Relationships Among Abilities in Elderly Adults: A Time Lag Analysis

Bert Hayslip, Jr. and Robert G. Brookshire

Previous research has suggested that relationships among primary abilities said to measure crystallized (Gc) and fluid (Gf) intelligences remain the same across cohorts if age is held constant, despite generational changes in the levels of abilities. The present study assessed differences in relationships among several components of Gf/Gc in two independent samples of elderly adults, tested in 1975 and 1979 by the same investigator. The 1975 sample consisted of 54 elderly adults aged 59 to 76 years (M = 67.7); the 1979 sample of 50 elderly adults was aged 55 to 82 (M = 69.4). Time-lagged differences in relationships among abilities measuring Gf and Gc (induction, figural relations, and verbal comprehension) were investigated using confirmatory factor analytic procedures. Although a two factor (Gf, Gc) model was common to both the 1975 and 1979 samples, significant differences in unique variances were observed across samples. Some, albeit weaker, evidence was found suggesting time-lagged differences in factor covariances. These data, for the most part, support previous research with younger individuals, suggesting consistency in factor structure across time and cohort.

Key Words: Crystallized intelligence, Ability structure, Fluid intelligence

In research dealing with maturational versus historical antecedents of structural changes in intellectual abilities, Reinert (1970) noted numerous factors (e.g., generation/time of measurement effects, selective dropout, practice effects, sampling, investigator effects) that cast doubt on the assumption that such changes are truly maturational. Recent studies have yielded conflicting findings (Baltes et al., 1980; Cunningham, 1980, 1981; Cunningham & Birren, 1980; Cunningham et al., 1975; Hayslip & Sterns, 1979). Moreover, they either are limited by the use of single (and diverse) measures of abilities or are cross-sectional. Using two samples of young adults, Cunningham and Birren (1980) found no time-lagged difference in factor structure, supporting an age-related interpretation of longitudinal changes in factor structure. Given that their time-lagged comparisons were specific to young adults, research that extends these findings to other age cohorts (controlling for investigator differences) is appropriate (Cunningham, 1980). The present study investigated time-lagged differences in crystallized (Gc) and fluid (Gf) intelligence in two independent groups of elderly persons tested by the same investigator.

METHOD

The first sample, taken in 1975, consisted of 27 women and 27 men, ranging in age from 59 to 76 years (M = 67.68). Levels of education ranged from 8 to 19 years (M = 12.76). The second sample, taken in 1979, consisted of 50 elderly persons ranging in age from 55 to 82 (M = 69.40). Twenty-five were men, and 25 were women; education varied between 8 and 24 years (M = 14.42). The 1975 and 1979 samples (all community-living volunteers in good health) did not differ significantly (p > .05) in age or level of education. Using the Gf-Gc Sampler (Horn, 1975), components of Gc were assessed (under unspeeded conditions) through multiple choice vocabulary (marking comprehension) and esoteric (abstruse) analogy items (marking semantic relations). Gf was measured using matrices (marking figural relations) and letter series items (marking induction). In addition, common analogy items (also marking semantic relations), which primarily assess Gf but also tap Gc (Horn, 1978), were used. Cattell's Culture Fair Matrices, Scale 2, Form A was administered to the 1975 sample. Time-lagged differences in the structure of abilities were tested using confirmatory factor analysis (LISREL VI, Jöreskog & Sörbom, 1984). Although the procedure for arriving at an a priori
Table 1. Factor Loadings and Unique Variances Across Samples

<table>
<thead>
<tr>
<th>Variable</th>
<th>Gc Factor Loadings</th>
<th>Gf Factor Loadings</th>
<th>Unique variance 1975</th>
<th>Unique variance 1979</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocabulary</td>
<td>1.000* (.853)</td>
<td>0*</td>
<td>1.769 (.321)</td>
<td>1.166 (.212)</td>
</tr>
<tr>
<td>Abstruse analogies</td>
<td>1.484 (.758)</td>
<td>0*</td>
<td>1.081 (.098)</td>
<td>2.269 (.206)</td>
</tr>
<tr>
<td>Common analogies</td>
<td>.613 (.313)</td>
<td>.406 (.388)</td>
<td>3.237 (.788)</td>
<td>1.013 (.246)</td>
</tr>
<tr>
<td>Letter series</td>
<td>0*</td>
<td>1.171 (.808)</td>
<td>2.256 (.206)</td>
<td>5.308 (.488)</td>
</tr>
<tr>
<td>Matrices</td>
<td>0*</td>
<td>1.000* (.854)</td>
<td>1.919 (.279)</td>
<td>1.886 (.275)</td>
</tr>
</tbody>
</table>

Note. Entries are unstandardized LISREL estimates; rescaled estimates are shown in parentheses.

