A DEVELOPMENTAL STUDY OF ATTENTION

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SUMMARY. This is a study of the development of attention in young children. A continuous response, 40-minute auditory vigilance task, was administered to 612 children between the ages of 7 to 13. Performance improved with age, with greatest improvement between the ages of 8 and 9. Girls were significantly better than boys at ages 7, 8 and 12. There were no correlations (within subsamples) between vigilance performance and intelligence (Raven's Progressive Matrices and Crichton Vocabulary Scale) or between vigilance performance and personality (extraversion and neuroticism scores on the Junior Eysenck Personality Inventory). All age groups showed variation in performance (the ' vigilance decrement ') within the task. Results are compared with previous findings and it is concluded that (i) attentional capacity is independent of intelligence and (ii) that critical changes in this capacity may occur between ages 8 and 9.

INTRODUCTION

ATTENTIONAL factors have been identified as a possible source of error variance in studies of cognitive development. However, there appear to have been no studies of the development of attention as such. The only real difficulty is a technical one, of finding a suitable task. Studies of physiological indicants of attention (i.e., the orienting response, Lynn, 1966) have been limited to neonates or to comparisons between criterion groups of brain-damaged and normal children (e.g., Hutt, Lenard and Prechtl, 1969). The cost and labour required for such electro-physiological investigations has precluded extensive developmental study.

The most commonly employed performance task devised for the study of attention in adults is the vigilance task, first used by Mackworth (1944) to simulate radar-watching conditions. Research in this area has been extensive, and excellent reviews of the key findings are given by Mackworth (1969, 1970) and Davies and Tune (1970). Vigilance tasks typically require detection of infrequent, irregular and barely discriminable signals ('wanted signals') against a background of monotonous and repetitive stimulation ; in order to perform well, subjects must sustain attention for long experimental periods. Davies and Griew (1965) review studies of ageing and vigilance and conclude that age is not a significant factor in performance. But their review examines evidence relating to young adults and the aged ; there is no empirical evidence to support their conclusion in relation to the *lower* age ranges. One source of this neglect is the difficulty of testing young children under vigilance conditions, since testing requires prolonged and monotonous isolation. We have overcome this difficulty by devising a group vigilance task, suitable for administration to children in their normal class groups. The task, therefore, generates developmental data relating to attention on a larger scale than would be possible with individual vigilance testing or with physiological instrumentation.

The task involves continuous response, with differential response for ' wanted ' signals. Continuous responding is necessary to reduce transmission

of cues between subjects in the group. Intelligence tests were administered to a sub-sample to examine the possibility that individual differences in vigilance performance are related to measured intelligence. Previous studies (Ware, 1961) have failed to show such a relationship and indicate that vigilance capacity is independent of intelligence. However, there is considerable evidence that personality (extraversion-introversion) influences the capacity for sustained attention in adults (Eysenck, 1967). The Junior Eysenck Personality Inventory was, therefore, administered to a sub-sample of 7-year-olds to test for the existence of such a relationship in young children.

PLAN OF THE INVESTIGATION

(i) *Subjects.*

Nine schools in the Exeter area (five junior and four secondary) were invited to co-operate in this experiment. Only three schools agreed to do so: one junior, one secondary for girls, and one secondary for boys. For the 7- to 10-year-old age groups, the sample has, therefore, been drawn from one school only. The entire attending population were tested (N=351). This school is located on a council housing estate on the outskirts of Exeter. It is co-educational and partially streamed. The children are largely from Social Classes III, IV and V, with only a small sprinkling of children from Social Class II. The distribution of intelligence for this school was, therefore, somewhat attenuated at the upper tail, compared with manual norms for the population as a whole. There were, at the time of testing, no co-educational or comprehensive secondary schools in Exeter. In order to obtain a reasonable match for social class and intelligence between the 7- to 10-year group and the 11- to 13-year group, it would have been necessary to test in at least four secondary schools (one secondary modern and one grammar school for each of the sexes). Since co-operation from such schools was not forthcoming, it was decided to test the A and B streams only of the one boys' and one girls' secondary modern schools which agreed to participate. The intention was to obtain a sample symmetrically distributed about the mean for intelligence. Since the high intelligence group for the older children were inaccessible (being at grammar schools), no attempt was made to test the available very low intelligence groups (C streams in the secondary modern schools). Mean and range of intelligence scores for the 11- to 13-year sample were 101 and 88–118 (Moray House Verbal Reasoning Test); individual scores were not made available. The 11- to 13-year sample cannot, therefore, be regarded as a continuous extension of the 7- to 10-year sample. The social class background was similar, however. In all, there were 612 children in the sample, of age range 7 years 4 months to 13 years 6 months. All testing took place within a period of two weeks during the month of November.

