Children's Figural Fluency Performance: Development of Strategy Use

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To this point, the focus in evaluating measures of figural fluency, including the Ruff Figural Fluency Test (RFFT), has been on the number of unique designs generated and the number of repetitions or perseverations. In addition to these quantitative measures, our study assesses the qualitative aspects of figural fluency production in determining the extent to which children use strategies on the RFFT. Accordingly, two main strategies were operationalized, and design complexity (number of lines used for each design) was analyzed. It was postulated that age would play a significant role. The 87 children tested were, therefore, selected across four age groupings: Grades 1 and 2, Grades 3 and 4, Grades 5 and 6, and Grades 7 and 8. Each child was individually administered all five parts of the RFFT. The results indicated that older children used strategies to complete the test, whereas young children did not, and that design complexity did not discriminate children according to age or grade.

Verbal fluency measures have demonstrated their utility in discriminating brain-damaged from control individuals (Borkowski, Benton, & Spreen, 1967) and their sensitivity to left frontal-lobe lesions (Jones-Gotman & Milner, 1977; Zangwill, 1966). As a result, verbal fluency measures and similar tasks (e.g., controlled word association) are used routinely to assess
the sequelae of head injury (e.g., Chadwick, Rutter, Shaffer, & Shrout, 1981), expressive language functions (e.g., Wiig & Semel, 1984), and learning disabilities (e.g., Sweeney & Rourke, 1985).

Analogous measures of right frontal-lobe dysfunction have been studied less extensively. Jones-Gotman and Milner (1977) first described nonverbal fluency as a means for assessing right frontal impairment. They devised two nonverbal fluency tests. The free condition required participants to invent drawings that did not represent actual objects, could not be named, and were not scribbling. The fixed condition was similar except that the drawings had to consist of exactly four lines. Their results indicated that, although verbal fluency was reduced secondary to left frontal lesions, the nonverbal measures were sensitive to right frontal lesions. Unfortunately, these unstructured nonverbal measures depend on subjective judgments for scoring—making reliability difficult to achieve.

Ruff and his colleagues developed a structured nonverbal fluency measure consisting of five black dots arranged within squares and allowing for easier and more reliable scoring. The Ruff Figural Fluency Test (RFFT) has been normed on 358 people 16 to 70 years old with education levels ranging from 7 to 22 years (Ruff, Light, & Evans, 1987). Moreover, the RFFT has been administered to groups of normal children; in general, the number of figures produced increases with age (Evans, Ruff, & Gualtieri, 1985; Vik, 1986) and peaks between 16 and 24 years of age. Scores remain fairly constant between 25 and 55 years and then decline (Ruff et al., 1987).

Motor speed, test intelligence, and verbal fluency have been compared to the RFFT. Motor speed does not significantly correlate with the number of unique designs generated. In adults, only the Performance IQ (and not Verbal IQ) of the Wechsler Adult Intelligence Scale–Revised was found to correlate moderately (Ruff et al., 1987). In addition, the RFFT effectively discriminated between intellectually bright and average children (Evans et al., 1985). The correlation of verbal fluency and the RFFT is mild and lacks significance, both for adults (Ruff et al., 1987) and children (Vik, 1986). Finally, the RFFT has proved sensitive to discriminating between samples of patients with moderate and severe head injuries (Ruff, Evans, & Marshall, 1986).

Up to this point, the focus in evaluating the RFFT has been on the number of unique designs generated versus the number of perseverations (repetition of the same figure). In addition to these quantitative data, however, our study addresses qualitative aspects of figural fluency. As emphasized by Kaplan (1983), neuropsychological measures must capture the process of the individual’s performance. Therefore, strategies that occur while generating different designs were categorized and juxtaposed with our earlier findings (Evans et al., 1985; Vik, 1986) that children’s performance on the fluency test increase with age. One explanation for the age-related
increase is that older children use strategies to complete the test. A related explanation is that younger children draw random complicated figures that require more time to complete.

Strategies require abstract logic to successfully aid in completing the RFFT. In particular, they help the person to conceive of and plan for the possible figures. This abstract ability to anticipate solutions characterizes Piaget's (1975/1985) formal operational level of thinking (Ginsberg & Opper, 1979). Consequently, children would most likely not use strategies until early adolescence when formal operational thinking begins.

Our purpose is to determine the extent to which children use strategies on the RFFT. In particular, we ask (a) if older children use strategies more than younger children, (b) if IQ mediates the use of strategies, and (c) if strategies account for improved retest scores among older children. In addition, design complexity was examined to evaluate whether younger children make more complex designs by drawing more lines per figure.