*aEstimates are based on the combined 1975 and 1979 samples.

*bEstimates are shown separately for the 1975 and 1979 samples.

Table 2. Factor Variances and Covariances

<table>
<thead>
<tr>
<th>Factor</th>
<th>Gc Variances</th>
<th>Gf Variances</th>
<th>Gc-Gf Covariances</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975 Sample</td>
<td>3.714</td>
<td>3.338</td>
<td>3.064</td>
</tr>
<tr>
<td>1979 Sample</td>
<td>4.207</td>
<td>4.358</td>
<td>3.706</td>
</tr>
</tbody>
</table>

Note. Entries are unstandardized LISREL estimates; standardized estimates are shown in parentheses.

Results

An initial test for the equivalence of the variance-covariance matrices yielded a solution, $\chi^2 (18) = 37.29, p = .005$, suggesting the sample covariance matrices were drawn from different populations. Further tests for the number of factors across samples suggested that, although a one-factor model was unable to explain the relationships among ability measures across samples, $\chi^2/df > 3, p < .001$, a two-factor (Gf-Gc) model (using exploratory maximum likelihood methods) was found to be adequate, $\chi^2 (10) = 2.78, p > .05$. This two-factor model fit significantly better ($p < .01$) than a null model specifying no shared variance among the variables, $\chi^2 (20) = 298.21, p < .001$, diff $\chi^2 (10) = 295.43, p < .01$.

When between-sample equality constraints were relaxed in the theta delta ($\Theta$) matrix of unique variances, a significant, diff $\chi^2 (5) = 14.37, p < .05$, improvement in fit was observed. When similar constraints on factor variances were removed, however, no improvement, diff $\chi^2 (2) = 2.41, p > .05$, in fit was found. Likewise, no better fit was achieved, diff $\chi^2 (1) = 2.27, p > .05$, when factor covariances were allowed to vary across samples. It can be observed in Table 1, however, that only the model in which the covariance between the factors is different between the samples adequately fits the data, $\chi^2 (10) = 18.25, p = .051$. Moreover, although the correlation between Gf and Gc (.691) in the 1975 sample was significantly different from zero, two-tailed $t = 3.525, p < .01$, such was not the case in the 1979 sample, $r = .302, t = 1.742, p > .05$.

When equality restrictions on the factor loading ($\Lambda$) matrix were relaxed, no further improvement in fit was noted, diff $\chi^2 (4) = 4.31, p > .05$. The model (IV) with factor loadings held constant fit significantly better, diff $\chi^2 (10) = 279.97, p < .01$, than one specifying no shared variance among the ability markers (null model). Last, when between-sample equality restrictions on factor means were relaxed, no differences were observed $\chi^2 (2) = 3.28, p > .05$. Tables 1–3 illustrate both the unstandardized and scaled solutions for the 1975 and 1979 samples and the goodness of fit index associated with the test of time-lagged differences in each.
component of the variance-covariance matrix across groups.

**DISCUSSION**

These data are consistent with those of Cunningham and Birren (1980), who found no evidence for cohort/period effects in ability factor structure. There is some, albeit weak, evidence for time-lagged differences in factor intercorrelations. Between-sample similarity was also observed for factor means. Due to a number of factors (e.g., sampling of ability markers, nature of administration, sample size), strict comparisons are cautioned, however. These samples were not drawn for the purpose of conducting comparative factor analysis; moreover, they were also relatively heterogeneous. Thus, results may not generalize to more homogeneous samples, particularly when complex models are tested. Regarding sample size, however, Bearden, Sharma, and Teel (1982) found that the chi-square statistic used in LISREL is distributed correctly with high reliability for two-factor models across a variety of sample sizes. It is interesting to note that the loadings for common analogies favor a Gc, not a Gf factor, in contrast to what might be predicted based on the Horn and Cattell research. These results cannot, however, address revisions of Gf/Gc theory (see Horn, 1978, 1982) incorporating other cognitive processes.

Although these data suggest that cross-sectional/longitudinal shifts in factor loadings (and to a lesser extent, shifts in factor covariances) may be age related, research using a wider array of ability measures and larger samples is nevertheless warranted. These data must be considered descriptive; further experimental work is thus necessary to explore the antecedents of such time-dependent changes in the structure of intelligence.

**REFERENCES**


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