(ii) *Experimental Procedure.*

(*a*) *The Vigilance Task.* The children were tested in their normal class groups (mean size 31 children). To avoid the possibility of time of day effects, testing was carried out after 12 noon at one of two times: 1.45 to 2.45 or 3.00 to 4.00 p.m. Subjects were instructed to listen to a tape recording lasting 40 minutes. The tape consisted of a continuous series of random letters presented at the absolute rate of two every three seconds. The subjects responded to each letter by ticking one square on a sheet of squared paper. 'Wanted' signals (single digits occurring in the place of a letter) were presented at a rate of one per minute but randomly placed within each minute. Thus, the

subjects heard the following: " a n l x b s r s m k 3 p t o . . . " The subject responded to the ' wanted ' signal by writing the digit itself in a square, rather than placing a tick in the square. Thus, the subjects were kept continuously active throughout the task. This procedure overcomes the major problem of administering group vigilance tasks. Normally, the subjects are instructed to respond only to the ' wanted ' signals; thus, in a group situation, it is difficult to prevent those subjects who *have* observed the ' wanted ' signal and who respond to it, from transmitting cues to other subjects. (Subjects might be responding to other subjects' responses rather than to the ' wanted ' signal itself). Our procedure, which keeps all the subjects continually active, reduces the possibility that such cues will be perceived. There is no real substitute, of course, for individual testing and it is unlikely that *all* such cues may be eliminated in the group situation. It is also likely that there are individual differences in the capacity to benefit from such cueing and that extraverted subjects are at a particular advantage (Davies and Tune, 1970). Prior to the actual administration of the task, subjects were given a thorough training session. No subject failed to understand the instructions. The procedure (training and task proper) lasted one hour.

(*b*) *Intelligence Tests.* Raven's Coloured Progressive Matrices and a modified version of the Crichton Vocabulary Scale were administered during the following week to the 7- to 10-year sample only (N=351). The vocabulary scale employed the synonym version only of Sets I and II, which enabled a doubling of the synonym items and a broadening of the range of scores. Individual intelligence scores for the 11–13-year group were not available.

(*c*) *Personality Test.* The Junior Eysenck Personality Inventory (JEPI) was administered to the 7-year-old children only (N=67), since only this age group was made available.

RESULTS

(i) *Vigilance Performance*: *Omission Errors.*

Each individual response sheet was scored for errors of omission, giving a score for each subject for each of the ' wanted ' signals. Errors of commission were also scored. However, these were so rare that further analysis was inappropriate. Mean and range scores for omission errors for each age/sex group are given separately in Table 1. One-way analyses of variance were performed on the age group scores for boys and girls taken both separately and together. In all cases there was a significant improvement with age: (boys: $F=29{\cdot}098$, $P<0{\cdot}001$; girls: $F=5{\cdot}044$, $P<0{\cdot}005$; boys and girls combined: $F=32{\cdot}260$, $P<0{\cdot}001$). The analyses of variance were followed by t tests (within and across sexes) in order to locate more precisely the source of the age differences (Edwards, 1962). The following comparisons were significant:

(i) *Boys (Age Comparisons).* 7-year-olds are inferior to (<) 9, 10, 11, 12 and 13-year-olds ($P<0{\cdot}001$); 8-year-olds <9, 10, 11, 12 and 13-year-olds ($P<0{\cdot}001$); 9-year-olds <11 ($P<0{\cdot}02$), 12 and 13-year-olds ($P<0{\cdot}001$); 10-year-olds <12 ($P<0{\cdot}01$) and 13-year-olds ($P<0{\cdot}05$).

