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7 *February* 1966)

Australian Journal of Psychology
Vol. 19, No. 1, 1967

IS TEMPORAL INTEGRATION A DISTINCT MENTAL ABILITY ?[1]

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Two tests of temporal integration were included in a battery with tests of five other mental abilities (general intelligence, verbal ability, spatial ability, meaningful memory and span memory). Test scores from 217 *Ss* were intercorrelated and factor analysed. Five significant and identifiable factors emerged. These factors could be interpreted as representing the other abilities tested, but no factor of temporal integration could be demonstrated.

Hearnshaw (1965, p. 5) describes temporal integration as ". . . the formation of contemporaneous patterns of action and meaning, when the units from which these patterns are constituted are serially ordered and in temporal succession." He gives an everyday example of the process (p. 10):

> I spend an hour going round a large store; some prices strike me as dear, some cheap; but my impression at the end is that on the average the store is inexpensive. I arrive at this conclusion without actually adding and averaging a representative sample of goods; nor, however, is my judgment just a matter of unconscious pooling, since certain key impressions are symbolically fixated and available for recall.

To measure this ability he devised special tests distinguished by the fact that they present information in discrete units and in succession, so that at no time is all of the relevant information physically present to *S*.

Two of Hearnshaw's tests, the CVR and the Letter Families tests, may be adapted for use with larger groups of *Ss*. Hearnshaw gives some information about these tests which indicates that they might be suitable for use in a factor-analytic study: the reliability of the CVR was ·78; neither of the temporal integration tests correlated with conventional mental tests (such as the Moray House, the Otis and the Raven PM) as highly as these conventional tests correlated with one another; and over a very small group of subjects the CVR and Letter Families tests correlated together ·28.

The aim of the present study was to obtain further information about the nature of temporal integration. If the CVR and Letter Families tests were included in a battery containing conventional tests of intelligence and other abilities, the results obtained could be intercorrelated and factor-analysed. If this battery included tests which appeared similar in content or process to the temporal integration tests, several sets of possible results might indicate something about the ability being measured by the temporal integration tests:

1. Temporal integration tests might mark a factor which was distinct from the other factors which emerged. (This would indicate that temporal integration was a distinct and separate factor for which further tests could then be constructed.)

2. Temporal integration tests might show a distinctive pattern of loadings on a factor representing general intelligence. (This would indicate that temporal integration was a basic dimension of intelligence, perhaps a dimension which has hitherto not been well measured by conventional intelligence tests.)

[1] This work was carried out at the University of Sydney as part of the author's research for the degree of Doctor of Philosophy. Thanks are due to Professor W. M. O'Neil for his advice and guidance.

3. Depending on the content and process factors measured, temporal integration tests might spread their variance over these other factors. (The most likely interpretation of this result would be that the temporal integration tests were measuring little more than was being measured by these other factorial-marker tests.)

4. Some combination of results 1, 2 and 3 might also be possible. (In this case the interpretation would have to depend on the particular factorial pattern which emerged in the study.)

relation to tests of general intelligence. The memory measures were used because it seemed likely that performance on temporal integration tests might involve some memory component: the temporal integration tests, if they were measuring anything novel, would have to be distinguishable from mere tests of memory. The content of the CVR test is spatial, so spatial markers were included as

TABLE 1

Details of Test Battery

Name	*Method*[a]	*Adapted from*	*Ability measured*	*Possible*[b] *score*
1 CVR	S	Hearnshaw (1956)	temporal integration	20
2 Letter Families	S	,,	,,	20
3 Number Span	S	Kelley (1954 or 1964)	span memory	18
4 Letter Span	S	,,	,,	18
5 Sentence Completion	N	,,	meaningful memory	40
6 Limericks	N	,,	,,	30
7 Matrices I	N	Raven PM 38	*g*	12
8 Matrices II	S	,,	*g* + temporal integration	12
9 Matrices III	S	Hunt & French (1952) NNMT	,,	6
10 Matrices IV	N	,,	*g*	6
11 Vocabulary	N	Thurstone & Thurstone (1941, 1943*a*, 1943*b*) PMA	verbal	50
12 Completion	N	,,	,,	45
13 Figures	N	,,	spatial	54
14 Cards	N	,,	,,	54

[a] S = successive presentation; N = non-successive presentation.

[b] The actual score assigned was in each instance the number correct, except in Figures and Cards, where number correct minus twice number errors was used.

METHOD

Materials

A battery was constructed (see Table 1) which contained measures of the following mental abilities: temporal integration, span memory, meaningful memory, *g*, *g* + temporal integration, verbal ability, spatial ability.

The measures of *g* were included so that it might be seen how the temporal integration tests behaved in the nearest content-factor. The Letter Families test contains verbal material, so the verbal markers were included as the nearest content-factor.

