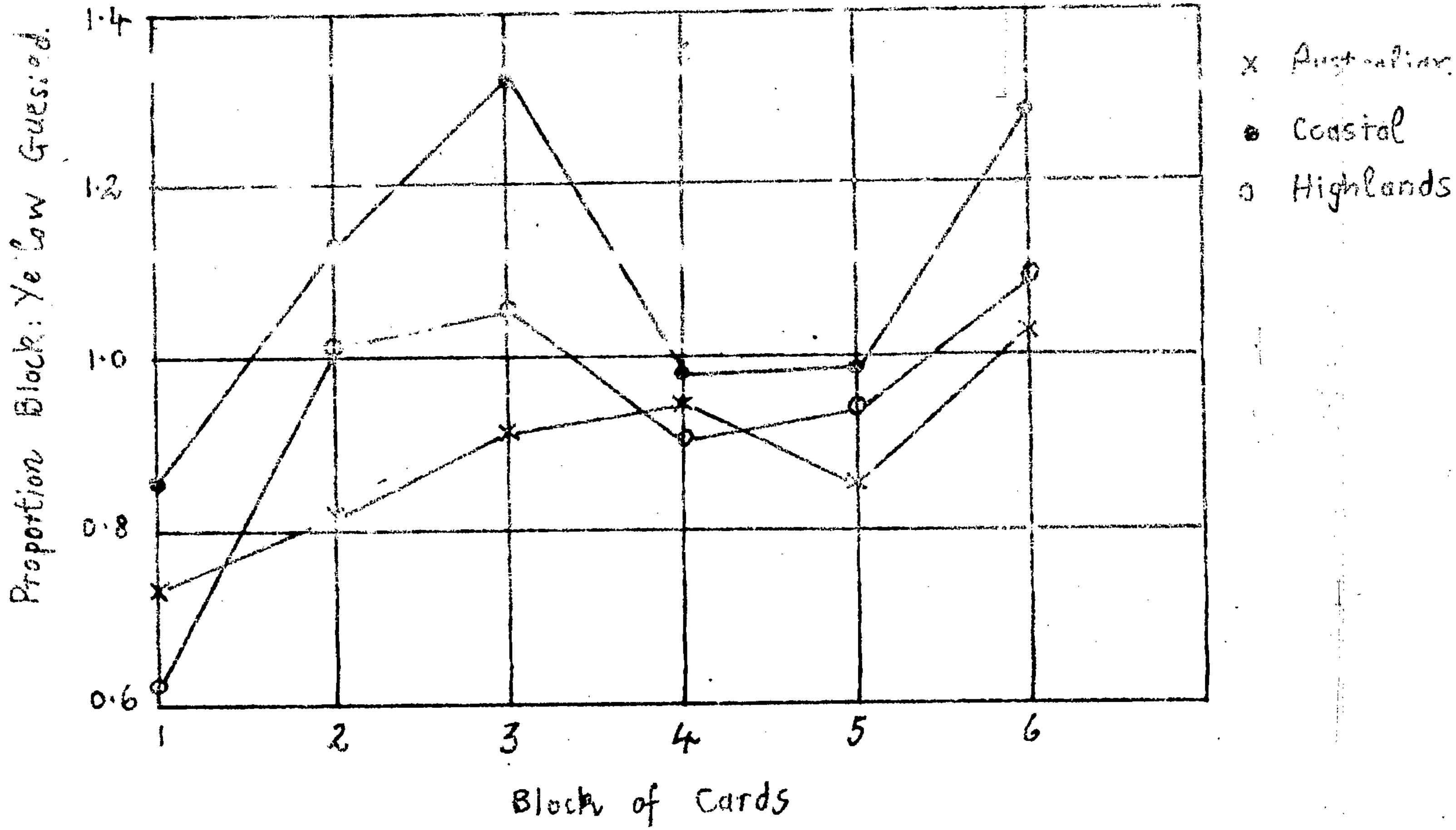

Fig. 3. 60 : 40 Black : Yellow

(ii) The Coastal group guesses the highest proportion of black:yellow during the preponderance of black cards, then switches back to the lowest proportion of black:yellow guesses on groups 5 and 6.