(ii) *Girls (Age Comparisons).* 7-year-olds <10 ($P<0{\cdot}05$), 11 and 12-year-olds ($P<0{\cdot}001$); 8-year-olds <10 ($P<0{\cdot}02$), 11, 12 ($P<0{\cdot}001$) and 13-year-olds ($P<0{\cdot}01$); 9-year-olds <11 ($P<0{\cdot}01$), 12 ($P<0{\cdot}001$) and 13-year-olds ($P<0{\cdot}02$).

TABLE 1

VIGILANCE SCORES: MEAN ERRORS OF OMISSION.

Age	Boys			Girls			Sexes Combined		
	N	Errors	Range	N	Errors	Range	Errors	Decrement	
								0–8 min	9-16min
7	31	9·48	1–29	36	5·30	0–23	7·24	0·73	1·22
8	48	8·63	1–27	41	4·56	0–17	6·75	0·44	1·59
9	54	3·65	0–15	40	3·27	0–11	3·49	0·16	0·60
10	57	2·93	1–12	44	2·75	0–12	2·85	0·32	0·67
11	32	1·40	0–9	54	1·75	0–7	1·63	0·13	0·57
12	66	1·60	0–9	56	1·09	0–6	1·37	0·06	0·35
13	35	1·57	0–9	18	1·50	0–8	1·55	0·14	0·35

(iii) *Boys and Girls (Compared at Different Ages).* 7-year-old boys <7-year-old girls ($P<0·01$) ; 8-year-old boys <8-year-old girls ($P<0·01$) and 12-year-old boys <12-year-old girls ($P<0·001$).

(iv) *Boys and Girls Combined (Age Comparisons).* A Scheffe multiple comparison test (Edwards, 1962) demonstrated that the difference between 7- and 8-year-olds (taken together) and the remaining age groups (i.e., 9–13 years, taken together) accounted for the variance revealed in the main analysis of variance ($P<0·01$).

(ii) *Vigilance Performance: Decrement.*

Omission scores were subdivided into 5×8-minute periods. Mean errors scores for first and second, 8-minute periods are given in Table 1. All groups showed a considerable decline in performance during the second 8-minute period and maintained that level for the remainder of the task. Thus, mean errors for all 612 subjects, for the 5×8-minute periods were: 0·27, 0·73, 0·74, 0·63 and 0·68. Since individual errors scores per period were low and yielded many ties, no statistical analysis was strictly appropriate. (If ties are neglected (Siegel, 1956) sign tests show first and second periods for all groups to be significantly different: $P<0·02$).

(iii) *Vigilance and Intelligence.*

The correlations between the tests and vigilance performance were negative and insignificant, both for individual age groups and overall with age partialled out. For example, in the latter case, the product-moment correlation (r) for vigilance and matrices was −0·145 and that between vigilance and vocabulary −0·016. These correlations were derived for the 7- to 10-year groups only.

(iv) *Vigilance and Personality.*

The correlations derived for the 7-year group between vigilance and both extraversion and neuroticism were negative and insignificant, i.e., r for vigilance and extraversion was −0·09 and for vigilance and neuroticism, −0·06,

DISCUSSION AND CONCLUSIONS

The results may be summarised as follows: (i) Capacity for sustained attention as measured by this task improves with age, with an acceleration in performance between ages 8 and 9 years. (ii) Girls give consistently higher performance than boys, but this sex difference diminishes with age and ceases to be significant from ages 8 to 11 years. The sex difference does become significant again at 12 years. (iii) All groups exhibit a decrement in performance following the first 8-minute period. (iv) There is no correlation with intelligence for this task (7–10-year groups only). (v) There is no correlation with either extraversion or neuroticism (7-year group only). (vi) However, examination of scores for individual children reveals a number of extreme cases; namely, children of 7 years who give 100 per cent performance, and at the other extreme, children of 9 and 10 years who perform at a level well below the mean score for 7-year-olds. (Where the relevant data were available extreme cases were distinguishable neither on the basis of intelligence nor personality scores.)