Each of the items in the temporal integration tests was presented "successively," i.e. never at any time was *S* able to see simultaneously all of the information that he would need to solve that item: this mode of presentation is important in inducing temporal integration. The span

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t Battery

rom	*Ability measured*	*Possible[b] score*
1956)	temporal integration	20
	,,	20
r 1964)	span memory	18
	,,	18
	meaningful memory	40
	,,	30
38	*g*	12
	g + temporal integration	12
ench	,,	6
MT		
	g	6
hurstone	verbal	50
43*b*) PMA		
	,,	45
	spatial	54
	,,	54

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Each of the items in the temporal integration tests was presented "successively," i.e. never at any time was *S* able to see simultaneously all of the information that he would need to solve that item: this mode of presentation is important in inducing temporal integration. The span memory tests were also so presented, both in their original form and in this study. Two of the Matrices tests (II and III) were also presented successively in an effort to induce temporal integration in their solution: Matrices I and II are parallel forms, as are Matrices III and IV. Thus any evident factorial differences between Matrices I and IV on the one hand and Matrices II and III on the other can be attributed to the action of temporal integration. Each of the test-groups (with the exception of the temporal integration tests) normally marks an identifiable factor, and these five factors can be regarded as orthogonal for this study.

Subjects

Complete test records were obtained for 217 Australian schoolchildren, 43 girls and 174 boys. The average age was 15 years 10 months with a standard deviation of 7·2 months.

Statistical analysis

Pearson product-moment correlations were calculated between all tests. The initial factor analysis was the Hotelling (1933) Principal Components solution: unit diagonal elements were used, and all 14 factors extracted. Subsequently 29 iterations of the solution were done by the Lawley (1940) Maximum Likelihood Method to estimate more accurately the correct number of statistically-significant factors present. The number was found to be five, and the five-factor iterated but unrotated solution is shown in Table 2.

TABLE 2

Final Unrotated Orthogonal Factor Matrix

	I	*II*	*III*	*IV*	*V*	h^2
1 CVR	+53	−10	−22	−05	−27	42
2 Letter Families	+42	−23	−13	+00	−03	25
3 Number Span	+38	−41	−33	+25	+22	53
4 Letter Span	+33	−39	−39	+30	+18	53
5 Sentence Completion	+39	−32	+26	−26	+28	47
6 Limericks	+49	−31	+40	−07	+30	60
7 Matrices I	+56	−20	−02	−11	−19	40
8 Matrices II	+46	−29	−22	−17	−21	42
9 Matrices III	+54	−21	−11	−16	−14	39
10 Matrices IV	+37	−19	−23	−49	+03	47
11 Vocabulary	+48	−27	+38	+21	−28	57
12 Completion	+64	−15	+27	+18	−11	55
13 Figures	+70	+48	+01	−00	+08	73
14 Cards	+78	+42	−07	+04	+04	79

Note.—Decimal points omitted.

These five factors were rotated using the Quartimax orthogonal rotation procedure, and this rotated solution is shown in Table 3.

IDENTIFICATION OF FACTORS

Factor I. This loaded highly on Figures and Cards, and moderately on the CVR, Matrices I and II and Completion. Although its loading on Completion is anomalous, this factor is easily identified as a spatial factor.

TABLE 3

Rotated Orthogonal Factor Matrix

	I	*II*	*III*	*IV*	*V*	h^2
1 CVR	+35	+27	+15	+23	−38	42
2 Letter Families	+19	+21	+23	+30	−14	25
3 Number Span	+09	+10	+18	+69	+01	53
4 Letter Span	+07	+06	+11	+72	−04	53
5 Sentence Completion	+08	+34	+52	+08	+26	47
6 Limericks	+16	+15	+68	+11	+27	60
7 Matrices I	+29	+30	+35	+16	−27	40
8 Matrices II	+17	+42	+22	+27	−32	42
9 Matrices III	+28	+36	+29	+21	−23	39
10 Matrices IV	+17	+65	+09	+12	−02	47
11 Vocabulary	+16	−11	+66	+06	−32	57
12 Completion	+38	−04	+60	+14	−18	55
13 Figures	+85	+03	+11	−03	+04	73
14 Cards	+87	+06	+13	−09	−03	78

Note.—Decimal points omitted.

Factor II. This loaded highly on Matrices IV, and moderately on CVR, Letter Families, Matrices I, Matrices II, Matrices III and Sentence Completion. It may be argued that this is a memory factor, but this interpretation is unlikely to be correct because Matrices IV (the non-successive version of the Navy-Northwestern Matrices Test) was the only test with a high loading. Following Vernon's work (1950) on the Progressive Matrices, Factor II might be regarded as a "reasoning" factor, that is what is left over when *g* is not fully disentangled from group factors. In this solution some of the general-factor variance has been transferred by rotation to group-factors such as the verbal and spatial factors; some of this variance remains, however, as a separate factor in tests such as the Matrices tests, thus accounting for the pattern of loadings shown by Factor II. Nothing in the pattern of loadings for this factor discriminated the temporal integration tests from the Matrices tests; this may indicate that the kind of reasoning tested by the temporal integration tests is not different from the *g* which is tested by the Matrices tests.