On the 4th block of cards it appears as if the Australian and Highlands samples are using a gamblers' fallacy strategy (see above) while the Coastal sample could be said to be employing a reverse gamblers' fallacy. It is interesting to compare this with the results of Cohen (1954) who worked with samples of British school children. To quote Cohen:

> "Certainly until the age of 10+, and probably later too, the choice of the non-preponderant outcome is generally preferred, at least in short runs." (p. 335).

The result for the Highlands and Australian samples tend to support this observation, but not so the results for the Coastal group. This point is taken up further in the next section.

With pack (b) the results for all groups are similar; pack (b) was "guessed" immediately following pack (a), and the results for the first block in pack (b) are almost identical with those for the last block in pack (a). It is interesting that in this case the switch from a 50:50 situation to a 30:70 situation has very little immediate effect on guessing pattern, whereas the earlier switch from a 50:50 to a 20:80 situation has a marked influence on the pattern of predictions. All groups end up guessing a significantly greater proportion of yellow cards, and the patterns for the increase in the number of "yellow" predictions are similar; although, the Highlands group continues to guess on a 50:50 basis until the 4th block of cards. None of the groups end up very close, in their proportion of guesses, to the actual proportion of cards (which is 0.43 : 1, black:yellow).

With pack (c), the patterns of guesses are similar for all three groups, although there are quantitative differences. All groups start off by continuing to guess in the same proportion as they were predicting at the end of the pack (b) series; thereafter, a steady increase in the proportions of "black" predictions is observed for all groups, with the Coastal group ending up by guessing closer to the actual distribution than either the Australian or Highlands samples.

Goodnow and Postman (1955) have found that for adults, proportions of guesses match actual distributions fairly closely for 50:50, 70:30, and 80:20 distributions; when confronted with a 60:40 distribution, subjects tended to respond on a 50:50 basis. The present results tend to follow the same trend, at least for the Highlands and Australian groups. A switch from a 50:50 to a 80:20 distribution led to an immediate change in the proportion of guesses; switching from 50:50 to 70:30 led to a gradual change in guessed proportions; on switching back to a 60:40 distribution, subjects tended to respond on a 50:50 basis.

The immediacy with which two of the groups altered their predictions during the 50:50 run could suggest that subjects are basing guesses primarily on the immediately preceding run of cards, rather than guessing more or less randomly within an overall "frequency framework". Certainly, the Australian and Highlands samples responded according to the gamblers' fallacy, whereas the Coastal group appeared to be more or less "following the cards" and guessing for the preponderant outcome. Cohen (1954) reports that 6 year old children are largely influenced by whether a guess is successful or not; success leads to a change in prediction, while failure leads to a repetition. Between the ages of about 7 and 11 a child is unaffected by success or failure in a particular guess, and bases predictions largely upon the observed overall distribution. The present results were analysed both for success/failure effects, and for the extent to which immediately preceding occurrences affected the guessing pattern.

2. Effect of Success or Failure upon Predictions

Each guess for all groups was analysed in terms of whether or not it was correct, and whether the subsequent guess was the same or not. The results are given in Table 1.

TABLE 1

Change of Prediction as a Function of Whether the Prediction was Wrong or Right

			Total - Wrong Predictions	Number of Prediction Changes	% Changes
Australian Group	Pack (a)	50:50	557	311	55.8
	Pack (b)	30:70	548	367	67.0
	Pack (c)	60:40	551	324	58.8
Coastal Group	Pack (a)	50:50	616	419	68.0
	Pack (b)	30:70	625	502	80.3
	Pack (c)	60:40	677	559	82.6
Highlands Group	Pack (a)	50:50	581	385	66.3
	Pack (b)	30:70	665	477	71.7
	Pack (c)	60:40	675	485	71.9

Table 1 (continued)

