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The Fate of Phonemic Awareness Beyond the Elementary School Years

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Metaphonological sensitivity to the component sounds of spoken words has been shown to develop in conjunction with alphabetic literacy. It is generally presumed that skilled readers possess and display a high degree of phonemic awareness. Data are presented that challenge this claim and indicate that many mature readers are unexpectedly inaccurate on phonemic awareness tasks. Alternative hypotheses about the nature and development of phonemic sensitivity in children and adults are considered. Implications for teacher training are also discussed.

The idea that explicit awareness of the segmental structure of spoken syllables and words greatly facilitates learning to read (Liberman, 1973; Liberman, Shankweiler, Fischer, & Carter, 1974) has received extensive support from research during the

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past two decades. Because the developmental relation between phonemic awareness and learning to decode printed words has been the main focus of research, most studies have examined the acquisition of these skills by children during their preschool and primary school years. Although metaphonological weaknesses of older children with reading disabilities and of adults who never learned to read an alphabetic system have also been documented, there has been almost no research on the phonemic awareness skills of nondisabled readers beyond the early school grades. It has been generally presumed that skilled readers not only attain full phonemic sensitivity during their school years but also retain such awareness thereafter. In this article, we present some evidence that challenges that assumption. We also explore several hypotheses about the nature and development of children's and adults' mental representations of speech sounds and the relation of these representations to orthography.

In principle, if a child does not appreciate that spoken words can be broken up into smaller components—not just syllables and subsyllabic units (onsets, rimes) but also phonemic segments—then it would be extremely difficult for the child to grasp the "alphabetic principle" that a correspondence exists between the string of letters that make up a printed word and the sequence of phonemes in the spoken form of that word. It is thus not surprising that how well young children can isolate, segment, and manipulate phonological units in spoken words has consistently been found to correlate well with their early literacy skills, both concurrently and prospectively (e.g., Bradley & Bryant, 1983; Lundberg, Olofsson, & Wall, 1980; Share, Jorm, Maclean, & Matthews, 1984). Moreover, several studies have demonstrated that providing novice readers with training that enhances their sensitivity to speech sounds and the letters that represent these sounds can substantially accelerate their progress in learning to read and spell (for a review, see, e.g., Blachman, 1991). Such findings indicate that metaphonological abilities play a causal role in literacy acquisition.

It is also clear, however, that the relation between phonemic awareness and learning to read involves reciprocal, rather than unidirectional, causation. That is, it appears that, as children begin to learn about the correspondences between graphemes and phonemes, their level of phonemic awareness increases (e.g., Ehri & Wilce, 1980, 1986; Perfetti, Beck, Bell, & Hughes, 1987). Even their perception of speech sounds is modified as a consequence of learning about the printed forms of words that were previously only familiar in spoken form (e.g., Ehri, 1979, 1984, 1993; Ehri & Wilce, 1980, 1986; Treiman, Cassar, & Zukowski, 1994). Further evidence that acquiring alphabetic literacy enhances phonemic awareness comes from demonstrations that adults who never learned to read an alphabetic writing system typically lack much phonemic awareness (e.g., Gombert, 1994; Morais, Cary, Alegria, & Bertelson, 1979; Read, Zhang, Mie, & Ding, 1986; Scholes & Willis, 1990). Research on children with reading disabilities is also consistent with this picture of bidirectional developmental interactions between the acquisition of

alphabetic decoding and the growth of metaphonological abilities during the school years and into adulthood (for a review, see Fowler & Scarborough, 1993).

The development of phonemic awareness in normally achieving readers beyond the early school years has not been closely studied. Although rarely voiced explicitly, there is an assumption that, after beginning readers acquire sensitivity to the segmental structure of spoken words, this skill is retained and continues to be used and refined. Clearly, people who study reading and language are able to attend to, appreciate, and analyze words according to their phonemic characteristics. Also, in several studies comparing control samples to adults with histories of reading disability, the normal adult readers have earned near-perfect average scores on measures of phoneme counting, phoneme deletion, and manipulation of segments to produce pig-latin phrases (e.g., Bruck, 1992; Gombert, 1994; Pennington, Van Orden, Smith, Green, & Haith, 1990).

