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ABSTRACT

This paper reviews studies in which scores on Piagetian tests of logical thought were correlated with IQ, mental age (MA) and chronological age (CA), and examines the possible effects of the size of the age range and mean age of subjects on these correlations. The data included 44 groups of subjects obtained from 36 studies in which Piagetian and intelligence tests were administered to intellectually normal children (mean IQ=109) from the preoperational through formal operational periods (40 to 216 months of age). Results revealed that averaged correlations between Piagetian tests and MA were consistently higher than the corresponding correlations for IQ and CA. The mean age of the subjects and no effect on the size of correlations between Piagetian tests and IQ, MA and CA, but the size of the age range was found to significantly affect the IQ and CA correlations (Piagetian tests/IQ correlations were higher within a narrow age range; Piagetian tests/CA correlations were higher within a wide age range; Piagetian tests/MA correlations showed no effect for size of age range). It was concluded that MA scores yield higher and more consistent correlations with Piagetian tests than either IQ or CA scores, and are not affected by the age range or mean age of the subjects sampled. (Authors/ED)

Relative Strengths of IQ, Mental Age and Chronological Age for Predicting Performance on Piagetian Tests

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Abstract

This paper reviews studies in which scores on Piagetian tests of logical thought were correlated with IQ, mental age (MA) and chronological age (CA). The possible effects of the size of the age range and mean age of the subjects on these correlations with Piagetian tests was also examined. The data were 44 groups of subjects obtained from 36 studies in which Piagetian and intelligence tests were administered to intellectually normal children from the preoperational through formal operational period. The results revealed that averaged correlations between Piagetian tests and MA were consistently higher than the corresponding correlations for IQ and CA. The mean age of the subjects had no effect on the size of correlations between Piagetian tests and IQ, MA and CA, but size of the age range was found to significantly affect the IQ and CA correlations. Specifically, correlations between Piagetian tests and IQ were higher within a narrow age range, while correlations between Piagetian tests and CA were higher within a wide age range. The size of the age range had no effect on the size of correlations between Piagetian tests and MA. It was concluded that MA scores yield higher and more consistent correlations with Piagetian tests than either IQ or CA scores, and are not affected by the age range or mean age of the subjects sampled.

Relative Strengths of IQ, Mental Age and Chronological Age for Predicting Performance on Piagetian Tests[1]

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This paper examines the relationship between Piagetian tests of logical thought and standardized intelligence tests, through a review of studies in which scores on these two different kinds of tests were correlated. Elkind (1969), DeVries (1974), and others have discussed the differences in the traditions leading to the development of Piagetian tests on the one hand, and psychometric tests of intelligence on the other. These two approaches to the measurement of intelligence represent different traditions concerning the nature and course of intellectual development, so it seemed appropriate to quantify the extent to which tests developed under the two traditions might be related.

One issue considered was whether "intelligence quotient" (IQ) or "mental age" (MA) scales provided stronger prediction of scores on Piagetian tests, and how these two types of intelligence test scales compared with chronological age (CA) as a predictor. From the standpoint of Piagetian theory, one might expect that CA, as an index of developmental maturity, would provide stronger prediction of performance on Piagetian tests than scores obtained from standardized intelligence tests. A second and related issue considered was whether the reported variability in the size of correlations between Piagetian tests and IQ, MA and CA might be due to age-related variables such as the age range and mean age of subjects sampled.

Studies meeting the following criteria were used for this review:

1. Piagetian tests were administered to intellectually normal children from the preoperational through formal operational periods;

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2. the range of IQs of the subjects was not restricted;
3. the age range for the subjects was continuous (if a study tested children in the first, third and fifth grades, it was not included unless the correlations were reported separately for each grade level); and
4. relationships between Piagetian and intelligence tests and CA were reported using product-moment correlations.

On the basis of these criteria, 36 studies were included, and from these studies, data for 44 independent groups of subjects were available. For these 44 groups, the mean IQ was 109, and the mean CA was 92 months, with a range from 40 to 216 months.

The psychometric tests were classified according to whether the tests were scored on a IQ or age-deviated basis, or on a MA or MA-like basis (such as raw scores or mental ages expressed in month or grade equivalents). The psychometric tests were also classified as general, verbal and nonverbal. To obtain the single best index of the correlations between Piagetian tests and IQ for each study, we used the correlation based on general IQ when available, or an average of the reported correlations based on the verbal or nonverbal IQ. The same procedure was used to obtain the single best index of the correlation between Piagetian tests and MA.