METHOD

Children

Eighty-seven children, attending both public and private schools, were grouped as follows: Grades 1 and 2, Grades 3 and 4, Grades 5 and 6, and Grades 7 and 8. Table 1 presents the mean age and IQ for each of the four groups. A subgroup of youngsters (n = 27, 31% of total sample) were retested following a 1-month interval (23 to 25 days) to assess the reliability of the strategies. Table 2 compares the age and IQ stratifications of this subgroup (n = 27) to the entire sample (N = 87).

Tests

The RFFT (Ruff et al., 1987) has five parts, each containing 35 identical stimulus items (see Figure 1). The items are arranged in a 5 × 7 matrix on

<p>| TABLE 1 |
| Sample Characteristics for Grade Groups |</p>
<table>
<thead>
<tr>
<th>Grades</th>
<th>n</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
<th>Age (in Years)</th>
<th>IQ</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 and 2</td>
<td>19</td>
<td>7.5</td>
<td>0.63</td>
<td>6.4 to 8.3</td>
<td>126.75</td>
<td>12.7</td>
<td>103 to 145</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 and 4</td>
<td>28</td>
<td>9.4</td>
<td>0.75</td>
<td>8.0 to 10.4</td>
<td>120.57</td>
<td>11.8</td>
<td>105 to 145</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 and 6</td>
<td>23</td>
<td>11.3</td>
<td>0.69</td>
<td>10.0 to 12.7</td>
<td>120.29</td>
<td>13.5</td>
<td>87 to 145</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 and 8</td>
<td>16</td>
<td>14.3</td>
<td>0.79</td>
<td>12.3 to 14.6</td>
<td>105.33</td>
<td>13.4</td>
<td>79 to 138</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TABLE 2
Sample Characteristics at 1-Month Retest

<table>
<thead>
<tr>
<th>Grade</th>
<th>n</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>10</td>
<td>7.8</td>
<td>0.28</td>
<td>7.4 to 8.3</td>
<td>130.4</td>
<td>10.4</td>
<td>111 to 145</td>
</tr>
<tr>
<td>4</td>
<td>11</td>
<td>9.8</td>
<td>0.31</td>
<td>9.3 to 10.4</td>
<td>123.6</td>
<td>10.2</td>
<td>110 to 145</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td>11.6</td>
<td>0.58</td>
<td>10.9 to 12.7</td>
<td>117.3</td>
<td>13.5</td>
<td>87 to 135</td>
</tr>
<tr>
<td>8</td>
<td>7</td>
<td>13.9</td>
<td>0.63</td>
<td>12.9 to 14.6</td>
<td>103.4</td>
<td>8.7</td>
<td>88 to 113</td>
</tr>
</tbody>
</table>


FIGURE 1 Examples of items, Parts I to V, of the RFFT.

Strategies

A strategy was defined as a sequence of at least three consecutive drawings and within the sequence each successive figure is systematically rotated or changed quantitatively. A strategy must be systematic; that is, each successive figure must logically continue the pattern established by the previous figures included in the strategy. In a rotation strategy, either the entire figure is systematically rotated or some portion of the figure is rotated while the rest of the figure remains fixed (see top portion of Figure 2). In a quantitative strategy, the basic figure remains constant while a single line is systematically added to or removed from each successive figure in the strategy (see bottom portion of Figure 2). The resulting figure then becomes the new basic figure to which a line is either added or removed.

Complexity

Complexity refers to the number of lines, from 1 to 10, used to connect the dots in each figure. Multiple lines connecting the same pair of dots are
counted only once. The average number of lines per figure reflects how complex a child's drawings are.

Procedure

Each child was individually administered all five parts of the RFFT. Sample items from Part I were placed in front of the child with the following instructions:

Here you see a pattern of dots. I want you to connect two or more dots, using straight lines, to make a design or picture. Work as quickly as you can, but make sure each picture your draw is different from the others. Here are some practice dots.

After completing the practice dots, the child was given Part I and was told to work as quickly as possible. Each of the five parts was timed for 60 sec, and sample items were given with each part.

Expressive One-Word Picture Vocabulary Test

This test (Gardner, 1983, 1985) was used to estimate the child's intelligence. Deviation IQ scores were generated based on the child's ability to name the
objects in a series of drawings. Pictures were shown to the child one at a
time. The child had 15 sec to name or identify the item in the drawing. The
test was discontinued when the child failed to correctly name six consecutive
drawings.