On the other hand, there are indications in the recent literature that fully literate adults sometimes exhibit unexpectedly low levels of phonemic awareness. Scholes (1993), for instance, informally explored a phenomenon that is familiar to anyone who has taught linguistics—namely, the difficulty that students have in grasping the notion of a phoneme and in learning how to segment speech phonemically in order to transcribe it. When Scholes asked students in his introductory linguistics course how many phonemic segments were present in short English words, he found that almost all students gave accurate counts for two-phoneme words like *it* but that about half considered three-phoneme items like *hat* to have only two phonemes, and a strong majority undercounted four-phoneme words such as *tent*. Similarly, Moats (1994) documented a variety of phoneme-counting and -segmentation errors made by many of the reading teachers enrolled in a workshop that she directed. Lindamood (1994) also described the prevalence of erroneous responses on phonemic awareness tasks by students of speech pathology and other well-educated adults.

To date, the only research that has explored age differences in phonemic awareness throughout the school years was a study to provide standardization data for the Lindamood Auditory Conceptualization (LAC) test—a widely used measure of phonological sensitivity (Calfee, Lindamood, & Lindamood, 1973). LAC tests were administered to 60 children per grade from kindergarten through Grade 6 and to 40 students per grade from Grades 7 through 12—all from a single district. LAC scores of the above-average and below-average readers, defined according to median splits of reading achievement scores, were compared for each grade. On the LAC portion that requires explicit phonemic segmentation, a typical sequence of items would begin with the examiner's presenting a row of three colored blocks and saying, "If that says *ips*, show me *vips*." The child would then be expected to add a new block in the appropriate position. The examiner would then continue, "If that says *vips*, show me *visp*," to which a correct response would be the transposition of the last two blocks in the row.

In presenting their data, Calfee at al. (1973) focused on the marked differences between the better and poorer readers; however, they overlooked another interesting aspect of the results. A monotonic decline in the scores of the above-average readers was evident, beginning in Grade 7 (82% correct) and continuing through the Grade 12 (58%), such that the overall age function was an inverted-U curve. It is quite remarkable that, among the better readers, the mean scores of the 10th to 12th graders (57% to 69% correct) were about the same as those of the 2nd to 4th graders (58% to 67%) in that cross-sectional sample.

Together, the findings of Calfee et al. (1973), Lindamood (1994), Moats (1994), and Scholes (1993) raise several questions about the development of phonological sensitivity beyond the primary grades. When adults with excellent reading abilities do less well than expected on phonemic awareness tests, do they actually have a low degree of phonemic awareness, or do their errors on such tasks arise for other reasons? Is it possible that some individuals achieve a high level of reading skill without ever attaining full phonemic awareness, or might their metaphonological skills develop fully during the early school years but then weaken or become less accessible? Does a reader's growing familiarity with, and reliance on, orthographic regularities produce changes in the way that spoken language is perceived and analyzed?

The three studies reported in this article were grouped to provide further evidence concerning the performance of mature readers on tests of phonemic awareness. Study 1 was carried out before the appearance of the recent reports, already noted here, that have challenged the assumption that full and accurate phonemic awareness is retained by adolescents and adults with good reading abilities (Lindamood, 1994; Moats, 1994; Scholes, 1993). The unexpected results of Study 1 spurred us to question our assumptions, to consider alternative hypotheses about the development of phonemic awareness in older children, and to seek converging evidence from other sources, as just reviewed. In the Study 2, we attempted to replicate Calfee et al.'s (1973) findings by conducting some new analyses of existing data on age differences in phonological sensitivity across the school years. In a new study (Study 3), we undertook to explore more directly the incidence and nature of phonemic awareness errors made by literate adults and the relation of such errors to English orthographic structure.

STUDY 1

Scarborough (1989, 1990, 1991a, 1991b, 1995b) conducted a longitudinal study of the development of language and literacy skills from age 2 to 14 years in a sample that varied widely in reading ability during the primary grades and adolescence. Scarborough found that reading abilities at Grade 2 were predicted by phonological-awareness measures both concurrently (at age 8) and prospectively (from age 5). Consequently, Scarborough reassessed phonemic sensitivity when the sample was followed up at the end of Grade 8 (age 14). It was expected that differences between disabled and nondisabled readers would persist, with the normal achievers exhibiting full mastery of phonemic awareness and the disabled readers continuing to lag behind in metaphonological sensitivity.

Method

Procedure. All follow-up testing was done during the summer between Grades 8 and 9, in a quiet area of the participant's home, in a single session lasting about 2.5 hr. After informed consent was obtained, many tests of achievement, IQ, and language abilities were administered. Performance on the two measures of phonemic awareness was the focus of Study 1.