The Piagetian tests were classified into five major categories, which are listed in Table 1. Within a particular study, if more than one correlation was available for any of these categories, then the correlations were averaged using Fisher's _r_-to-_Z_ transformation. For example, a study might report separate correlations between IQ and conservation of continuous and discontinuous quantity, so these two quantity correlations were averaged to yield a single correlation between conservation of quantity and IQ. Once pooled correlations were obtained _within_ studies, it was then possible to average correlations _across_ studies, again using Fisher's _r_-to-_Z_ transformation, and weighting the averaged correlations by the sample size on which each separate correlation was based. These averaged correlations across the 44 groups of subjects between Piagetian tests and IQ, MA and CA are reported in Table 1. For example, the entry for Conservation of Area and IQ is ".21(5;485)". This indicates that correlations between these two tests were found for five different groups, that the groups included a total of 485 subjects, and that the weighted average of these correlations was .21.

The overall correlations between Piagetian tests and IQ, MA and CA that appear in the bottom row of Table 1 directly address the first issue raised: namely, which of these variables yields the best prediction of performance on Piagetian tests. The overall correlations for IQ, MA and CA were .36, .51 and .38 respectively, indicating that correlations between Piagetian tests and MA are likely to be higher than the correlations with either IQ or CA. Inspection of the entries for each of the Piagetian categories confirms that the correlations with MA are consistently higher, throughout the table, than correlations with either IQ or CA. Eliminating the two subtotal categories for Conservation and Logical Operations, there are 15 categories of Piagetian tests. In every category where a comparison can be made, the MA correlations are higher than the corresponding IQ correlations, and in all but two categories, the MA correlations are higher than the CA correlations. For both the MA and IQ, and MA and CA comparisons, the differences are significant ($p<.01$) using a sign test. However, 8 of the CA correlations are higher than the corresponding IQ correlations, and 5 are lower, a difference which is not significant using a sign test. The IQ, MA and CA columns in Table 1 are based on data from partly dependent and partly independent groups, so a sign test is not fully appropriate for making this comparison. Nevertheless, the pattern which emerges from Table 1 is that Piagetian and MA relationships are consistently higher than either Piagetian and IQ or CA relationships, and that IQ and CA are about equally strong for the purposes of predicting scores on Piagetian tests.

The second issue considered in this review was whether the two age-related variables, namely age range and mean age, might influence the size of the correlations between Piagetian tests and IQ, MA and CA. Rank-order correlations between these two age-related variables and the IQ, MA and CA correlations were calculated, and these are shown in Table 2. To index the age ranges, the reported ages were converted into months. However, a surprising number of studies--half of the 44 independent groups--did not report actual age ranges, but indicated only the grade levels or mean ages of the subjects. For these studies, an age range was estimated by converting each grade level into a 12 month age range, and using the reported mean age, when available, as the mean age for those subjects. (This probably underestimates the actual age ranges to some extent, but if these studies had been eliminated, it would have severely limited the number of groups available for this analysis). The age ranges varied from 6 to 71 months, with a mean age range of 27 months.

The results in Table 2 indicate that the size of the correlations between Piagetian tests and IQ, MA and CA were not affected by the mean ages of the subjects. None of the rank-order correlations between mean age and the IQ, MA and CA correlations were significant. The results also indicate, however, that the size of the correlations between Piagetian tests and the other variables is moderated by the age range of the subjects sampled. The rank-order correlation between age range and the Piagetian-CA correlations is significant and positive (.57, $p < .01$), indicating that the correlations with CA tend to be higher in studies with a wide age range. The rank-order correlation between age range and the Piagetian-IQ correlations is significant and negative (-.48, $p < .01$), indicating that the correlations with IQ tend to be higher in studies with a narrow age range. Thus, age range has significant but opposite effects on the CA and IQ correlations. By contrast, the rank-order correlation between age range and the Piagetian-MA correlations is not significant, indicating that these correlations are not appreciably affected by the size of the age range sampled.

Table 3 further illustrates the effects of age range on the correlations with Piagetian tests, by comparing the averaged correlations for groups having low and high age ranges. (The groups were dichotomized at 27 months, the mean age range, and these averaged correlations are not weighted by their respective sample sizes.) The *t*-tests for differences between the two groups indicate that the groups with low and high age ranges differ significantly in the size of IQ and CA correlations, but not in the size of MA correlations. The *t*-tests use almost the same information that is used by the rank-order correlations in Table 2, and show the same direction of effects. It is clear in Table 3 that the MA correlations are comparable in size to the IQ correlation for the low-age-range group, and comparable to the CA correlation for the high-age-range group. The mean ages for groups above and below the age range mean are also reported in Table 3, and while the high-age-range group is slightly older, the difference does not reach significance.

