# Naming speed and phonological awareness as predictors of reading development[1]

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This paper investigates how well individual differences in kindergarten in phonological awareness and naming speed account for subsequent reading development. We report two series of analyses from the one data set. In the first, we use regression analyses to predict subsequent reading development, with various other factors controlled. In the second series, we follow the reading development of four groups of children selected to have the various combinations of adequate or inadequate phonological awareness and naming speed in kindergarten.

Considerable evidence has accumulated that phonological awareness is a key component in the development of reading ability, and that poor phonological awareness is a, or perhaps the, core deficit in reading disability (Adams, 1990; Goswami & Bryant, 1990; Share & Stanovich, 1995; Wagner, Torgesen, Laughon, Simmons & Rashotte, 1993). A separate body of evidence is accumulating in favor of the importance of naming speed in reading development, and for its causal role in reading disability (e.g., Wimmer, Mayringer & Landerl, 2000; Wolf & Bowers, 1999). Studies of phonological awareness and naming speed as predictors of reading development have value in helping to understand the nature of the cognitive processes underlying reading, but also have more applied value. Early identification of children who are at risk to develop reading difficulties requires reliable and valid assessments that can be administered without the requirement of unaffordable resources, and early intervention programs need to target the key processes, perhaps with some tailoring of programs to the individual child's pattern of potential difficulties.

A number of studies have investigated the roles of phonological awareness and naming speed in reading development, but the evidence is somewhat inconsistent, there are gaps in the evidence, and several issues remain. Many studies have found phonological awareness and naming speed to have significant unique effects upon current or later reading (e.g., Badian, 1994, 1997, 1998; Kirby & Parrila, 1999; Manis, Doi & Bhadha, 2000; Scarborough, 1998; Torgesen, Wagner, Rashotte, Burgess & Hecht, 1997), but in some cases one or the other effect disappears when prior achievement (an autoregressor) is included as a predictor (e.g., Torgesen et al., 1997). The studies vary greatly in terms of when the predictors and outcomes are measured, what and how many predictors are used, what other predictors are in the equation, and whether autoregressors are included. Some of the unresolved issues include the independence of phonological awareness and naming speed, whether naming speed should be measured with tasks involving school-learned content (letters and digits), whether phonological awareness and naming speed predict different outcome measures, and whether phonological awareness and naming speed have different predictive roles at different points in reading development.

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We set out to do a study with the following key characteristics:

- measurement of predictors before formal reading instruction had begun
- use of multiple measures of constructs (to lessen the effect of error)
- use of predictors with no school-learned content
- assess reading development beyond the early years of schooling
- examine the effects of controlling other variables

## Method

### Subjects

The subjects were 161 children who began the study in senior kindergarten (first year of compulsory schooling, with no formal reading instruction), and then were retested annually until they were in grade 5. Over the 6 years of the study, attrition reduced the sample to 122, 106, 99, 86, and 79; each year comparisons indicated that the subjects who left the study were not significantly different from those who remained. Each year the subjects received a battery of cognitive, linguistic, reading and spelling measures, only some of which are used here.

### Measures

In kindergarten, the following (all taken from Wagner et al., 1993) were used as measures of phonological awareness: Blending onset and rime, Blending phonemes, Phoneme elision, and Sound isolation. In each case the score was the number of items correct. Two measures of naming speed were developed, based upon tasks described by Wolf, Bally and Morris (1986): Color naming and Picture naming. In each task the child had to name a series of 32 colors or pictures, each taken from a set of 4; practice was provided to ensure that the children were familiar with the standard names of the colors and pictures. The child's score in each task was the number of seconds taken to name the stimuli correctly.

Two tests from the Das-Naglieri Cognitive Assessment System (Das & Naglieri, 1997) were used in kindergarten to measure general mental ability, to be included as covariates. Figure Memory asks subjects to identify a previously-seen simple figure in a more complex figure; the score is the number of embedded figures identified correctly. In Spatial-Verbal Relations children are asked to identify which picture from a set corresponds to an orally presented phrase or sentence (e.g., "The book is under the table"). Letter knowledge was measured by asking the children to identify each of the upper and lower case letters, with two different fonts used for lower case *a* and *g* (Clay, 1993).