RESULTS

Strategy and Age

Analysis of variance (ANOVA) was used to determine if older children
differed from younger children in the number of figures and strategies
produced. Dependent variables were the number of strategies and figures
included in a strategy, as well as total figures, unique figures, and
perseverations. In addition, two ratios were calculated: error ratio (per­
severations/unique figures) and average number of lines (number of
lines/total figures).

Total figures and unique figures were significant across age groups, $F(82,$
$3) = 9.56, p < .001,$ and $F(82, 3) = 14.41, p < .001,$ respectively. Figure
3 shows the mean total and unique figures for all four age groups.
Newman–Keuls post hoc analysis indicated that older students (Grades 5
through 8) made significantly more total figures than younger children
(Grades 1 through 4). Likewise, older students drew significantly more
unique figures than the younger children, with seventh and eighth graders
drawing significantly more than all other students.

Number of strategies and number of figures included in a strategy were
significantly different across age groups, $F(82, 3) = 2.76, p < .05,$ and

![Image of bar chart showing mean total and unique figures for each grade group.](Image)

FIGURE 3 Mean total and unique figures for each grade group.
FIGURE 4 Mean number of strategies and figures included in a strategy by grade group.

TABLE 3
Mean Unique Scores for Each Part of RFFT by Grade Group

<table>
<thead>
<tr>
<th>Grades</th>
<th>RFFT Part</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 and 2</td>
<td>I</td>
<td>7.21</td>
<td>8.26</td>
<td>8.84</td>
<td>9.32</td>
<td>8.84</td>
</tr>
<tr>
<td>3 and 4</td>
<td>II</td>
<td>9.14</td>
<td>9.86</td>
<td>9.89</td>
<td>10.57</td>
<td>10.93</td>
</tr>
<tr>
<td>5 and 6</td>
<td>III</td>
<td>12.39</td>
<td>13.35</td>
<td>13.26</td>
<td>14.04</td>
<td>14.70</td>
</tr>
<tr>
<td>7 and 8</td>
<td>IV</td>
<td>14.44</td>
<td>16.00</td>
<td>16.31</td>
<td>16.13</td>
<td>17.25</td>
</tr>
</tbody>
</table>

$F(82, 3) = 2.83, p < .05$, respectively. The means are shown in Figure 4. Newman–Keuls post hoc analysis indicated that seventh and eighth graders scored significantly higher on both variables than did the third and fourth graders. Perseverations, error ratio, and average number of lines were not significantly different across grades.

Unique score and number of strategies in Parts I through V were compared within each age group. The results are presented in Tables 3 and 4. There was a tendency for unique scores to be lower in Part I and for strategies to appear more often in Parts II and III.

Correlational procedures were used to determine the effect of age on total figures, unique figures, number of strategies, and figures in a strategy. Age correlated significantly with both total figures ($r = .52$) and unique figures ($r = .60$). Number of strategies and figures in a strategy correlated moderately with age ($r = .29$ for each).
TABLE 4
Percentage of Children Using a Strategy on a Given Part of the RFFT

<table>
<thead>
<tr>
<th>Grades</th>
<th>RFFT Part</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 and 2</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3 and 4</td>
<td>3.6</td>
<td>10.7</td>
<td>0</td>
<td>0</td>
<td>7.1</td>
<td></td>
</tr>
<tr>
<td>5 and 6</td>
<td>13.0</td>
<td>17.4</td>
<td>17.9</td>
<td>17.4</td>
<td>17.4</td>
<td></td>
</tr>
<tr>
<td>7 and 8</td>
<td>25.0</td>
<td>25.0</td>
<td>12.5</td>
<td>18.8</td>
<td>25.5</td>
<td></td>
</tr>
</tbody>
</table>

FIGURE 5  Mean unique figures at baseline and at 1-month retest grouped by grade.

Effect of Intelligence

A $t$ test was used to determine how intelligence related to strategy use. This analysis was restricted to Grades 5 through 8, as younger grades rarely used
strategies. The mean Expressive Vocabulary IQ score was 119.4 when strategies were present and was 107.9 when they were not. This difference was significant, $t(30) = 2.27, p < .05$.

Retest Improvement Over Time

Repeated-measures ANOVAs were used to determine improvement over time. Figures 5 and 6 show the improvement over time for total and unique figures, respectively. Total figures improved significantly over time, $F(34, 1) = 16.99, p < .001$, as did unique figures, $F(34, 1) = 27.06, p < .001$. In addition, total figures demonstrated a significant Grade $\times$ Time effect, $F(34, 3) = 3.63, p < .01$. Figures in a strategy had a significant time effect, $F(34, 1) = 6.68, p < .02$, whereas the number of strategies approached but did not reach significance over time, $F(34, 1) = 4.06, p = .0519$.