Measures of phonemic awareness. At Grade 8, a phoneme-deletion task was given early in the session, and a phoneme-counting task was given during the second hour of testing. These tasks were adapted from the work of Bruck (1992), and all stimuli were monosyllabic pseudowords. In both tasks, in order to verify that the items had been heard correctly, the examiner instructed participants to repeat these "fake words" aloud before making their responses.

The phoneme-deletion task was introduced by discussing the idea that spoken words are made up of "little sounds." The examiner explained that she would pronounce some pseudowords. Sometimes she would ask the participant to say what would be left if the first little sound was omitted, and sometimes she would ask that the last sound of the pseudoword be left off. Several examples were then presented and discussed (removing the first little sound from *lem,* the last sound from *vash,* the first sound from *treg*). One practice item with corrective feedback was then given (deletion of the first sound from *dreel*). In the 24 items that followed, there were two blocks requiring the deletion of the initial consonant and two blocks in which final consonant had to be elided. Within blocks, the order of presentation of items of various types (to be discussed) was quasi-randomized.

Although the participants were explicitly instructed to base their responses on sounds rather than on imagined spellings of the pseudowords, eight "catch trials" were included for the purpose of detecting the use of an orthographic letter-deletion strategy (e.g., saying that removing the first sound of *chud* leaves *hud*). The other 16 items were of four types—deletion of initial singleton consonants from /vut/ (*voot*), /lib/ (*leeb*), /sog/ (*soag*), and /rætʃ/ (*ratch*); deletion of final singleton consonants from /drat/ (*drot*), /kwIm/ (*quim*), /tʃʌt/ (*chut*), and /tɛb/ (*teb*); deletion of the initial consonant from /trɛm/ (*trem*), /snʌp/ (*snup*), /braiv/ (*brive*), and /plʌn/

(*plun*), which each begin with a consonant cluster; and removing the last consonant from /lʌsk/ (*lusk*), /klIsp/ (*clisp*), /sænt/ (*sant*), and /rIlb/ (*rilb*), which each end with a cluster. The percentage of correct responses was computed for each type of item (excluding the catch trials).

In the phoneme-counting task, the child was asked to decide how many "little sounds" were contained in each "fake word" spoken by the examiner. Participants were encouraged to use their fingers, or say the sounds aloud, as an aid to counting. Three examples and one practice trial, with stimuli like those used for the phoneme-deletion task, were given, followed by the 45 test items. These included 30 items that are not discussed further here (15 catch trials to detect the use of a letter-counting strategy + 15 items designed to examine how diphthongs would be analyzed). The 15 items of interest for the present analyses occurred randomly within the longer list and included 5 pseudowords with two phonemes, /ɛt/ (*et*), /ab/ (*ob*), /ʌg/ (*ug*), /æp/ (*ap*), /Im/ (*im*); 5 pseudowords with three phonemes, /sɛp/ (*sep*), /dæg/ (*dag*), /nʌd/ (*nud*), /vɛb/ (*veb*), /zɛt/ (*zet*); and 5 pseudowords with four phonemes, /mʌnt/ (*munt*), /bæst/ (*bast*), /flIb/ (*flib*), /gamp/ (*gomp*), /tIsk/ (*tisk*). The percentage of correct responses on each stimulus set was scored.

Participants. Of the 78 children whose development through Grade 2 had previously been studied longitudinally, 64 were reevaluated within 3 months of their completion of Grade 8 (mean age = 14.0 years). Scores on phonemic awareness measures were obtained for 61 of these participants—all had normal IQ (based on five assessments between ages 3 and 14), were from working-class to upper middle class backgrounds (Levels I, II, III, and IV of Hollingshead's five-tiered scale based on parental education and occupation), and were monolingual speakers of English.