Three subtests from the Woodcock (1987) Reading Mastery Tests – Revised were used to assess reading development in kindergarten and grades 1 to 5: Word Attack (k-5), Word Identification (k-5), and Passage Comprehension (1-5). The Gates-MacGinitie Reading Comprehension test (MacGinitie & MacGinitie, 1992) was also given in grade 5.

## Results

### Factor analysis of predictors

The scores on the 6 predictor variables were entered into a principal axis factor analysis. Two factors were extracted, based on theory, eigenvalues > 1.0, and the scree plot, and these were rotated to a direct oblimin criterion; they accounted for 69.1% of the variance. Principal axis analysis was used, as opposed to principal components, to reduce error, and the oblique rotation allowed the

factors to correlate, so that independence could be assessed. The rotated factor loadings (pattern matrix) are presented in Table 1. The first factor was identified as phonological awareness, the second as naming speed; the correlation between the two factors was .47, indicating a moderate degree of relation. These factors were used to construct regression factor scores for each subject (M = 0.0, SD = 1.0). (An orthogonal factor analysis was also performed, yielding similar results.)

Prediction of reading

A series of hierarchical regression analyses was conducted, for each of the dependent variables at each age level. The basic model reported here employed two steps. In the first step, 3 (covariate) kindergarten variables were entered. Figure Memory and Verbal-Spatial Relations represented general mental ability, and Letter Recognition represented both initial "achievement" and to some extent home background. In the second step, the two predictors of interest, the phonological awareness and naming speed factor scores, were entered. The results of these analyses for Word Attack, Word Identification, and Passage Comprehension at each grade level can be seen in Tables 2, 3 and 4. The results reported are standardised regression coefficients

The results for the three reading outcomes are quite consistent. At each age level, the phonological awareness and naming speed factor scores add significantly to the variance. The effect of phonological awareness is greatest in kindergarten and grade 1, declining thereafter. Naming speed, on the other hand, has weaker though significant (except for Word Attack) effects in kindergarten and grade 1, but much stronger effects in the later grades. This pattern suggests that phonological awareness either becomes less relevant in later grades (perhaps due to an increased reliance upon orthographic processing), or that kindergarten phonological awareness is increasingly less valid as an index of later phonological processing.

These analyses were repeated with orthogonal factor scores as predictors (not reported here). The variance accounted for by these factors was of course the same, but the effects of the individual factors were somewhat different. Phonological awareness was still more powerful early and then less so later, and naming speed still demonstrated increasing power with grade level, but the individual coefficients were slightly larger and were more likely to be statistically significant.

A parallel set of analyses was performed without Letter Recognition as a predictor. The factor scores now had greater effects, but the overall variance accounted for was only slightly lower.

The analyses were also repeated with a model in which autoregressors (previous year's score on the dependent variable, or if it had not been given, a related variable) were entered prior to the factor scores. In these analyses (not reported here) the amount of variance added by the factor scores was greatly reduced, but phonological awareness retained its influence in the early grades. Naming speed lost its effects upon Word Attack, but retained effects on Word Identification (in grades k, 1, 3 and 4), Passage Comprehension (k, 4) and Gates-MacGinitie comprehension (5).

These results show that kindergarten phonological awareness and naming speed are able to predict subsequent reading development quite well. Even though the two factors correlate moderately, they make independent contributions to the various reading measures. Kindergarten phonological awareness has most impact in the early grades, whereas naming speed's influence

increases with grade level. The autoregressor analyses suggest that these predictors are also causally related to year-to-year changes in reading skills, though these effects are smaller and less regular.

Identification of Groups

We next used the orthogonal factor scores to define 4 kindergarten groups (see Figure 1). The orthogonal factor scores were used to facilitate the selection process. The goal was to identify groups with low phonological awareness and slow naming speed (Double Difficulty, DD), low phonological awareness and adequate naming speed (Phonological Awareness Difficulty, PAD), adequate phonological awareness but slow naming speed (Naming Speed Difficulty, NSD), and with adequate phonological awareness and naming speed (Normally Achieving, NA). Subjects were selected so that the groups with slow naming speed (DD and NSD) had equivalent levels of naming speed, those with adequate naming speed (PAD and NA) were equivalent in naming speed, those with low phonological awareness (DD and PAD) were equivalent in phonological awareness, and those with adequate phonological awareness (NSD and NA) were equivalent in phonological awareness. We did this to ensure that, for instance, children with slow naming speed did not inadvertently have slightly lower than average phonological awareness.

