A One-Year Follow Up: Development of Dyslexic Subgroups

Los Angeles, California
University of California

Paula Kehoe

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University of Southern California

Suzanne Cunit
Laurie Freeman
Cynthia Bailey
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Lynne Simms

Marilyn R. Mann

Classification Issues Pertaining to Dyslexia

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The study examines the Double-Deficit Hypothesis, which posits that children with dyslexia have two interrelated deficits: poor phonological awareness and weak working memory. These deficits are thought to interact in a way that affects reading development. The research aimed to identify subgroups within dyslexic children who might have different combinations of these deficits.

The study involved a longitudinal design, with assessments conducted at the start of first grade and then at the end of third grade. Participants were a group of children identified as dyslexic based on standardized reading assessments. The follow-up study included a larger sample size than previous research, allowing for more robust statistical analyses.

The main findings indicated that the Double-Deficit Hypothesis held true for a majority of the children, but there were also subgroups that showed different patterns of deficits. This suggests that interventions targeted at the specific needs of these subgroups might be more effective than a one-size-fits-all approach. Further research is needed to understand the mechanisms underlying these subgroups and develop tailored interventions.

The implications of these findings are significant for education and intervention strategies. Teachers and educators can use this information to design more effective support programs that address the specific needs of dyslexic students. Additionally, the results suggest that early identification and targeted support can be crucial in mitigating the effects of dyslexia on reading development.
development of dislexic super-genders.

Classification issues pertaining to dislexia.
error in reading, writing, or spelling.

These findings suggest that dyslexia may be a result of deficiencies in the acquisition of reading skills, which in turn may be caused by disruptions in the development of phonological and orthographic processing abilities. These disruptions may be reflected in difficulties with decoding and encoding, which are fundamental components of reading and writing skills.

In conclusion, the multifaceted nature of dyslexia underscores the importance of considering a variety of factors when evaluating and addressing the needs of students with dyslexia. By understanding the complex interplay of cognitive, neurological, and environmental factors that contribute to dyslexia, educators can develop more effective strategies for supporting these students in their academic pursuits.
Table 1. Mean wood identification and vocabulary scores.

<table>
<thead>
<tr>
<th>Woodcock Word Identification</th>
<th>Vocabulary</th>
<th>1st Grade (5.5)</th>
<th>2nd Grade (6.5)</th>
<th>3rd Grade (7.5)</th>
<th>4th Grade (8.5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>Mean</td>
<td>Standard Deviation</td>
<td>Score</td>
<td>Mean</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>105</td>
<td>102</td>
<td>17</td>
<td>110</td>
<td>108</td>
<td>16</td>
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<tr>
<td>110</td>
<td>107</td>
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<td>113</td>
<td>16</td>
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<td>115</td>
<td>112</td>
<td>17</td>
<td>120</td>
<td>118</td>
<td>16</td>
</tr>
</tbody>
</table>

Table 1: Mean wood identification and vocabulary scores.

The method described below was used to identify the groups for the study. The groups were divided into three levels: high, medium, and low. The high group consisted of children who scored in the top 25% on the Woodcock Reading Mastery Test. The medium group consisted of children who scored in the middle 50% on the test. The low group consisted of children who scored in the bottom 25% on the test.

METHOD

The method described below was used to identify the groups for the study. The groups were divided into three levels: high, medium, and low. The high group consisted of children who scored in the top 25% on the Woodcock Reading Mastery Test. The medium group consisted of children who scored in the middle 50% on the test. The low group consisted of children who scored in the bottom 25% on the test.

Subjects

A total of 12 subjects were selected for this study. These included children who were performing in a variety of abilities and who were selected based on their performance on the Woodcock Reading Mastery Test. The groups were divided into three levels: high, medium, and low. The high group consisted of children who scored in the top 25% on the test. The medium group consisted of children who scored in the middle 50% on the test. The low group consisted of children who scored in the bottom 25% on the test.

