Behav. Res. & Therapy, 1966, Vol. 4, pp. 213 to 217. Pergamon Press Ltd. Printed in England.

CHANGE IN LEVEL OF AROUSAL DURING CHILDHOOD

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(*Received 7 December* 1965)

Summary—The problem of changes in arousal at different ages during childhood is considered. The Necker Cube reversal rate is taken as a measure of arousal and data are reported showing a lowering of arousal level as children get older. The results, together with other characteristics of children's performance, are considered in terms of cortical–subcortical relations.

INTRODUCTION

THERE is a good deal of evidence that the process of ageing from maturity onwards is accompanied by a decrease in arousal, as one of us has argued in detail (Lynn, 1961, 1962, 1963). In this paper we turn our attention to the possibility that there are shifts in arousal from infancy to maturity. The existing evidence does not yield any obvious solution to this question. To casual observation, the almost inexhaustable energy of children suggests that they are hyperaroused and in this respect they seem to resemble amphetamine-intoxicated adults. Consistent with this is children's speedy conditionability (Braun and Geiselhart, 1959) and the body of evidence assembled by Luria (1963) which he interprets within the Pavlovian framework as showing a predominance of excitatory over inhibitory processes. This evidence points to children being hyperaroused. On the other hand there are certain ways in which children perform like underaroused adults. In particular, they are slow on reaction times (Woodworth, 1937), poor at vigilance tasks (Gale and Lynn, 1965) and have the slow EEG rhythms characteristic of underaroused adults (Lindsley, 1960).

The existing data are therefore confusing, but before attempting a reconciliation of these paradoxical facts our concern is to present additional evidence on the problem. We have taken Necker Cube reversal rate as a measure of arousal and investigated changes in arousal, as assessed by this index, during childhood. The use of this measure may need some justification. Our assumption is that the faster the reversal rate, the higher the level of arousal. This assumption, which is also advanced by Meldman (1964a), is made on the basis of the following facts:

(1) subjects high on arousal, such as neurotics with phobias, have high reversal rates (Meldman, 1964a);
(2) increasing the stimulus intensity of the reversible perspective figure increases the rate of reversal (Fisichelli, 1947; Lynn, 1961); this may be understood as a result of an increase in arousal resulting from increasing stimulus intensity;
(3) stimulant drugs which increase arousal increase the reversal rate (Meldman, 1964b; Cesarec and Nilsson, 1965), and
(4) the process of ageing, which involves a decrease in arousal, is accompanied by a decrease in reversal rate (Lynn, 1962, 1963; Speakman, 1958).

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THE INVESTIGATION

Subjects

Three age groups of subjects were tested. Each group consisted of 12 Ss, six of each sex. The two younger groups were 7–8-yr olds, mean age 7.11, and 10–11-yr olds, mean age 10.10, randomly selected from a primary school. The third group consisted of university students, mean age 20.0 yr.

Stimulus material

Two Necker Cubes were presented, one measuring $2 \times 2 \times 1{\cdot}4$ in., and a smaller one measuring $0{\cdot}5 \times 0{\cdot}5 \times 0{\cdot}35$ in. The cubes were drawn in black ink on a white card, without fixation points. The Ss were tested for spontaneous reversals and for "active" reversals in which S was instructed to try to make the cube reverse as fast as possible. The number of reversals in 30 sec was recorded.

Experimental design

The experimental variables examined were age, size of the cube and passive vs. active viewing by the subject. The Ss were divided into subgroups and tested with balanced presentation of cube size and conditions of viewing.

RESULTS

The age trends in reversal rates are shown in Fig. 1. It is evident from inspection that there is quite a striking tendency for the reversal rate to fall off as children get older. An analysis of variance on the results is presented in Table 1.

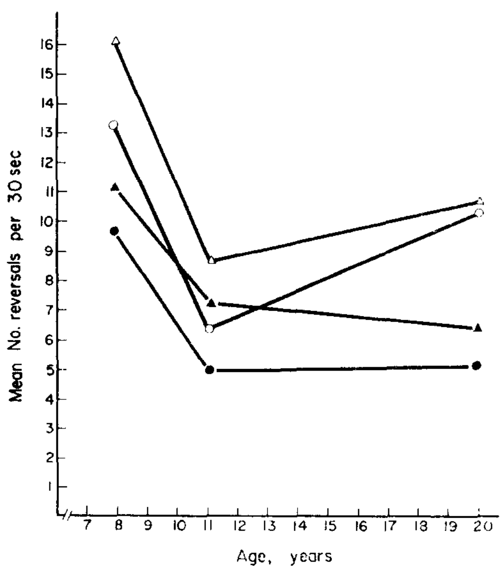

FIG. 1. Reduction of reversal rate with age.