We then graphed the mean performance of the 4 groups on each of the outcome measures, to observe the course of reading development. Each group began with 24 or 25 members; attrition across the years affected some groups more than others, but again those who left were not significantly different from those who remained.[4] Results are presented in Figures 2 to 4.

The graphs show consistently that the NA subjects did well and the DD poorly. PAD subjects performed poorly at the beginning, but then approached the NA subjects in performance. NSD subjects did poorly throughout, almost as poorly as the DD. In general it can be seen that the DD lag behind the NA by almost two years of achievement, and show no sign of beginning to accelerate to catch up; much the same is true for the NSD.

Finally we investigated the development of reading difficulties in these groups. We set the criterion in grade 3 at a score of 38 on Word Identification (equivalent to 1.3 grades below grade placement), in grade 4 at 51 (1.5 grades below), and in grade 5 at 56 (2 grades behind). Table 5 shows the percentage of subjects remaining in each group who had Word Identification scores less than these criteria. Even though the n's remaining are not high, there is a clear tendency for children in the Double Difficulty group to develop reading difficulties.

These results demonstrate that subsequent reading difficulties are most common in the DD group identified in kindergarten, followed by NSD then PAD.

## Discussion

The results indicate that phonological awareness and naming speed, measured in kindergarten, make independent contributions to the prediction of reading. Phonological awareness is the more powerful predictor in kindergarten and grade 1, whereas naming speed is more powerful in the later

[4] In the Double Difficulty group, n went from 24 to 15, 11, 10, 9, and 7 across years. In the Phonological Difficulty group, n went from 25 to 22, 19, 19, 18, and 17. In Naming Speed Difficulty, it went from 25 to 19, 16, 12, 9 and 8. In the Normally Achieving group n went from 25 to 19, 18, 19, 14 and 14.

grades. Children who have low phonological awareness *and* slow naming speed in kindergarten make slower progress in reading development, and are more likely to suffer from reading difficulties by grade 5.

The diminished effect for phonological awareness was somewhat surprising. There are two apparent interpretations. One interpretation is that the nature of reading has changed by the later grades, shifting from a phonetic to a more orthographic approach, rendering phonological awareness less related to success. The second explanation is that some children improve their phonological awareness skills during and after kindergarten, so that their kindergarten phonological awareness scores become a poorer index of later phonological awareness, which remains related to reading success. Both explanations could be true.

The effects of naming speed were more intriguing. Individual differences in it prior to formal reading instruction were still moderately associated with reading success five years later, in spite of controlling for initial general mental ability and letter knowledge. That these effects remained after kindergarten letter knowledge was accounted for is relevant to the suggestion that children with slow naming speed may lack reading experience. We would expect children's pre-school reading experience to be related to their kindergarten letter knowledge; if so, then our results suggest that there is more to the naming speed effect than exposure to print.

These results are also relevant to the argument that naming speed is required for orthographic skill (Wolf & Bowers, 1999). If kindergarten letter knowledge is a basic level of orthographic skill, controlling for it in the present study can only have lessened the apparent naming speed effects. On the other hand, if later reading development relies upon orthographic skill (e.g., Ehri, 1997), the strength of the naming speed effects in the later grades is consistent with this argument. There appear to remain many questions, however, about how orthographic skill is measured, how it is affected by instruction, and whether pre-instructional predictors of it can be devised. Further research is required.

Children with slow naming speed, and especially those with the both naming speed and phonological difficulties, were more likely to develop subsequent reading difficulties. There would seem to be merit in the use of both phonological awareness and naming speed screening measures, to aid in the early identification of at-risk children. Further work is needed to determine how to instruct these children, especially those with naming speed difficulties (e.g., Wolf, Miller & Donnelly, 2000).