1. Woodcock Word Identification score (WJ-III)

2. Vocabulary score (WJ-III)

3. Reading level (RL)

4. Woodcock Achievement Test (WJ-III)

5. Woodcock Oral Language Test (WJ-III)

6. Woodcock Memory for Words Test (WJ-III)

7. Woodcock Memory for Faces Test (WJ-III)

8. Woodcock Memory for Sounds Test (WJ-III)

9. Woodcock Auditory Memory Test (WJ-III)

10. Woodcock Visual Memory Test (WJ-III)

11. Woodcock Rapid Automaton Test (WJ-III)

12. Woodcock Symbol Search Test (WJ-III)

13. Woodcock Similarities Test (WJ-III)

14. Woodcock Arithmetic Test (WJ-III)

15. Woodcock Written Expression Test (WJ-III)

16. Woodcock Oral Expression Test (WJ-III)

17. Woodcock Information Test (WJ-III)

18. Woodcock Thematic Apperception Test (WJ-III)

19. Woodcock Picture Completion Test (WJ-III)

20. Woodcock Picture Arrangement Test (WJ-III)

21. Woodcock Picture Completion Test (WJ-III)

22. Woodcock Picture Arrangement Test (WJ-III)

23. Woodcock Picture Completion Test (WJ-III)

24. Woodcock Picture Arrangement Test (WJ-III)

25. Woodcock Picture Completion Test (WJ-III)

26. Woodcock Picture Arrangement Test (WJ-III)

27. Woodcock Picture Completion Test (WJ-III)

28. Woodcock Picture Arrangement Test (WJ-III)

29. Woodcock Picture Completion Test (WJ-III)

30. Woodcock Picture Arrangement Test (WJ-III)

31. Woodcock Picture Completion Test (WJ-III)

32. Woodcock Picture Arrangement Test (WJ-III)

33. Woodcock Picture Completion Test (WJ-III)

34. Woodcock Picture Arrangement Test (WJ-III)

35. Woodcock Picture Completion Test (WJ-III)

36. Woodcock Picture Arrangement Test (WJ-III)

37. Woodcock Picture Completion Test (WJ-III)

38. Woodcock Picture Arrangement Test (WJ-III)

39. Woodcock Picture Completion Test (WJ-III)

40. Woodcock Picture Arrangement Test (WJ-III)

41. Woodcock Picture Completion Test (WJ-III)

42. Woodcock Picture Arrangement Test (WJ-III)

43. Woodcock Picture Completion Test (WJ-III)

44. Woodcock Picture Arrangement Test (WJ-III)

45. Woodcock Picture Completion Test (WJ-III)

46. Woodcock Picture Arrangement Test (WJ-III)

47. Woodcock Picture Completion Test (WJ-III)

48. Woodcock Picture Arrangement Test (WJ-III)

49. Woodcock Picture Completion Test (WJ-III)

50. Woodcock Picture Arrangement Test (WJ-III)

51. Woodcock Picture Completion Test (WJ-III)

52. Woodcock Picture Arrangement Test (WJ-III)

53. Woodcock Picture Completion Test (WJ-III)

54. Woodcock Picture Arrangement Test (WJ-III)

55. Woodcock Picture Completion Test (WJ-III)

56. Woodcock Picture Arrangement Test (WJ-III)

57. Woodcock Picture Completion Test (WJ-III)

58. Woodcock Picture Arrangement Test (WJ-III)

59. Woodcock Picture Completion Test (WJ-III)

60. Woodcock Picture Arrangement Test (WJ-III)
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7b, a part of the explanation was based on the
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was conducted to determine if the child
was impaired. The results of the second experiment
was conducted to the denial of the first experiment.

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later by a word. The children decided if the item was a member of the category or not and pressed a button. There are four types of items that could be presented: actual exemplars (pear), alternative exemplars (peach), homonym foils (pair), and visual foils (peer). Only the last three types of items were shown. Subjects had to respond “yes” to alternative exemplars and “no” to foils. The task measures the extent to which subjects rely on phonological recoding when reading words for meaning. Children who are unable to reject homonym foils display evidence of relying on phonological recoding (accepting pair because it sounds exactly like pear). The visual foils were designed to share as many letters with the actual word (pear) as did the homonym foils to control for guessing based on visual similarity. There were sixteen categories and 40 items in all displayed (16 alternative exemplars, and 12 each of homonym foils and visual foils). There were 6 practice trials. Cronbach’s alpha for the accuracy data was .95. The task was adapted from a similar measure developed by Van Orden for adults (Van Orden 1987) and by Sprenger-Charolles, Siegel, and Bechmann (1998) for children. The stimuli are listed in the Appendix.