△—active reversal, small cube.
○—active reversal, large cube.
▲—spontaneous reversal, small cube.
●—spontaneous reversal, large cube.

TABLE 1. ANALYSIS OF VARIANCE OF DATA IN TERMS OF NUMBER OF REPORTED PERSPECTIVE REVERSALS DURING 30 SEC TEST PERIOD

Source	d.f.	M.S.	*F.*
A	2	437·5	23·8***
S	1	112	6·1*
R	1	480·3	26·1***
$A \times S$	2	7·1	0·4
$A \times R$	2	43·3	2·35
$S \times R$	1	0	0
$A \times R \times S$	2	3·8	0·2
Within treatments (error)	132	18·4	
Total	143		

A=age.
S=size of cube.
R=reversal condition.

The table shows that the reduced reversal rate with age is highly significant at $P < \cdot 001$. The smaller cube produced significantly more reversals than the larger at $P < \cdot 05$ (this is a standard finding with Necker Cube studies and was introduced here to check the phenomenon on children). The active condition produced significantly more reversals than the passive condition at $P < \cdot 001$. None of the interaction terms were significant.

It will be observed that there is a tendency for active reversals to rise from the 10-yr-old group to the adult. As this rise does not appear in the passive condition it seems likely that this is due to the greater sophistication of the student subjects, because there is a trick of increasing reversal rate by eye movements which these Ss doubtless used. The significance of the differences between the groups were tested by *t* tests and the results are shown in Table 2.

TABLE 2. COMPARISONS BETWEEN 7–8 YEAR AND 10–11 YEAR AND BETWEEN 10–11 YEAR AND ADULT AGE-GROUPS, BY *t* TESTS. GROUPS WERE COMPARED FOR EACH TESTING CONDITION

Test condition	Age groups compared			
	7–8 yr and 10–11 yr group		10–11 yr and adult group	
	t	*P*	*t*	*P*
0·5×0·5×0·35 in. Necker Cube; spontaneous reversal	2·38	>·02*	0·28	<·25
0·5×0·5×0·35 in. Necker Cube; active reversal	4·37	>·001***	1·52	<·10
2×2×1·40 in. Necker Cube; spontaneous reversal	2·71	>·01**	0·19	<·25
2×2×1·40 in. Necker Cube; active reversal	3·95	>·001***	2·52	>·02*

DISCUSSION

Our results are clearly in line with the findings cited in the introduction indicating that children are high on arousal and that there is a decline in arousal with maturity. The most plausible explanation for this finding probably lies in a consideration of the relationship between the ARAS (ascending reticular arousal system) and the cerebral cortex. There is a wide measure of agreement that the cortex exerts an inhibitory influence on the ARAS (e.g. Lindsley, 1957; Samuels, 1959).* Thus when the cortex is impaired its inhibitory function is reduced and the ARAS is released, leading to an increase in arousal. This effect can be observed after a subject has taken alcohol or barbiturates, the effect of which is to reduce cortical activity and (for a brief period) increase arousal (Gellhorn, 1957). A similar effect is obtained with frontal lobe damage, which produces hyper-activity and impairment in not responding, which can plausibly be regarded as resulting from an increase in arousal. An argument along these lines has been presented by Konorski (1961). A review of the evidence for the inhibitory functions of the cortex is available in Lynn (1966, chapter 4).

Applying this theory to children it can be maintained the children are analogous to frontally impaired adults, since in children the frontal lobes do not reach their mature level of functioning until about the age of 12 yr. This can be inferred from the EEG findings showing that adult frequencies are only attained at about this age (Lindsley, 1960). Thus in children the ARAS is inadequately inhibited by the cortex and hence their high level of arousal.

This theory enables us to explain unequivocally some of the paradoxical facts about children cited in the introduction, while others can be accommodated without too great embarrassment. On some measures the scores of children can be accounted for in terms of their high level of arousal. This applies especially to their fast reversal rates. The fact that frontally damaged adults also show fast reversal rates is consistent with our theory at this point (Cohen, 1959) (but this is not true of other sites of cortical damage). The speedy conditionability of children can also be understood in terms of their high level of arousal, and although their inadequately developed cortex might be expected to reduce their conditionability it can be assumed that the high level of arousal more than compensates for this. On measures of vigilance and reaction time, where children do poorly, it can be assumed that the immaturity of the cortex is critical and great weight is added to this interpretation by the consideration that it is at the age of about twelve when the EEG becomes mature that performance on reaction tines (Woodworth, 1937) and vigilance tasks (Gale and Lynn, 1965) also reach adult levels.

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* The term "inhibitory" is used here in the Pavlovian sense of internal inhibition, implying an active controlling process, and not in the Hullian sense of reactive inhibition.

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