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Table 1. Factor Analysis of Kindergarten Phonological Awareness and Naming Speed variables (pattern matrix) (N = 161)

| Test | Factor | |
|---|---|---|
| | Phonological Awareness | Naming Speed |
| Blending phonemes | .962 | -.101 |
| Blending onset-rime | .901 | -.05 |
| Phoneme elision | .772 | .06 |
| Sound isolation | .627 | .152 |
| Colour naming | .03 | -.898 |
| Picture naming | -.05 | -.746 |

Correlation between factors = .47

Note: Principal axis factors, direct oblimin (oblique) rotation

Table 2. Predicting Word Attack in grades k to 5 from kindergarten phonological awareness (PA) and naming speed (NS) factor scores with the addition of Letter Recognition (LR), Figure Memory (FM), and Verbal-Spatial Relations (VSR) scores.

| | Step 1 | Beta Coefficients | | | Step 2 | Beta Coefficients | |
|---|---|---|---|---|---|---|---|
| Grade | $R^2$ | LR | FM | VSR | $R^2_{chng}$ | PA | NS |
| K | .146 *** | .177 * | .171 * | .154 | .155 *** | .504 *** | -.101 |
| Grade 1 | .205 *** | .324 ** | .137 | .111 | .217 *** | .570 *** | -.140 |
| Grade 2 | .292 *** | .392 *** | .113 | .170 | .102 *** | .344 ** | -.157 |
| Grade 3 | .263 *** | .385 *** | .085 | .166 | .067 * | .153 | -.247 * |
| Grade 4 | .252 *** | .369 ** | .082 | .176 | .092 ** | .256 * | -.241 * |
| Grade 5 | .358 *** | .323 ** | .094 | .349 ** | .055 * | .088 | -.260 * |

Note. *p < .05. **p < .01. ***p < .001.

Table 3. Predicting Word Identification in grades k to 5 from kindergarten phonological awareness (PA) and naming speed (NS) factor scores with the addition of Letter Recognition (LR), Figure Memory (FM), and Verbal-Spatial Relations (VSR) scores.

| | Step 1 | Beta Coefficients | | | Step 2 | Beta Coefficients | |
|---|---|---|---|---|---|---|---|
| Grade | $R^2$ | LR | FM | VSR | $R^2_{chng}$ | PA | NS |
| K | .218 *** | .273 ** | .219 ** | .112 | .203 *** | .540 *** | -.179 * |
| Grade 1 | .309 *** | .432 *** | .169 * | .083 | .255 *** | .591 *** | -.203 ** |
| Grade 2 | .378 *** | .458 *** | .157 | .153 | .101 *** | .302 ** | -.209 * |
| Grade 3 | .354 *** | .400 *** | .127 | .233 * | .092 ** | .152 | -.306 ** |
| Grade 4 | .409 *** | .433 *** | .108 | .269 ** | .097 ** | .113 | -.347 ** |
| Grade 5 | .377 *** | .368 *** | .144 | .290 ** | .079 ** | .141 | -.293 ** |

Note. *p < .05. **p < .01. ***p < .001.

Table 4. Predicting Passage Comprehension in grades 1 to 5 and Gates-McGinitie in grade 5 from kindergarten phonological awareness (PA) and naming speed (NS) factor scores with the addition of Letter Recognition (LR), Figure Memory (FM), and Verbal-Spatial Relations (VSR) scores.

| | Step 1 | Beta Coefficients | | | Step 2 | Beta Coefficients | |
|---|---|---|---|---|---|---|---|
| Grade | $R^2$ | LR | FM | VSR | $R^2_{chng}$ | PA | NS |
| Grade 1 | .302 *** | .436 *** | .155 | .081 | .260 *** | .560 *** | -.261 ** |
| Grade 2 | .390 *** | .488 *** | .158 | .124 | .080 ** | .225 * | -.228 * |
| Grade 3 | .366 *** | .370 *** | .163 | .253 ** | .064 ** | .064 | -.284 ** |
| Grade 4 | .509 *** | .422 *** | .166 | .338 *** | .082 ** | .070 | -.332 *** |
| Grade 5 | .433 *** | .262 ** | .194 * | .409 *** | .089 ** | -.015 | -.366 *** |
| Gates-MacGinitie | .423 *** | .385 *** | .220 * | .295 ** | .068 * | .077 | -.281 ** |

Note. *p < .05. **p < .01. ***p < .001.