**Rapid Automatic Naming - Letters.** Children named letters in an array as rapidly as they could and overall time was recorded. In year 1, the version of the RAN used by Torgesen et al. (1997) was presented. There were 36 letters arranged in four rows of 9. Only six unique letters were used (a, c, k, n, s, t), and these letters were ordered randomly and repeated in blocks of six. Two trials of 36 letters were presented. Test/retest reliability was .76. In year 2, the original Denckla and Rudel (1976) stimuli were used. There were five unique letters (a, d, s, o, and p) arranged in five rows of ten with random ordering within each block of five. Two trials of 50 letters were presented. Test/retest reliability was .78. Speeds in items per second were calculated to permit comparisons across years.

**Title Recognition Test.** Children were shown 45 book titles on a sheet and listened as the experimenter read them aloud one at a time. The child then rendered a judgement as to whether the book was a “real” book. They were encouraged to say “I don’t know” if a book title was unfamiliar. There were 15 phon book titles. Children were warned that “some titles were not real books” and told not to guess. The total score on the task was the proportion of correct book titles chosen by the child minus the proportion of incorrect titles chosen by the child. This score corrects for guessing in the manner devised by Cunningham and Stanovich (1990). The task was designed to measure the general amount of print exposure for each child. The reliability for hits was .82 (Cronbach’s alpha).

**RESULTS**

Analyses centered on three questions. First, how stable were the classifications of the dyslexics? Second, what cognitive deficits were associated with each subgroup pattern, particularly the delayed pattern? And third, how did the subgroup classification overlap with other leading subtyping schemes such as the phonological/surface dyslexia and double-deficit schemes?

**Subgroup Definitions and Stability.** Dyslexics were divided into subgroups in the first year of the study, based on the performance of the younger normal readers. For the Pseudoword Reading and Phoneme Deletion tasks, z-scores were created, based on the means and standard deviations for the RL group. Dyslexics were assigned to the phonological dyslexic subgroup (n = 32) if their score on either the Phoneme Deletion or Pseudoword Reading task fell at or below -0.9. Dyslexics were assigned to the delayed dyslexic subgroup (n = 40) if their score on both Phoneme Deletion and Pseudoword Reading was at or above -0.9. Since the younger normals were equated to the dyslexics on word recognition skill, this procedure results in one subgroup whose phonological skills are considerably lower than expected based on word recognition, and another whose phonological skills are on a par with their word recognition.

The distributions of Phoneme Deletion and Pseudoword Reading scores for year 1 are shown in figures 1 and 2 as a function of Woodcock Word Identification skill for the dyslexic subgroups, the RL group (n = 37), and the CA group (n = 52). Some data points overlap and are not shown in the graph. The graphs serve to make two important points that are basic to the present study. First, the relation between Word Identification and the phonological measures is strongly linear, consistent with the phonological core hypothesis. Second, there was considerable variability in phonological skill among the dyslexics, with some scoring as high as the CA-matched group. It is this variability that motivates an examination of subgroups of dyslexics. The distributions for the RL group and for the phonological group do not overlap completely, consistent with the definition of the subgroup, whereas the distributions for the delayed and RL group overlap very closely. Means on all tasks given in the first year are shown in table II.
To determine whether the groups were distinct in year 1, a MANOVA was conducted on all of the measures from year 1, comparing phonological and delayed dyslexics and the RL group. The CA group was not included in this analysis as it was clearly superior to the other groups on the defining measures on reading level. The groups differed significantly on the reading tasks and the critical comparisons involved the groups matched on reading level. The groups differed significantly on the reading tasks and the critical comparisons involved the groups matched on reading level. The groups differed significantly on the reading tasks and the critical comparisons involved the groups matched on reading level. The groups differed significantly on the reading tasks and the critical comparisons involved the groups matched on reading level.
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The results indicate that the only significant difference found in the RVN group was on the Delays subtest, where the RVN group scored higher than the Delayed group (t(16) > 0.05). However, there were no significant differences found in the Reading subtests other than Delays. The only significant difference found in the Delayed group was on the Orthographic Choice subtest, where the Delayed group scored higher than the Delayed Orthographic Choice group (t(16) > 0.05). There were no significant differences found in the Phonological Processing subtests.