		Total - Correct Predictions	Number of Prediction Changes	% Changes
Australian Group	Pack (a) 50:50	586	353	60.2
	Pack (b) 30:70	592	305	51.5
	Pack (c) 60:40	592	363	61.3
Coastal Group	Pack (a) 50:50	608	369	60.7
	Pack (b) 30:70	596	322	54.0
	Pack (c) 60:40	547	310	56.7
Highlands Group	Pack (a) 50:50	651	383	58.8
	Pack (b) 30:70	624	314	50.3
	Pack (c) 60:40	584	313	53.6

From Table 1, three points are immediately obvious.

(i) Overall, the Highlands and Coastal groups are much more likely to change a prediction when they have guessed wrongly than when they have made a correct guess.

(ii) This trend is not nearly so marked for the Australian group.

(iii) Overall, the groups are much more likely to change a prediction, regardless of its correctness, than they are to repeat that prediction.

The result for the Australian group is roughly in line with Cohen's (1954) reporting of the fact that British schoolchildren are unaffected by the success of a particular prediction in deciding whether to change it or not; this is not the case for the results of the Coastal and Highlands groups.

To a large extent, it is not possible to separate the possible influence of success/failure from the possible influence of the gamblers' fallacy or a "reverse" gamblers' fallacy. If the gamblers' fallacy is followed, then there will be a marked tendency for subjects to change their predictions more often after they have made <u>correct</u> predictions; if a "reverse" gamblers' fallacy is operational, then the marked tendency will be for subjects to change their predictions more often following an <u>incorrect</u> guess. This means that the Coastal and Highlands samples in particular could be influenced mainly by whether they have guessed correctly or not, or by a "reverse" gamblers' fallacy based on the outcomes immediately preceding a particular outcome.

To enquire further into the possibilities, each subject was ranked on total performance in guessing on each of the packs of cards, according to the following scheme:

(a) Random: meaning that there is no significant tendency (at the 0.05 level of probability) for a subject to favour changing as a result of either correct or incorrect predictions.

(b) Gamblers' fallacy (gf): meaning in effect that there is a significant tendency (at the 0.05 level of probability) for a subject to favour changing after correct predictions or repeating a guess after incorrect predictions or both. Or alternatively, this may be thought of as being a tendency for subjects to expect a change rather than a repetition; i.e. the reasoning would be: if a yellow card has just appeared, then the chance of a black appearing next time is greater than that of a yellow being turned up.

(c) Reverse gamblers' fallacy (rgf): meaning effectively that there is a significant tendency (at the 0.05 level) for subjects to favour changing after incorrect guesses or repeating predictions after correct guesses or both. This is equivalent to the state of affairs where subjects "follow the cards"; i.e. they expect a yellow to turn up next time because a yellow has just been turned up.

Results for the three groups are given in Table 2 below.

TABLE 2

(Proportions of Adopted Strategies)

	Proportion of random	Proportion of gf	Proportion of rgf
Australian	0.368	0.228	0.316
Coastal	0.159	0.048	0.603
Highlands	0.333	0.048	0.524

For the proportions of rgf (i.e. "following the cards") and gf ("not following the cards"), the differences between the Australian sample and the Coastal/Highlands samples are significant at the 0.025 levels; there is a difference on the "random" measure between the Coastal and Australian/Highlands samples which is significant at the 0.05 level.

Overall, there seems to be a predominant strategy adopted by the Highlands/Coastal group which can be summed up as: change when wrong, stick when right. This strategy is also popular with the Australian group, but not to the same extent; the most popular strategy with the Australian group is a "random" one. It is not however random to the extent that all outcomes are seen as equally probable, since the distribution of guessed outcomes, for pack (b) in particular, show that the observed distribution of outcomes is being taken into account.

Ross and Levy (1958) have investigated the extent to which the gamblers' fallacy (or maturity of chances) is dependent upon the number of consecutive identical outcomes, and have found that in general no gamblers' fallacy effect (or the reverse) exists for fifth grade children (average age 10 years), on runs between 3 and 7 identical consecutive outcomes. This was tested in the present investigation by looking at the subsequent prediction following the "runs" described below.