Table 5. Percentage of subjects in 4 diagnostic groups demonstrating reading difficulties on Word Identification (see text for criteria) in grades 3, 4, and 5, and number of subjects remaining (in parentheses).

| | Double Difficulty | Phonological Difficulty | Naming Speed Difficulty | Normally Achieving |
|---|---|---|---|---|
| Grade 3 | 50 (10) | 5 (19) | 25 (12) | 5 (19) |
| Grade 4 | 56 (9) | 11 (18) | 22 (9) | 0 (14) |
| Grade 5 | 43 (7) | 6 (17) | 25 (8) | 0 (14) |

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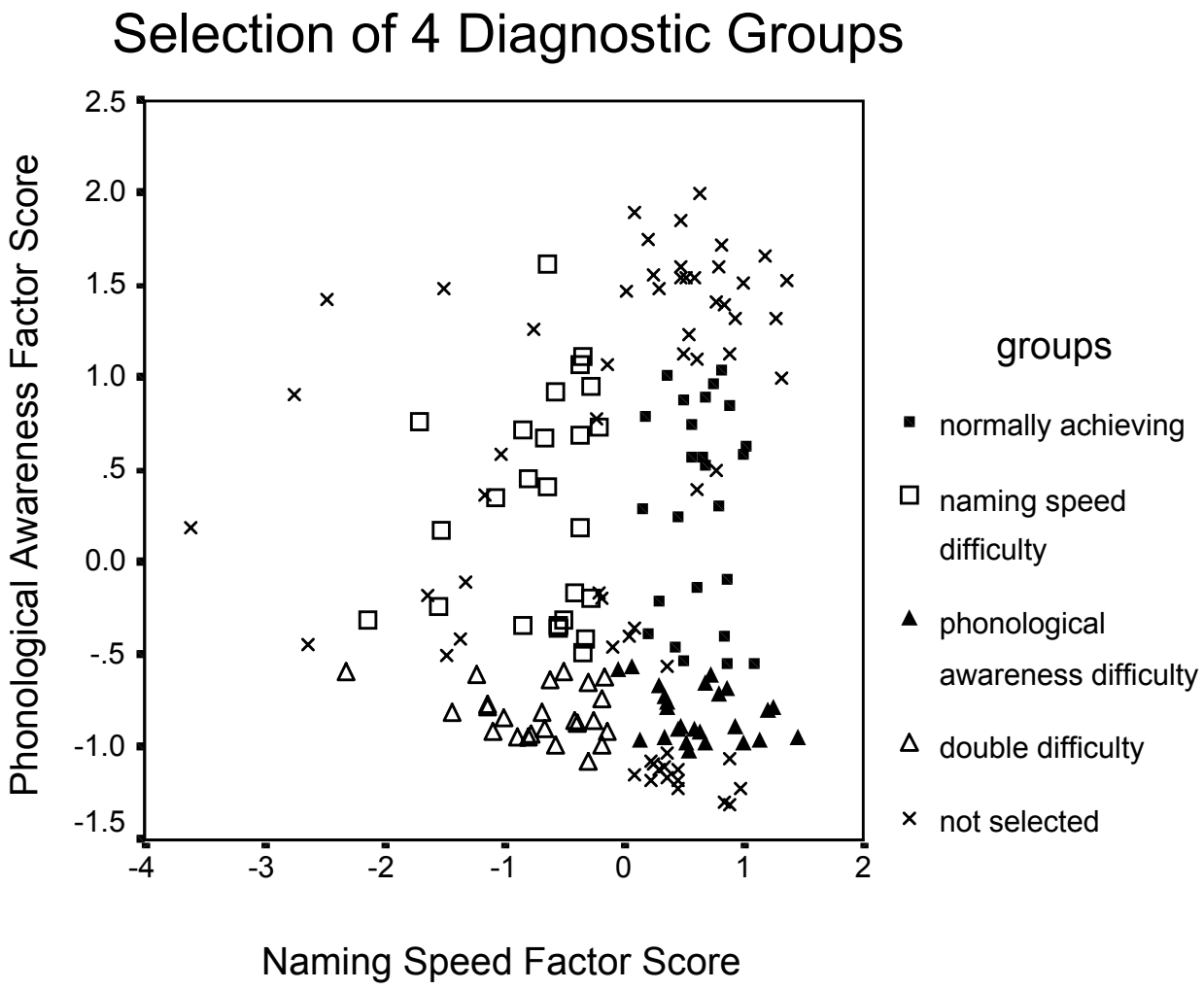



Figure 1. Selection of subjects for 4 diagnostic groups.

