Relations Between Design Copying and Other Tests of Sensory Integrative Dysfunction: A Pilot Study

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The purpose of this pilot study was to investigate possible relations between performance on the atypical approach parameters of the Design Copying (DC) subtest of the Sensory Integration and Praxis Tests (SIPT) (Ayres, 1989) and scores on the Southern California Sensory Integration Tests (SCSIT) (Ayres, 1980). An existing data set was used that consisted of SCSIT and SIPT-DC scores from 32 children identified by their performance on the SCSIT as having sensory integrative dysfunction. Three questions were addressed: (a) Are there relations between scores on the atypical approach parameters of the SIPT-DC and SCSIT scores? (b) To what extent do the SCSIT scores collectively predict the presence or absence of the SIPT-DC atypical approach parameters? and (c) Are there relations among scores on the SIPT-DC atypical approach parameters? The results suggest that the scores on individual SIPT-DC atypical approach parameters may be related to the scores on the SCSIT subtests. In particular, significant relationships were found between some of the SIPT-DC parameters and the SCSIT subtests that assess visual, tactile, and motor components.

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The Southern California Sensory Integration Tests (SCSIT) have been widely used by occupational and physical therapists since their initial publication (Ayres, 1980). Comprising 18 subtests, the SCSIT assesses visual perception, somatosensory functions, vestibular processing, and praxic abilities. Although the SCSIT has been valuable in evaluating children suspected of having sensory integrative dysfunction, the theory of sensory integration can be further developed only as the ability to identify and measure the discrete characteristics of sensory integrative function increases. To provide a more definitive identification of the discrete characteristics of dysfunction related to graphic praxis, Ayres substantially revised the Design Copying (DC) subtest of the SCSIT for inclusion in the Sensory Integration and Praxis Tests (SIPT) (Ayres, 1989), adding new items and expanding the scoring system. The original Design Copying subtest consisted of 13 designs, which the child copied onto a dot grid. The child's designs were then scored on parameters of accuracy alone. In revising the test, Ayres added a second part with an additional 12 designs, which the child copies without the use of a dot grid. This section was added to reach a wider "range of praxic skill and to make programming requirements most apt to elicit drawing approaches more typical of dysfunctional than of nondysfunctional children" (A. J. Ayres, personal communication, March 1987).

In addition to these new items, the scoring system was altered and greatly expanded. Of the 25 test items, 20 are now scored on both accuracy and the method of approach used by the child while drawing, with the remaining 5 items scored on accuracy alone. Of central interest to the present study are the parameters that assess the child's approach to the copying of a design. These are called Should Not Have parameters and indicate the following unfavorable, atypical, or immature qualities or graphic dyspraxia: (a) the inability to stay within the boundaries, (b) the presence of illogical additions, (c) the segmentation of designs, (d) the reversal of designs, (e) the inversion of designs, (f) the act of drawing from right to left, and (g) the presence of jogs, or ears, at corners or at line intersections (Ayres, 1989). A description of these seven atypical approach parameters of the SIPT-DC and a discussion of pertinent research is presented below.

Atypical Approach Parameters of the SIPT-DC

Boundary: The SIPT-DC parameter of Boundary is scored yes any time a child's picture touches or is drawn outside the printed lines that surround each response area (Ayres, 1989). Hayworth (1970), who developed a similar design copying test, found that
the occurrence of this type of error rarely exceeded 10% to 20% for 5-year-olds without dysfunction and decreased to 5% for 8-year-olds.

Additions. The SIPT-DC parameter of Additions refers to extra lines that are “grossly inappropriate, non-normal, deliberate, illogical additions to a figure” (Ayres, 1989, p. 48). Again, Hayworth (1970) found that few nondysfunctional children over 6 years of age made this type of error, but that the incidence of additions was greater among children with mental retardation or learning problems.

Segmentation. The SIPT-DC parameter of Segmentation is scored yes if the design “is not drawn in a logical sequence,” thereby suggesting that “the child perceives the whole drawing as separated parts joined together and, hence, depicts them as such” (Ayres, 1989, p. 51). Hayworth (1970) found that the incidence of segmentation disappeared almost entirely in the nondysfunctional sample by 7 and 8 years of age. Fuller (1969), however, found that it rarely occurred in nondysfunctional children over 6 years of age.

Reversals. The SIPT-DC parameter of Reversals refers to a figure “in which details on one side of the drawing are drawn on the opposite side, creating a mirror image” (Ayres, 1989, p. 51). Wildereth (1934) and Lewis and Lewis (1965) studied the ability of grade-school children to copy letters and symbols and found a very low incidence of reversals among the children's drawings. Quast (1961) researched the incidence of reversals in children with suspected brain damage and children with suspected emotional disturbances. The results indicated that reversals occurred in 3% of the normative sample, in none of the children with suspected emotional disturbance, and in 29% of the children with suspected brain damage.