Effect of Strategies on Improved Unique Score

Finally, correlation analysis was used to test the hypothesis that increased strategy use accounts for improved unique scores. Changes in unique figures correlated significantly with number of strategies, $r(36) = .46, p < .01$. Likewise, figures in a strategy correlated significantly with improved unique score, $r(36) = .66, p < .001$.

FIGURE 6 Mean total figures at baseline and at 1-month retest grouped by grade.
DISCUSSION

The results confirmed the hypothesis that older children use strategies more often than younger children. Somewhat unexpectedly, this notion was further confirmed by retesting all four age groups after 1 month. Without the utilization of strategies, the gains of the younger children were modest in comparison with those of the older children. Thus, this study has successfully introduced a qualitative delineation of strategies, which in turn can enhance an analysis of the processes taking place during fluency generation. This finding should be relevant when contrasting the performance of both children and adults with focal lesions. Tests are needed to determine whether patients with frontal lobe damage will perseverate within a particular strategy and whether those with right parietal-lobe damage will have difficulty in generating effective figural strategies.

It is interesting to note that design complexity did not differ across grades. This dispels the concern that younger children might feel compelled to connect all five points simply because they are drawn into the box. It appears that the instructions are followed to connect two or more dots, and that typically children can start with one- or two-line designs independent of age. From a clinical neuropsychological perspective, it is important to evaluate each patient with respect to design complexity because it directly influences the number of unique designs generated; that is, many more one-line designs can be drawn than five-line designs—hence, fewer unique designs for those patients who feel compelled to consistently draw five-line designs.

In general, the results regarding children's improvement with age support the previous findings (Evans et al., 1985; Regard, Strauss, & Knapp, 1982; Vik, 1986) that children's scores improve with age. In addition, test intelligence appears to interact with age to influence design production. It is not clear, however, why some older children use strategies yet others do not and if a link exists with test intelligence per se. Strategies appear sporadically among children in younger grades but appear more consistently starting around fifth grade. Rather than linking this to intelligence per se, more power is gained by the theoretical explanation that strategies surfacing around age 12 may reflect a shift from concrete to formal operational thought. This argument is particularly tantalizing, considering the abstract, logical nature of design strategies. When applying this notion to neurologically impaired patients, who revert to concrete thinking, there in turn may be a limitation on their ability to generate strategies.

The influence of intelligence cannot, however, be totally dismissed when analyzing a child's ability to use strategies. Although the use of strategies first appeared around fifth grade, many older children still did not use them. Evans et al. (1985) reported findings suggesting that children with higher IQs may obtain fluency skills in a different progression than
do children with normal IQs. Our finding that children using strategies had significantly higher IQ scores than those not using strategies supports the notion of intelligence as mediating the attainment of fluency skills. However, this in turn may mean that the youngsters with higher IQs were simply more advanced in their ability to formally operationalize their thinking.

On a psychometric level, some interesting results were obtained by comparing the five parts within the RFFT (see Tables 2 and 3). First, there appeared to be a trend toward improvement over time, which slightly increased with age. When comparing Parts I to V, the earlier grades improved by one or two unique scores, whereas Grades 5 to 6 and 7 to 8 improved by two to three scores, respectively. Second, when the mean number of strategies was compared for each of the five parts, a slight improvement was particularly noted in Grades 7 to 8 between Parts I, II, and III. However, once the systematic five-dot patterns are changed to more random arrangements in Parts IV and V, the ratio drops off. In summary, there appears to be a slight yet nonsignificant learning effect taking placing over the five parts. Moreover, the number of strategies generated tends to be negatively affected once the dot arrangement becomes more randomized.

Although the present study may raise more questions than it can answer, an important advance has been made in assessing qualitative strategies within a figural fluency task. Moreover, the proposed strategies were sensitive enough to yield an age effect, which may correspond with the transition from concrete to formal thinking. Having developed the conceptual framework for quantifying strategies, further study and explanation of figural fluency in other populations is possible, for example, with various populations suffering from neurological disorders. With time, figural fluencies may be applied alongside the analogous verbal fluency measures, which are most commonly administered in neuropsychological evaluations. Moreover, it seems reasonable to assume that, by introducing the classification of strategies, more sensitivity may be possible. To develop state-of-the-art neuropsychological measures, we should not be limited to two scores—a sum of unique figures and a sum of perseverative errors after 5 min of testing. Instead, breaking down and classifying the types of strategies used, in the context of design complexity, will allow the empirical quantification of the process within this neuropsychological measure.

REFERENCES