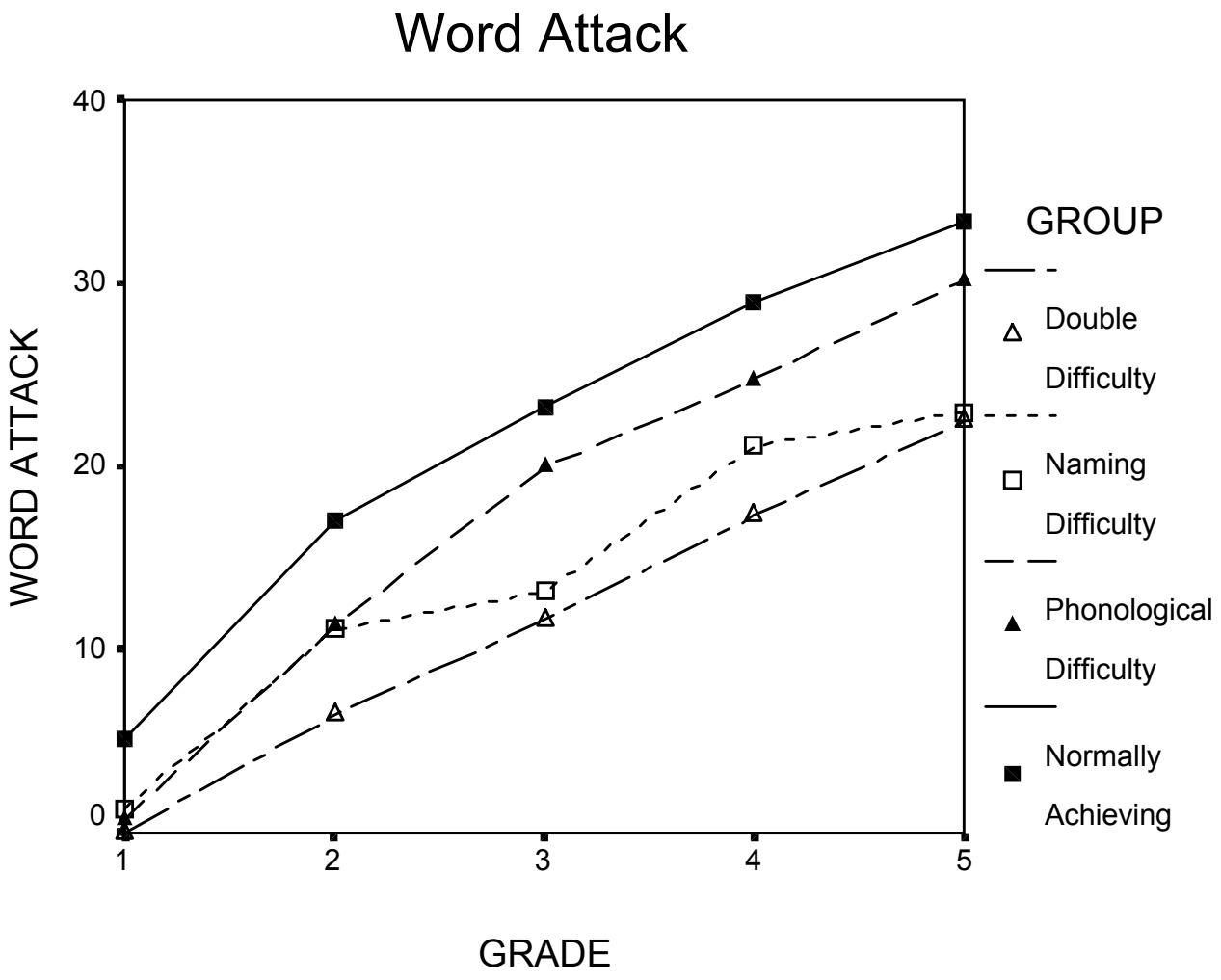