Inversion. The SIPT-DC parameter of Inversion refers to a figure in which details from the bottom are drawn on the top, thereby creating a figure that is upside down (Ayres, 1989). In the literature, inversion is often included under the category of reversals. In a study by Lewis and Lewis (1965), however, inversions were found to be rarer than reversals; of 18,010 total letters copied by the first-grade sample, only 87 were inverted, whereas 498 were reversed.

Right to left. The SIPT-DC parameter of Right to Left refers to the direction in which a child draws a line or the location at which he or she begins a drawing (Ayres, 1989). Gesell and Ames (1946) determined that the majority of children of all ages draw a vertical line from top to bottom and a horizontal line from left to right. Weiss (1969, 1971) researched directional tendencies of Israeli children in the copying of designs and found that, despite the fact that these children read and write from right to left, their tendency to draw from left to right increased from 48% in kindergarten to 92% by the ninth grade.

Jogs. The final SIPT-DC parameter, Jogs, or Ears, refers to a “definite and identifiable quality of irregularity at a corner or in a line apparently due to confusion on the part of the child” (Ayres, 1989, p. 48). Beery (1982) and Hayworth (1970) found that jogs rarely occurred among nondysfunctional children beyond the age of 5 years. Additionally, Hayworth found that the presence of jogs on a diamond figure discriminated well between children without dysfunction and children with mental retardation.

During the pilot-testing phase of SIPT development, the seven DC parameters were found to discriminate between children without dysfunction and children with sensory integrative dysfunction (A.J. Ayres, personal communication, March 1987), thus suggesting a possible association between performance on these parameters and certain aspects of sensory integrative function. Although the literature indicates that such difficulties in design copying appear more often in children with dysfunction than among children without dysfunction, there is not yet adequate information on the relations between these parameters and established measures of sensory integrative function.

The purpose of this study was to further investigate the relations between performance on these atypical approach parameters of the new DC test of the SIPT and the established SCSIT, thereby providing some insight into the construct validity of the SIPT-DC. The scores of the SCSIT served as criteria by which the meaning of the scores on the atypical approach parameters of the SIPT-DC could be better understood.

The research questions addressed by this study were as follows:

1. Will there be a statistically significant correlation between the scores on the seven SIPT-DC atypical approach parameters and the individual SCSIT scores of children with sensory integrative dysfunction?
2. Which linear combination of SCSIT scores of children with sensory integrative dysfunction best predicts the presence or absence of atypical approach characteristics on the SIPT-DC?
3. Will there be statistically significant correlations among scores on the atypical approach parameters of the SIPT-DC for children with sensory integrative dysfunction?

Method

Subjects and Data Collection

An existing data set of 32 children—18 boys and 14 girls—from a private occupational therapy clinic in Southern California was used. The children ranged in age from 5 years to 8 years 10 months. Each 1-year age
The children presented varied types of dysfunction, including learning disabilities, motor problems, speech deficits, and behavioral problems.

The clinic's occupational therapists gave the children the SCSIT as part of the routine evaluation process. The test mechanics were closely monitored and the interpretation of results was reviewed by the clinic director, A. Jean Ayres. Because of this monitoring process, it was assumed that test protocol and interpretation were consistent between examiners. All of the subjects were identified by this process as having sensory integrative dysfunction.

Each child returned to the clinic within 1 month of the SCSIT evaluation and was tested with the SIPT-DC by a clinical research assistant. The atypical approach parameters were scored by the first author according to standard instructions (Ayres, 1989).

The SCSIT scores were recorded by the clinical occupational therapists in the form of standard deviations from the mean, based on normative data (Ayres, 1980). The SIPT-DC atypical approach items were assigned scores of yes or no, based on whether or not the characteristic described was present, or were labeled unscorable if the parameter's presence or absence could not be determined.

Data Analysis

The first research question was addressed in the following manner. Descriptive statistical procedures used to determine the distribution of the data, including normal probability plots and measures of skewness and kurtosis, revealed that some of the data were not normally distributed. Because of this, a non-parametric correlation procedure, the Spearman rank order correlation (Zar, 1984), was used to correlate standard scores on the SCSIT with the frequency of occurrence of the seven atypical approach parameters. A review of the data revealed that the 5-year-old subjects tended to have a greater percentage of items on the SIPT-DC that were unscorable or were refused. Because these subjects would therefore have a lower frequency of occurrence of atypical parameters relative to the subjects who were able to complete all items, the inclusion of the 5-year-old subjects in the correlation analysis would tend to make their performance appear better than it actually was and would bias these results. The correlations, therefore, were computed for the 6- to 8-year-olds only.