How do these results fit in with previous studies of vigilance and with theoretical interpretations of vigilance? The improvement with age, though hardly surprising, appears at an interesting point. Fois and Low (1961) report a shift to higher frequency and lower voltage EEG between 8 and 10 years, until by 11 years the resting EEG begins to show the characteristic features of the adult, more 'aroused' EEG. Bickersteth (1917), in a developmental study of capacity for self-paced continuous tapping, also obtains a maximum increase in performance between the ages of 8 and 9. Thus, the Bickersteth study, the present study, and the EEG data, point to some change in attentional capacity at this age. Further studies are required, however, before any definite conclusion may be reached.

At the same time, it must be acknowledged that 'attention' is a polymorphous concept, and the present task may not be considered as ecologically appropriate to the classroom. Studies with adults do demonstrate, however, that, apart from exhibiting variation in performance and systematic variation in physiological reactivity, the subject also experiences subjective changes in alertness during tasks of this nature (Gale, Haslum and Penfold, 1971). The task, therefore, reflects aspects of attention which are immediately recognisable as such. Until the role of attention in learning has been described in more detail, the vigilance task will remain the best measure of sustained attention available to us. The particular version employed here was deliberately oversimplified to enable age comparison. Increase in the order of difficulty or in cognitive complexity is not precluded.

The differences in performance for boys and girls may be a reflection of general sex differences in developmental rate (Tanner, 1961). For example, Kagan (1964) suggests that greater reading difficulties commonly reported to be more prevalent among boys are associated with sex-role differences in the perception of the school. It is possible, however, in the light of our findings that such reading difficulty is attributable in part to a more fundamental attentional deficiency (of a biological rather than socio-psychological nature), independent of measured intelligence, but related developmentally to sex. Thus, there might be an inherent tendency among boys rather than girls for attentional capacity to lag behind the development of measured intellectual capacity.

The decrement in performance is a typical feature of vigilance tasks and demonstrates that in spite of group administration performance follows the normal pattern.

The failure to correlate performance with intelligence confirms earlier findings (Ware, 1961) and again indicates the possible existence of attention as an independent factor.

Previous studies support the view that introverts are superior to extraverts on tasks involving continuous attention. There is no reason either on theoretical grounds or on the basis of previous studies to expect a relationship between neuroticism and vigilance. Two testing conditions which improve the performance of extraverts are group testing and afternoon testing (Colquhoun, 1960; Colquhoun and Corcoran, 1964). Thus, our failure to obtain a relationship between extraversion and performance might well be attributable to our testing conditions. Individual rather than group testing might yield different results. However, there are grounds for suspecting the reliability (and, therefore, possibly the validity) of the JEPI itself (e.g., Bennett, 1972).

A more intensive study of individuals with performance levels deviating excessively from the mean levels for their age is at present under way. It is possible that other indices of attentional capacity also reflect those differences in vigilance performance indicated by the present study. Thus, in a further study (Gale and Lynn, in preparation) comparing good, medium and poor vigilance performers among the 7-year-olds in the present sample, we have shown that these criterion groups are distinguishable on two further tasks. Good vigilance performers are *more* physiologically reactive than poor performers (habituation of the orienting response, Lynn, 1966) and obtain *lower* scores in a free operant button-pressing 'stimulus-hunger' task (e.g., Gale, 1969). Such findings provide strong support for an arousal theory interpretation of individual differences in vigilance performance and also provide external validation of the present findings.

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