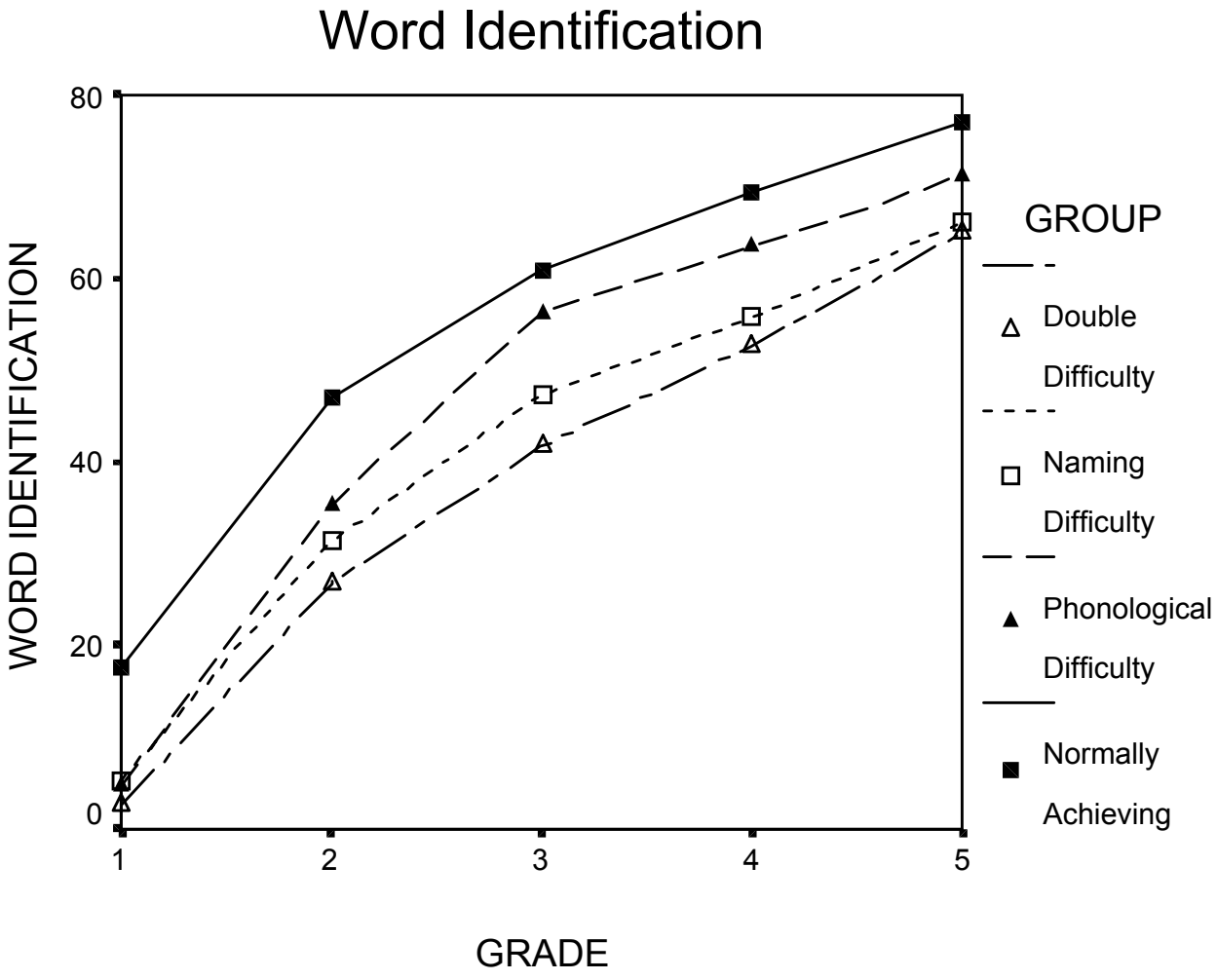