The second research question was addressed with the use of stepwise discriminant analyses. The dichotomous dependent variable was the presence or absence of a specific atypical approach parameter. Thus, seven separate discriminant analyses were conducted, one for each atypical parameter. The independent variables were the standard scores on the SCSIT. Because some of these SCSIT variables were not normally distributed in this sample, data transformations were used to achieve normality for these variables. Specifically, a logarithmic transformation was used for Design Copying and Bilateral Motor Coordination; a square-root transformation was used for Double Tactile Stimuli, Standing Balance with Eyes Closed, and Postrotary Nystagmus; and the square of Crossing Midline of the Body was used to normalize these variables.

Because several subjects had missing data on the Position in Space subtest of the SCSIT (thereby potentially eliminating them from a discriminant-analysis procedure), this variable was removed from the analysis.

Analysis of the final research question employed statistical procedures similar to those used for the first research question. A Spearman rank order correlation was performed on the 6-, 7-, and 8-year-old subjects only. Again, the 5-year-olds were excluded from this analysis due to the high incidence of unscorable items.

Results

The results of the analysis conducted to answer the first research question regarding relations between SIPT-DC atypical approach parameters and individual SCSIT scores are presented in Table 1. Only the correlations that were statistically significant at the .05 level are listed. All correlations were moderate, ranging from .40 to .61, and negative, except for the correlation of the Right to Left parameter and Figure-Ground Perception. Because a low score on the SCSIT and a high score on the SIPT-DC atypical approach parameters both suggest dysfunction, negative correlations would be expected. The SIPT-DC parameters most frequently correlated with the visual subtests of the SCSIT (i.e., Space Visualization, Figure-Ground Perception, Position in Space, and Design Copying). The SIPT-DC parameters also correlated with other SCSIT subtests that contain visual components, that is, the Motor Accuracy and Manual Form Perception subtests. A relationship was also suggested between these atypical approach parameters and some motor skills, as seen in the correlations between Motor Accuracy and the Additions and Reversals parameters and between Imitation of Postures and the Boundary and Inversion parameters. Both Motor Accuracy and Imitation of Postures are SCSIT subtests that rely heavily on motor performance. Additionally, the correlations between Standing Balance: Eyes Open and the Reversals and Right to Left parameters suggest a possible relationship between these parameters and postural mechanisms.
Table 1
Relations Between the SCSIT and SIPT–DC Atypical Approach Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SCSIT Variable</th>
<th>n</th>
<th>r</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boundary</td>
<td>Space Visualization</td>
<td>24</td>
<td>-.41</td>
<td>.046</td>
</tr>
<tr>
<td></td>
<td>Position in Space</td>
<td>18</td>
<td>-.50</td>
<td>.036</td>
</tr>
<tr>
<td></td>
<td>Imitation of Postures</td>
<td>24</td>
<td>-.53</td>
<td>.007</td>
</tr>
<tr>
<td>Additions</td>
<td>Space Visualization</td>
<td>24</td>
<td>-.49</td>
<td>.014</td>
</tr>
<tr>
<td></td>
<td>Design Copying</td>
<td>24</td>
<td>-.62</td>
<td>.001</td>
</tr>
<tr>
<td>Segmentation</td>
<td>Space Visualization</td>
<td>24</td>
<td>-.46</td>
<td>.024</td>
</tr>
<tr>
<td></td>
<td>Figure–Ground Perception</td>
<td>24</td>
<td>-.50</td>
<td>.013</td>
</tr>
<tr>
<td>Reversals</td>
<td>Space Visualization</td>
<td>24</td>
<td>-.50</td>
<td>.012</td>
</tr>
<tr>
<td></td>
<td>Standing Balance: Eyes Open</td>
<td>24</td>
<td>-.57</td>
<td>.003</td>
</tr>
<tr>
<td></td>
<td>Motor Accuracy (Left)</td>
<td>24</td>
<td>-.40</td>
<td>.050</td>
</tr>
<tr>
<td>Inversion</td>
<td>Figure–Ground Perception</td>
<td>23</td>
<td>-.43</td>
<td>.040</td>
</tr>
<tr>
<td></td>
<td>Design Copying</td>
<td>24</td>
<td>-.48</td>
<td>.018</td>
</tr>
<tr>
<td></td>
<td>Manual Form Perception</td>
<td>24</td>
<td>-.43</td>
<td>.018</td>
</tr>
<tr>
<td>Right to Left</td>
<td>Imitation of Postures</td>
<td>24</td>
<td>-.45</td>
<td>.053</td>
</tr>
<tr>
<td>Jogs</td>
<td>Position in Space</td>
<td>18</td>
<td>-.57</td>
<td>.015</td>
</tr>
</tbody>
</table>


The results of the analysis conducted to answer the second research question regarding the relations between SCSIT variables and the presence of atypical approach parameters are presented in Table 2. The atypical approach parameters of Boundary, Additions, Segmentation, Reversals, and Inversion were best predicted by linear combinations of tests that address the visual, motor, and tactile areas as well as postural mechanisms. No SCSIT variables entered as significant predictors of the atypical approach parameters of Right to Left and Jogs.