(i) A run of 3 blacks - pack (a)

(ii) A run of 3 yellows
A run of 4 yellows - pack (c)
A run of 5 yellows

(iii) A run of 3 blacks
A run of 4 blacks - pack (c)

The proportion of subjects displaying the gamblers' fallacy (i.e. changing to the non-preponderant outcome) for each of the groups are given below in Table 3

TABLE 3

Proportion of Subjects Displaying the Gamblers' Fallacy

		Australian	Coastal	Highlands
(i)	Run of 3 black	0.47	0.38	0.52
(ii)	Run of 3 yellow	0.53	0.52	0.62
	" " 4 "	0.26**	0.28**	0.38
	" " 5 "	0.47	0.43	0.33*
(iii)	Run of 3 black	0.47	0.33*	0.43
	" " 4 "	0.58	0.24**	0.52

* - Significantly different from 0.5 at 0.05 level.

** - Significantly different from 0.5 at 0.01 level.

The results from the Table may be summarised as follows:

(i) None of the groups display gf or rgf on pack (a).

(ii) All of the groups display one example of rgf on pack (b), the Australian and Coastal groups after a run of 4, the Highlands group after a run of 5.

(iii) The Coastal group, alone, displays rgf after runs of 3 and 4 on pack (c).

(iv) There is no example of gf among any of the groups on any of the packs.

CONCLUSIONS

Overall, the predominant result which arises from the study is that Papua New Guinea schoolchildren are much more likely than their Australian counterparts to be influenced by whether or not they have predicted correctly; a correct guess is likely to lead to the repetition of a prediction, while an incorrect guess usually leads to a change in the prediction. If this strategy is followed more or less slavishly, then it is possible for subjects to arrive at a distribution of predictions which is very close to the actual existent pattern, without any concept of the overall distribution. Since the Australian children opt more often for a random strategy, yet still approach the actual distribution in their prediction patterns, one could argue that their concept of the overall distribution of outcomes is the better developed. At the same time, the preponderance of the "change when wrong" strategy among Papua New Guinean schoolchildren is very marked, and in fact, as a rule of thumb ploy for use in a variety of situations with different outcome probabilities, it is reasonably efficient strategy. Further elucidation of the extent to which the strategy is "reasoned" would need a different experimental design; possibilities include the explicit matching of sections of frequency distributions (Cohen and Hansel, 1955) and the use of a non-binary situation. In addition, it would be desirable to extend the work to older age groups, so that the relative developmental aspects could be investigated.

There is no doubt that the appreciation of the nature of frequency distributions is crucial for the understanding of most quantitative subjects; it is central to much of science and social science. As such, the extent to which this concept has developed, and the way in which it is developing, is of great importance to teachers and curriculum designers. Possibly the most important aspect of the whole area is the extent to which children realise that certain outcomes (in the physical sciences for example) are very precisely determinable, while others (in the social sciences, say) are probabilistic by nature, but "regular" overall. The use of guessing games in probabilistic contexts, and the contrasting of these with precisely determinable situations might be one approach to the better appreciation of the nature of the distribution of outcomes of events.

References

Cohen, J. Conjecture and risk. Advancement of Science, 1954, 11, 333-339.

Cohen, J. and Hansel, C.E.M. The idea of independence. British Journal of Psychology, 1955, 46, 178-190.

Goodnow, J.J. and Postman, L. Probability learning in a problem solving situation. Journal of Experimental Psychology, 1955, 49, 16-22.

Grant, D.A., Hake, H.W. and Hornseth, J.P. Acquisition and extinction of a verbal conditioned response with differing percentages of reinforcement. Journal of Experimental Psychology, 1951, 42, 1-5.

Ross, B.M. and Levy, N. Patterned predictions of chance events by children and adults. Psycholgical Reports, 1958, 4, 87-124.