Figure 2. Performance of 4 diagnostic groups on Word Attack across grades (see text for numbers of subjects per group).

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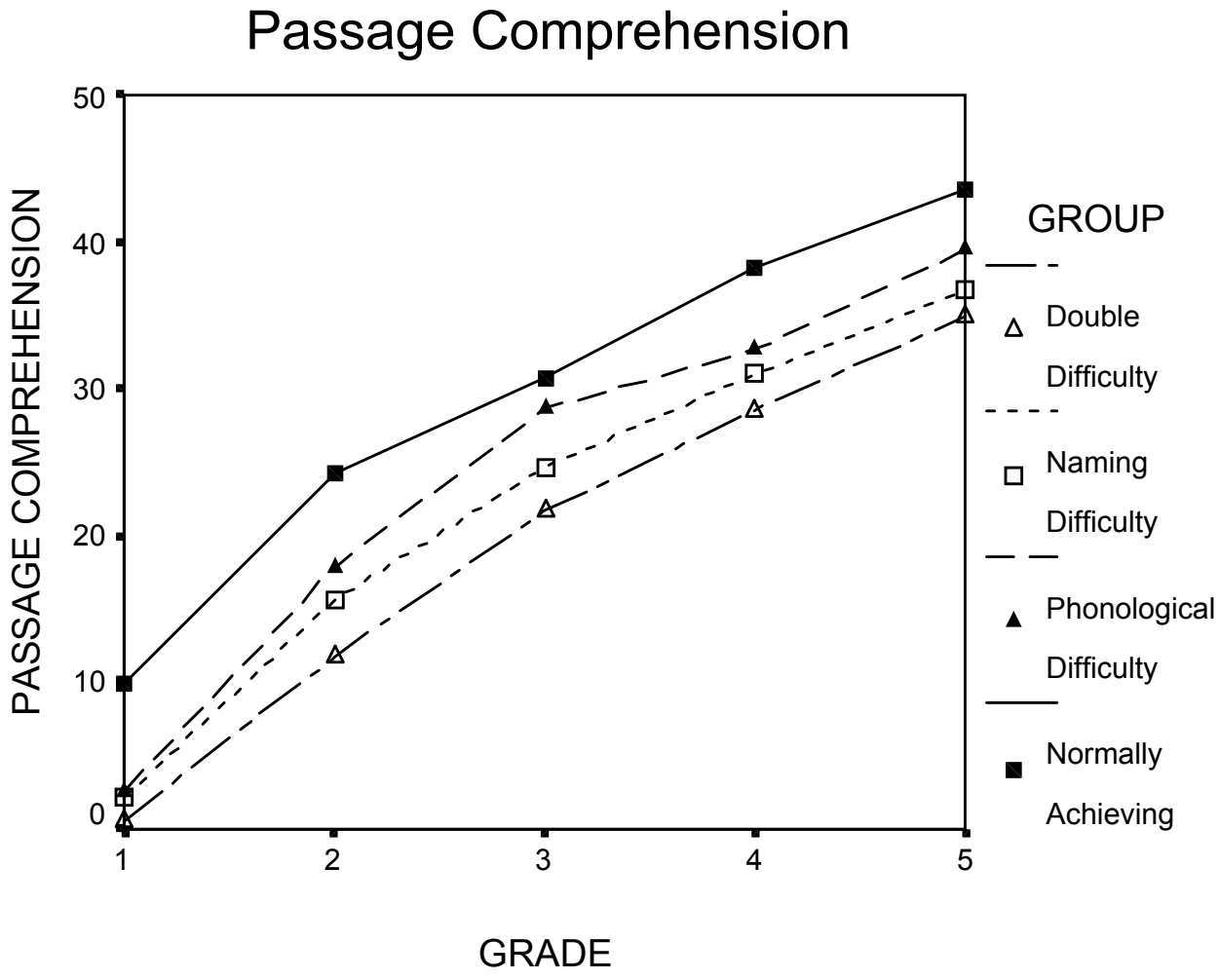


Figure 4. Performance of 4 diagnostic groups on Passage Comprehension across grades (see text for numbers of subjects per group).