On the basis of their scores on the Reading cluster of the Woodcock–Johnson Psychoeducational Battery at the end of the Grade 2, 24 children were designated as *reading disabled* (RD group), and the other 54 were designated as *normally achieving* (NRD group).[1] (See Scarborough, 1989, for details of these assessments.) The 61 adolescents who were the focus of the present analyses included 19 assigned to the RD group and 42 assigned to the NRD group; however, because 1 participant from each group declined the phoneme-counting task, scores are available for only 18 RD and 41 NRD cases on that measure. Reading-achievement differences were quite stable ($r = .72$) over the 6-year interval between the Grade 2 and Grade 8 assessments (Scarborough, 1995b). At age 14, all NRD participants scored at or

[1]The atypically high proportion of disabled readers in the sample derives from the fact that children from families with incidence of dyslexia (i.e., children considered at risk to develop reading disabilities) were deliberately overrepresented when the sample was recruited during their early preschool years (see Scarborough, 1989).

above the Grade 8 level on the Word Identification and/or Word Attack subtests, but few RD participants had acquired grade-appropriate decoding skills.

Results and Discussion

The performance of the RD and NRD groups on the two phonemic awareness measures is summarized in Table 1. What is most striking is not that the RD group did more poorly overall, $t(32) = 2.09$, $p = .045$, but that so many eighth graders with good past and present reading achievement failed to perform at a high level of accuracy on these tasks. The NRD group's scores on the phoneme-deletion task were subjected to a 2 × 2 (Complexity: Singleton vs. Cluster × Position: Initial vs. Final) repeated-measures analysis of variance (ANOVA). Main effects of both complexity, $F(1, 40) = 25.6$, $p < .001$, and position, $F(1, 40) = 8.6$, $p = .005$, were qualified by an interaction of these variables, $F(1, 40) = 19.83$, $p < .001$. That is, performance was more accurate on items that required the deletion of singleton consonants than on items that required the deletion of consonants in clusters (96.1% vs. 76.2%, respectively). Also, for items involving consonant clusters, accuracy was higher for those in the final position than in initial position (87.5% vs. 64.5%, respectively); position did not influence the participants' accuracy at deleting single consonants (94.7% vs. 97.6%, respectively). Similarly, a one-way repeated-measures ANOVA on the NRD group's counting scores revealed a main effect of number of phonemes per item, $F(2, 80) = 37.9$, $p < .001$. Subsequent t tests (with significance levels adjusted by the Bonferroni method) indicated that means for all three types of items differed from one another, all $ts(40) > 3.9$, $p < .003$, with the four-phoneme items responded to least accurately and the two-phoneme items most accurately.

Virtually all errors on the deletion task involved removing portions of the pseudoword stimulus that were larger than a single phoneme—for example, saying that the removal of the last sound from /lʌsk/ leaves /lʌ/ rather than /lʌs/. Almost every error on the counting task reflected a failure to detect all the phonemes in the pseudoword (i.e., undercounting)—for example, saying that /tIsk/ is made up of only three sounds.

As is evident in Table 1, there was considerable variability among the NRD readers, particularly for the three- and four-phoneme counting items and the deletion items with consonant clusters, with scores ranging from 0% to 100% correct. On the 8 items requiring the deletion of a consonant within a cluster, 33% of the NRD readers made no errors, 26% made one error, 15% made two or three errors, 19% made four or five errors, and 7% made six or more errors. Similarly, on the 5 four-phoneme items from the counting task, only 27% of NRD readers made no errors, 12% made one error, 12% made two errors, 15% made three errors, 24% made four errors, and 10% counted none of the items correctly. Furthermore, 7 of the adolescents who made no deletion errors and 4 who made no counting errors apparently did so by relying on a letter-based strategy, according to their

TABLE 1
Percentage of Correct Responses on phonemic Awareness Tasks by 14-Year-Olds Who Had Been Disabled Readers (RD) or Nondisabled Readers (NRD) in Grade 2

		RD Group				NRD Group			
Task	*Item Type*	*M*	*SD*	*Range*	*% No Errors*[a]	*M*	*SD*	*Range*	*% No Errors*
Phoneme deletion	Singleton	95.4	6.2	75 to 100	63.2	96.1	6.0	88 to 100	68.4
	Cluster	57.2	24.8	13 to 100	10.5	76.2	26.5	0 to 100	33.3
Phoneme counting	2 phonemes	88.9	25.9	0 to 100	77.8	95.1	12.5	60 to 100	82.9
	3 phonemes	66.7	38.8	0 to 100	50.0	77.6	33.5	0 to 100	56.1
	4 phonemes	37.8	39.9	0 to 100	11.1	54.6	35.8	0 to 100	26.8
Combined		70.9	19.6	35 to 100	5.6	81.1	16.0	29 to 100	14.6

[a]Percentage of participants who made no errors on these items.

performance on the catch trials used to detect noncompliance with the instruction to attend to the sounds rather than imagined spellings of the pseudowords.[2] The means in Table 1 are thus somewhat inflated because they include scores from individuals who disregarded the task instructions in this way.