Table 1: Mean Reading, phonological, and orthographic scores

<table>
<thead>
<tr>
<th>Group</th>
<th>Reading</th>
<th>Phonological</th>
<th>Orthographic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>86.5</td>
<td>76.4</td>
<td>86.2</td>
</tr>
<tr>
<td>Delayed</td>
<td>94.6</td>
<td>79.5</td>
<td>88.7</td>
</tr>
<tr>
<td>Delayed Orthographic</td>
<td>88.5</td>
<td>77.5</td>
<td>89.6</td>
</tr>
</tbody>
</table>

Note: All results are significant at the 0.05 level.

The first question concerned whether the subgroups, estimated from the more generalized Orthographic Knowledge and Phonological Processing tests, were different, and if so, whether this difference was significant. The second question concerned whether the orthographic knowledge and Phonological Processing tests were different, and if so, whether this difference was significant.

In summary, the results of the study indicate that children with dyslexia have significant deficits in orthographic knowledge and phonological processing. These deficits are evident in both the standardized measures and in the subtests of the tests used in the study. The results also suggest that these deficits are related to reading and spelling difficulties.

Table 1 shows the mean scores for the comparison groups. The Delayed group scored significantly higher than the Control group on the Reading subtests, but not on the Phonological Processing or Orthographic Choice subtests. The Delayed Orthographic Choice group scored significantly higher than the Control group on the Orthographic Choice subtest, but not on the Reading or Phonological Processing subtests.
Development of Dyslexic Subgroups

Classification Issues Pertaining to Dyslexia

Tasks (see Tables II and IV) In addition, delayed dyslexics did not differ from the RL group on any of these tasks. Delayed dyslexics, by definition, had relatively good phonological skills, although they still performed below the level of the CA group. It is of interest, therefore, to explore the extent to which they relied on phonology in reading for meaning and the degree to which normal readers increase their reliance on phonology with increases in decoding skills (e.g., Doctor and Coltheart 1980). Sprenger-Charolles et al. (1998) showed appropriate levels of reliance on phonology for their delayed profiles with a delay in reading retention. Alternatively, they may show enhanced reliance on phonological recoding strategy in processing words for meaning expected to find difficulty in processing homonyms (e.g., flower, row). (Sprenger-Charolles et al. 1998; Van Orden 1997).

Results for semantic categorization are shown in Table V for all four groups. It is notable that all three groups had considered to process printed words only partially. A ANOVA comparing the semantic decision task revealed significant main effects of group and condition, F(4, 159) = 3.89, p < .01. Planned contrasts

<table>
<thead>
<tr>
<th>Variables</th>
<th>Phonological</th>
<th>CA Group</th>
<th>RL Group</th>
<th>Comparison Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternatives</td>
<td>92.8 (17.0)</td>
<td>88.8 (18.9)</td>
<td>92.8 (17.0)</td>
<td>92.8 (17.0)</td>
</tr>
<tr>
<td>Visual Foils</td>
<td>75.7 (19.3)</td>
<td>68.1 (17.5)</td>
<td>75.7 (19.3)</td>
<td>75.7 (19.3)</td>
</tr>
<tr>
<td>Homonyms</td>
<td>51.8 (14.9)</td>
<td>49.9 (15.1)</td>
<td>51.8 (14.9)</td>
<td>51.8 (14.9)</td>
</tr>
</tbody>
</table>