The results that answer the final research question addressing the relations between SIPT–DC atypical approach parameters are presented in Table 3. Each parameter showed significant correlations with at least one other parameter. All significant correlations were in the moderate range (.41 to .63) and were positive except for the correlation between the Right to Left and Segmentation parameters. The correlations were not high enough to suggest that any two parameters were essentially measuring the same trait.

Discussion

The results of this study are summarized in Table 4. Only those associations significant at the .05 level are presented. Because of study limitations, relational trends rather than individual test associations will be discussed.

Generally, the visual subtests of the SCSIT most frequently showed significant relationships with SIPT–DC parameters. All parameters (except Right to Left) correlated significantly with the SCSIT visual subtests. The occurrence of three of the SIPT–DC atypical approach parameters (Additions, Segmentation,
Table 3
Correlations Between SIPT-DC Atypical Approach Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Boundary</th>
<th>Additions</th>
<th>Segmentation</th>
<th>Reversals</th>
<th>Inversion</th>
<th>Right to Left</th>
<th>Jogs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boundary</td>
<td>1.00</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Additions</td>
<td>0.43*</td>
<td>1.00</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Segmentation</td>
<td>0.61*</td>
<td>0.65*</td>
<td>1.00</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Reversals</td>
<td>0.37</td>
<td>0.52*</td>
<td>0.19</td>
<td>1.00</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Inversion</td>
<td>0.26</td>
<td>0.55*</td>
<td>0.28</td>
<td>0.11</td>
<td>1.00</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Right to Left</td>
<td>-0.23</td>
<td>-0.35</td>
<td>-0.45*</td>
<td>0.21</td>
<td>-0.37</td>
<td>1.00</td>
<td>—</td>
</tr>
<tr>
<td>Jogs</td>
<td>0.55*</td>
<td>0.19</td>
<td>0.39</td>
<td>0.15</td>
<td>0.07</td>
<td>0.05</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Note. SIPT-DC = Sensory Integration and Praxis Tests (Ayres, 1989).
* p < .05.

...tion, and Inversion) being best predicted by visual subtests of the SCSIT suggests that the SIPT-DC parameters may reflect aspects of visual space management. Space management refers to "the ability to conceptualize, organize, and execute hand movements (i.e., drawing) in interacting with extracorporal space" (Ayres, personal communication, April 1987). Space management appears to be reflected in the ability to relate parts to the whole and in the ability to reproduce designs with the correct directionality of movement and organization of the design.

The Boundary, Additions, Segmentation, and Inversion parameters were correlated with or predicted by tactile tests of the SCSIT. Additionally, all of these parameters, along with Reversals, either correlated with or were predicted by those subtests of the SCSIT that contained motor components.

The Segmentation parameter may also reflect...
deficits in vestibular and bilateral integration. Standing Balance: Eyes Open and Bilateral Motor Coordination were present in the linear combination, which best predicted this parameter. The Reversals parameter correlated with and was predicted by Standing Balance: Eyes Open, a test that aids in identifying deficits in vestibular processing (Ayres, 1976).

Interpretation of these data should be considered cautiously for several reasons. Most notably, the power of the present study to detect truly significant relations was reduced by the small sample size. The discriminant analysis procedures may have yielded spurious solutions due to the large number of independent variables assessed relative to the number of subjects used. Additionally, the small sample size made it difficult to sufficiently assess the influence of age, sex, or handedness on the measures under study. Because of the present study’s exploratory nature, therefore, the results were interpreted in terms of trends rather than of the significance of individual tests.

The results of this study may have practical implications for professionals who perform research or who treat children with sensory integrative dysfunction. These children sometimes display difficulties with such functional skills as writing, cutting with scissors, and other fine motor tasks (Ayres, 1979). The outcome of this study suggests relations between specific components of eye–hand coordination and sensory integrative performance. Despite the small sample size, the information obtained may provide further insight into possible interpretations of the atypical approach parameter scores of the SIPT–DC. Additionally, the findings lend support to the value of similar studies with larger samples with use of the tests of the SIPT rather than the SCSIT. These results demonstrate the complexity of sensory integrative functions, which future research may help to elucidate. ▲

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References