In short, the unexpectedly low group means for complex items in Table 1 were not merely the result of just a few extremely low scores but rather reflected a very real tendency for many normally achieving adolescents to make errors on phonemic awareness tasks. In concrete terms, a surprising number of 14-year-olds with good past and present reading skills asserted that *bast* contains only three sounds and that removing the first sound of *trem* leaves *em*. About half the sample made such errors on 2 or more of the 8 deletion cluster items and on 3 or more of the 5 four-phoneme counting items. To be sure, quite a few other adolescents did very well on these tasks, but that is what we expected to see for all good readers.

One reason the adolescents and adults in this sample and in those studied by Scholes (1993) and Moats (1994) might have had difficulty is that the precise nature of the tasks could have been unclear to them. Perhaps older children and adults are able to manipulate phonological components of spoken words at various levels but fail to appreciate that the finest grained (phonemic) divisions are what tests such as these call for (from the researcher's viewpoint). Even when the examiner provides a little instruction and an example or two to illustrate phonemic segmentation (as in this study), other examples are typically consistent with alternative levels of analysis also, permitting the individual perhaps to conclude that any level of analysis is acceptable, especially if many subsequent test items yield the same correct solution regardless of whether subsyllabic or phonemic segmentation is used. This potential ambiguity in the task requirements may account for some of the variability observed on tasks requiring deletion or counting of phonemic segments by good readers. The potential effects of ambiguity in the demands of some phonemic awareness tasks are considered further in Studies 2 and 3.

In seeking to explain the observed performance levels of good readers on phonemic awareness tests, we also think it bears mentioning that, on both tasks in Study 1, quite a few adolescents appeared to have a great deal of overt difficulty. Field notes by the examiners indicated that participants often produced their responses slowly and tentatively and that several participants spontaneously remarked on the difficulty of the tasks (e.g., "This was a real struggle for her"; "He said 'That was really hard!'"; etc.). These kinds of behaviors and comments occurred even for some individuals who nevertheless managed to achieve high scores, indicating that, for these adolescents, the problem did not arise simply from a failure to undertand the task. If participants were merely segmenting speech at a

[2]Inappropriate responding on the catch trials was also seen for a few participants who did not earn perfect scores otherwise—3 from the NRD group and 1 from the RD group on the phoneme-counting task and 1 from each group on the phoneme-deletion task.

level that was not phonemic but was (they thought) appropriate, one would expect their responses to be made promptly and with little doubt or hesitation. That some NRD readers instead often struggled to reach an answer suggests that what we were asking them to do was unusual, drawing on abilities that they were not accustomed to exercising.

The results of this study confirm that it is not terribly unusual for a normally reading adolescent or adult to make segmentation errors on tests of phonemic awareness, particularly on items in which the two segments of consonant clusters must be differentiated. Sheer carelessness is unlikely to be the explanation for this, given the relatively unchallenging stimulus items in our tasks and the examiners' observations of effortful behavior by the participants. One possibility is that some individuals become good readers without having attained full phonemic segmentation abilities. Alternatively, after skilled decoding is achieved, good readers' metaphonological skills may deteriorate or become less accessible. A further possibility is that phonemic awareness may not yet be fully attained by the end of the Grade 8 (age 14) by some individuals, who may instead still rely on less fine-grained levels of phonological analysis. In Study 2, the developmental course of phonemic awareness received a closer look.

STUDY 2

A variety of phonological awareness tests has been administered over the years to participants in the well-known Colorado Twin Study of the genetic contributions to individual differences in reading and related cognitive abilities (e.g., Olson, Forsberg, & Wise, 1994; Olson, Wise, Conners, Rack, & Fulker, 1989). For Study 2, all available scores on two phonological-awareness measures were extracted from that database for 2nd through 12th graders of different reading-ability levels. The main goal of the analyses was to test the counterintuitive hypothesis, suggested by Calfee et al.'s (1973) results for the LAC test, that phonological sensitivity of good readers might actually decline during adolescence.