Our results indicate that the correlations between Piagetian tests and CA are strongly affected by <u>restriction of range</u>, as classically conceived and understood in the psychometric literature (e. g., Gulliksen, 1950). Correlations between Piagetian tests and IQ, on the other hand, are strongly affected by what might be called "<u>overlapping of range</u>" when wide age ranges are used. The overlapping-of-range effect arises with IQ scores because bright young children and dull older children may be answering approximately the same number of questions on a test, implying that they are similar in performance, or in mental age. In the metric of IQ scores however, the young child's performance is treated as "high" and the older child's performance is treated as "low." For studies using a narrow age range (about 12 months), it probably will not matter whether IQ or MA scales are used as a measure of intelligence, since both scales will rank the children in approximately the same way. But for children in a wide age range, our results indicate that MA scales should always be used.

In conclusion, it is preferable to index the relationship between Piagetian and standardized intelligence tests in terms of MA rather than IQ, for two reasons. First, as shown earlier, the correlations of Piagetian tests with MA are consistently higher than the corresponding correlations with IQ. Second, the correlations with IQ are strikingly affected by the age range of the subjects sampled, while the correlations with MA are not. Similarly, we conclude that the correlations between Piagetian tests and MA are consistently higher and less affected by age range than the corresponding correlations between Piagetian tests and CA. This suggests that MA provides a more consistent index of developmental level than CA for purposes of predicting performance on Piagetian tests.

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Table 1

Summary of Averaged Correlations between Piagetian Tests and IQ, MA and CA

Piagetian Tests	IQ	MA	CA
I. Conservation			
A. Area	.21(5;485)	.32(3;342)	.17(5;458)
B. General conservation batteries	.36(8;570)	.51(10;994)	.51(7;652)
C. Length	.21(1;102)	.32(4;615)	.50(1;75)
D. Number	.28(7;1316)	.47(6;931)	.45(5;630)
E. Quantity	.29(8;677)	.45(5;469)	.32(7;609)
F. Volume	.33(3;674)	.52(4;724)	.45(3;336)
G. Weight	.15(4;397)	.38(4;419)	.32(4;391)
Subtotal: conservation	.31(17;2278)	.47(14;1827)	.40(13;1205)
II. Logical operations			
A. Class inclusion	.35(5;308)	.57(2;146)	.40(5;354)
B. Classification	.33(3;117)	.47(2;168)	-
C. General logical operations batteries	-	.52(1;210)	-
D. Seriation	.38(6;450)	.50(2;230)	.34(4;383)
E. Transitivity	.13(1;165)	.40(5;520)	.36(3;405)
Subtotal: logical operations	.33(8;540)	.48(7;833)	.36(7;663)
III. General concrete operational batteries	.51(5;339)	.58(4;320)	.21(6;492)
IV. Spatial concepts	.33(8;701)	.49(5;400)	.30(8;590)
V. Formal operations	.17(1;61)	.20(1;61)	.14(1;61)
Total Piagetian tests	.36(29;2909)	.51(22;2142)	.38(21;1966)

Note. Entries following correlations are the number of groups and the total number of subjects on which the averaged correlation is based. Correlations are averaged using Fisher's *r*-to-*Z* transformation. A dash indicates unavailable information.

Table 2

Rank-order Correlations between Age-related Variables and Correlations between Piagetian Tests and IQ, MA and CA

Age-related Variables	Correlation between Piagetian tests and: IQ	MA	CA
Size of Age Range	-.48**	.27	.57**
Mean Age	-.05	-.24	-.17
Number of groups	29	22	21

**$p < .01$, 2 tailed test

Table 3

Averaged Correlations between Piagetian Tests and IQ, MA and CA by Size of Age Range

Size of Age Range	Mean Age	Correlation between Piagetian tests and: IQ	MA	CA
Low (Under 27 months) N=27	86	.47(21)	.48(10)	.25(9)
High (Over 27 months) N=17	100	.30(8)	.53(12)	.45(12)
t test of difference	1.73	-2.56*	-.67	2.69*

<u>Note</u>. Numbers in parentheses represent the number of groups on which the averaged correlation is based. Correlations are averaged using Fisher's *r*-to-*Z* transformation.

*$p < .05$, 2 tailed test