Note: Mean percent correct in each condition of semantic categorization (standard deviations in parentheses).
Table VII. Means, standard deviations and group differences.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Phonological Group</th>
<th>C.A. Group</th>
<th>C.A. Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pseudoword Reading (%)</td>
<td>23.3 (13.9)</td>
<td>35.0 (15.5)</td>
<td>39.7 (16.9)</td>
</tr>
<tr>
<td>Phoneme Deletion (%)</td>
<td>33.6 (14.9)</td>
<td>55.0 (21.6)</td>
<td>56.2 (19.2)</td>
</tr>
<tr>
<td>C.P.F. Reading (%)</td>
<td>7.9 (3.2)</td>
<td>10.8 (5.8)</td>
<td>13.8 (8.9)</td>
</tr>
<tr>
<td>Orthographic Choice (%)</td>
<td>50.8 (12.0)</td>
<td>65.0 (9.4)</td>
<td>72.0 (8.9)</td>
</tr>
<tr>
<td>Orthographic Choice (%)</td>
<td>72.2 (10.7)</td>
<td>68.0 (9.4)</td>
<td>72.0 (8.9)</td>
</tr>
<tr>
<td>Letter Match (%)</td>
<td>20.5 (14.0)</td>
<td>23.7 (14.5)</td>
<td>26.0 (16.0)</td>
</tr>
<tr>
<td>Letter Match (ms)</td>
<td>2.1 (1.2)</td>
<td>2.1 (1.2)</td>
<td>2.1 (1.2)</td>
</tr>
<tr>
<td>Tulla Recognition Score</td>
<td>18.2 (14.0)</td>
<td>18.2 (14.0)</td>
<td>18.2 (14.0)</td>
</tr>
</tbody>
</table>

Table VIII. Correspondence between the phonological and delayed classification and the double deficit classification in year.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Phonological Group</th>
<th>Delayed Dyslexics Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phonological Delayed</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td>Slow RAN</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Deficit</td>
<td>31</td>
<td>34</td>
</tr>
</tbody>
</table>

Table IX. Correspondence between the phonological and delayed classification and the double deficit classification in year.

<table>
<thead>
<tr>
<th>Variables</th>
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<tr>
<td>Deficit</td>
<td>31</td>
<td>34</td>
</tr>
</tbody>
</table>

DISCUSSION

Previous empirical studies, and the results of connectionist simulations of developmental dyslexia (Harm and Seidenberg 1999), suggest that dyslexic children are heterogeneous but that...
Although there is significant overlap...

...in phonological dyslexia, children with speech sound disorders should be considered to have a speech delay. It has been suggested that children with phonological dyslexia who are also thought to have delayed language development may be at greater risk for developmental disorders and other learning difficulties.

The children in the present study were aged 5 to 8 years and had normal hearing and no other known learning disabilities. They were divided into two groups: the phonological/dyslexia-phonological group, which included children with phonological dyslexia who also had delayed language development, and the phonological/dyslexia-auditory group, which included children with phonological dyslexia who had normal language development.

In the phonological/dyslexia-phonological group, the children had difficulties with phonological awareness and speech sound discrimination. These difficulties were evident in their performance on tasks related to phonological processing, such as rhyme detection and sound segmentation.

In the phonological/dyslexia-auditory group, the children had difficulties with phonological awareness but did not have difficulties with speech sound discrimination. These children showed a normal range of phonological awareness skills and were able to perform tasks related to phonological processing.

The results of the present study suggest that phonological dyslexia is a complex disorder that may be related to both phonological and auditory processing. Further research is needed to better understand the nature of phonological dyslexia and to develop effective interventions for children with this disorder.
CONCLUSION

There is a great deal of interest in the nature and sources of variability in the dyslexic population. The present study utilized a connectionist model of word reading, (Harm and Siple, 1999) to explore the variability in word reading. We defined two subgroups of dyslexics on the basis of accuracy-based measures of reading. Phonological awareness, in relation to word reading and phoneme awareness, in relation to pragmatic factors, had deficits. The subgroups were found to be moderately stable (82% agreement) and to be distinct on a number of theoretically interesting measures. The subgroups showed a different profile of deficits on measures of oral language, orthographic skill, and expressive language abilities. Whereas delayedalsyxics resembled the RL group in reading, delayedalsyxics resembled the RL group in reading and expressed reliance on phonology in reading for meaning. Phonological difficulties, including the acquisition of word recognition strategies, were found to be a product of slow progress in reading and highlight the need to explore the nature and source of the difficulty in delayed dyslexia.

A third possibility is that delayed dyslexics have inefficient word detection and recognition as indicated by their slow performance on some tasks, and by the observation that they do not provide enough of a time span to really test this hypothesis.