Method

Measures of phonological awareness. A modified version of the LAC test has been used in recent years in the Colorado Twin Study.[3] To increase task difficulty and reliability, 6 items were added to the 12 items in Part II of the original version (described earlier). The percentage of correct responses on these 18 items was available for every 2nd through 12th grader in the Colorado sample who received the expanded LAC test.

In addition, many participants received a phoneme-deletion task, adapted from Bruce's (1964) and Rosner and Simon's (1971) measures so as to be appropriate for a wide range of ages. On each of 6 practice-with-feedback trials and 40 test trials, participants heard a tape-recorded pseudoword (e.g., *prot*), repeated it, and then were asked to say it again without a designated phoneme (e.g., say *prot* without /r/) within 4 sec. Correct responses were always real English words (e.g., *pot*). The phoneme to be elided in the first 7 items was a singleton consonant, in the next 25 items was from a two-consonant cluster, and in the last 8 items was from a three-consonant cluster.

Because the phoneme to be deleted was identified for the participant, the level of analysis required was potentially made more explicit than for the phoneme-deletion task used in Study 1. Limiting correct responses to real words also was intended to diminish any confusion participants may have had about how finely the stimuli should be segmented, because rarely would any alternative manipulation (i.e., other than phoneme deletion) result in a real word. On the other hand, this aspect of the task may also have made it possible to arrive at correct responses through association or analogy (e.g., by producing the most similar English word to the pseudoword), such that some correct responses might not reflect true phonemic analysis of the stimulus by the participant.

Participants. In the Colorado project, twins with reading disabilities and normally achieving students were selected through examinations of school records and subsequent psychometric evaluations. Assessments of many reading-related skills were also made for other members of the children's immediate families who consented to participate. Data for twins' siblings in Grades 2 through 12 are therefore included in the analyses to be reported.

Children were assigned to one of three levels of reading status based on their performance on the Peabody Individual Achievement Test (PIAT) for word recognition and on a second experimental measure of word recognition. The age-adjusted scores for all children were standardized based on the distribution of scores in a normal-range comparison group with no school history of reading failure. Participants assigned to an RD group were at least 1.5 *SD*s below the mean of the comparison group; participants in a low-average NDR (NRD–L) group were between −1.5 *SD*s and the mean of the comparison group, and participants in a high-average NDR (NRD–H) group were all above the mean of the comparison group.

LAC scores were available for 296 RD, 87 NRD–L, and 166 NRD–H cases, and phoneme-deletion scores were available for 444 RD, 146 NRD–L, and 268 NRD–H cases. Sample sizes at each grade ranged from 0 to 109; given the small numbers of observations available for some groups at some (especially upper) grades, in a

[3]The measures used in this long-standing research have changed somewhat over the years, such that participants did not all receive precisely the same battery. Results for a third measure of phonemic awareness, a "pig-latin test," which was given to many of the participants, were similar to those for the LAC test and the phoneme-deletion task but are not described here.

few instances the data for adjacent years were combined in the analyses so that means were based on no fewer than 6 LAC scores and no fewer than 9 phoneme-deletion scores (median $N = 22$).

Procedure. Participants were individually examined at the University of Colorado. Within the lengthy testing session, the phoneme-deletion test preceded the LAC by about 1 hr, during which many other measures were given.

Results and Discussion

Mean scores by grade for the three groups are shown for each test in Figure 1. It is patently clear that, contrary to Calfee et al.'s (1973) findings, in none of the groups was there a suggestion of a decline in LAC or phoneme-deletion scores beyond Grade 7. Instead, the cross-sectional curves for both measures are asymptotic in appearance. On average, the best readers (NRD–H) appeared to reach an asymptote by Grade 7 of about 85% to 89% correct on the LAC test and about 88% to 91% correct on the phoneme-deletion task. The curves for the NRD–L group suggest that these children ultimately attained nearly as high accuracy on these tests but not until several years later, although there are insufficient data for this group at older ages to warrant a firm conclusion. Consistent with prior research findings, the RD group's performance remained poorer than that of the two NRD groups throughout the high school years.

Direct comparisons are difficult to make between the LAC test and the phoneme-deletion task in Study 2 and the two measures used in Study 1, given the many differences in stimuli and procedures from test to test, but LAC performance in this study and in Calfee et al.'s (1973) study can be compared, even though slightly different versions of the test were used. Up to Grade 7, LAC means for the RD and NRD–H Colorado samples are very similar to those for the below-average and above-average samples in the earlier study, respectively, but, from Grade 8 on, means tended to be about 10% to 15% higher for both Colorado groups.