Factor III. This had high loadings on the verbal tests Vocabulary and Completion and on the meaningful memory tests Sentence Completion and Memory for Limericks. Though it loaded moderately on Matrices I, Matrices II, Matrices III and Letter Families, this appears to be factor of

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l Factor Matrix

III	*IV*	*V*	h^2
+15	+23	−38	42
+23	+30	−14	25
+18	+69	+01	53
+11	+72	−04	53
+52	+08	+26	47
+68	+11	+27	60
+35	+16	−27	40
+22	+27	−32	42
+29	+21	−23	39
+09	+12	−02	47
+66	+06	−32	57
+60	+14	−18	55
+11	−03	+04	73
+13	+09	−03	78

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Factor IV. This loaded highly on the span memory markers Number Span and Letter Span, and moderately on the CVR, Letter Families, Matrices II and Matrices III. Factor IV has a pattern of loadings which might be expected of a temporal integration factor: it loaded on both of the temporal integration tests, and on the successively-presented Matrices tests; however, its loadings on Number Span and Letter Span, which seem to lack most of the basic features of temporal integration, definitely mark this as the span memory factor. It is also possible that the temporal integration tests and Matrices II and III loaded on this factor because of the way in which they were presented rather than because of their content. Both of the span memory tests were presented successively (one letter or number at a time) as were the temporal integration tests and Matrices II and III. While it is reasonable to assume that successive presentation of an item might introduce some memory process into its solution, it seems unlikely that such large differences in the sizes of the loadings would occur if these other successively-presented tests were loading on Factor IV solely because of their span memory content. The safest conclusion here is that Factor IV, marked by the span memory tests, loads on the temporal integration tests and the successively presented Matrices tests because these six tests *were* all presented successively, and not because they all test span memory.

Another argument against the suggestion that the temporal integration tests involve simply some memory processes is the fact that neither of these tests shows much relation to the factors which define meaningful memory (Factors III and V).

Factor V. This loaded positively on Sentence Completion and Limericks, and negatively on Vocabulary, Completion and the Matrices tests. It also loaded negatively on the CVR thereby classifying this as a reasoning test and not as a test of memory.

DISCUSSION

In this study the only tests with high loadings on only one factor were the spatial and span memory markers. The verbal and meaningful memory markers can be adequately accounted for by two factors, one a factor of general verbal ability, and the other a bipolar factor which discriminates tests of verbal memory from those of verbal reasoning.

Specific findings were:

1. No distinct factor of temporal integration emerged. The two temporal integration tests did not load highly and similarly on any one factor. The presentation of the information piece-by-piece to the *S*s in the temporal integration tests had the effect of causing these tests to load on the obtained factor of span memory: this successive presentation did not, however, lead to the emergence of a factor of temporal integration. This was also indicated by the fact that the successively-presented Matrices tests, which might be expected to contain some temporal integration process, were not clearly differentiated from their non-successively presented counterparts.

2. Both of the temporal integration tests loaded reasonably highly on the obtained factor of span memory: the Letter Families test of temporal integration had its highest loading on this factor. This may simply reflect the fact that all of these tests were presented successively. This is suggested by the observation that the other successively-presented tests in the battery (viz. the Matrices tests, which are known to test *g*), also had loadings on the span memory factor: this outcome is believed to have arisen not because span memory is a component of *g*, but because these particular Matrices tests were presented in a similar manner to the span memory tests.

3. The two temporal integration tests did not behave similarly. The CVR was classified by this study as a reasoning test, rather than as a memory test, and some spatial content was also revealed in it. The Letter Families test showed some similarity to the span memory tests, and its loading on the general verbal factor also reflected its verbal content. From the test scores in this study Kuder-Richardson 20 reliability coefficients were calculated for the temporal integration tests: for the CVR this coefficient was almost ·8, and for the Letter Families it was ·73. Therefore unreliability cannot have contributed too much to the doubtful results which emerged. This indicates that a fair amount of the variance of these two tests is unaccounted for here.

It might be argued that the inclusion of more temporal integration tests would have led to the emergence of a temporal integration factor or to a more distinctive pattern of loadings for the temporal integration tests. Against this viewpoint can be set the fact that most of the other factors which clearly did emerge are marked by only two tests. This may be an unfair argument in the case of the spatial and verbal factors, where the tests used were the known and traditional markers for the factors required. But the memory factors in Kelley's study (1954) were originally discovered using many more than two tests per factor, and they still emerged clearly in the present study when only two markers were used for each factor.

The temporal integration tests were selected using similar criteria: these two tests, about which some earlier information was available were selected because it was maintained that they *were* both reasonably good tests of one ability. Why, then, do these temporal integration tests give so little information in this present study ? The only reasonable conclusion to be drawn is that the test-battery was unsatisfactory since it included no other tests with which the temporal integration tests could correlate. It appears then that a description of the nature of temporal integration by factor-analytic methods must wait until some other tests are found which show a pattern of correlations with the currently used tests of temporal integration.

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(*Manuscript received* 11 *February* 1966)