These new analyses of age differences on the LAC test fail to confirm the existence of an inverted-U function relating phonological awareness to grade level in good readers, and there is no ready explanation for the differences between these data and those collected 20 years earlier by Calfee et al. (1973). One possibility, which we are not in a position to evaluate, is that the data for older children may have reflected cohort differences resulting from curricular or demographic changes within the school from which the earlier sample was drawn. In the absence of any longitudinal evidence for a decline in phonemic sensitivity in adolescence, we feel that, on the grounds of parsimony, this interesting possibility should be viewed as the less likely picture of the developmental trajectory.

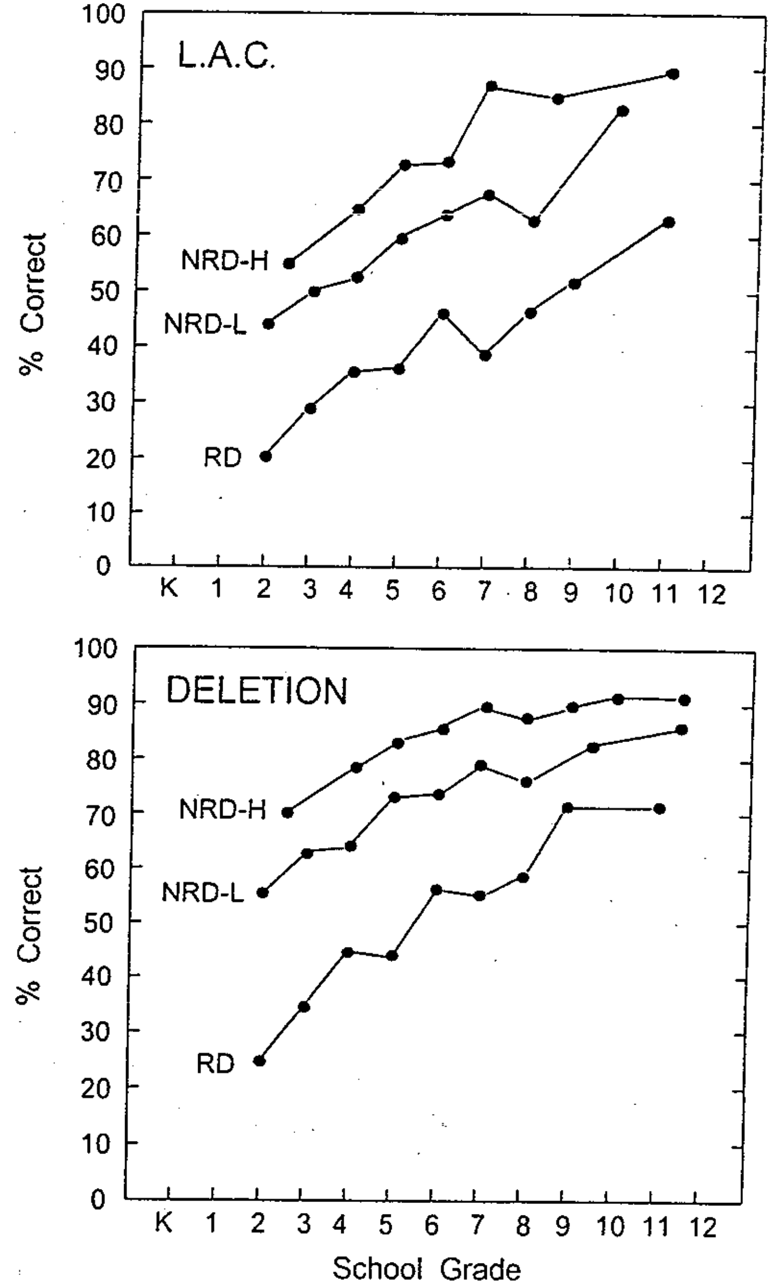

FIGURE 1 Mean scores on the last 18 items of the expanded version of the Lindamood Auditory Conceptualization (LAC) test and on the phoneme-deletion task for 2nd through 12th graders in three groups—reading-disabled children (RD) and normally achieving readers with higher (NRD–H) and lower (NRD–L) reading scores in Study 2.

In other respects, the Colorado data are more consistent with other recent descriptions of the performance of normal adolescent and adult readers on phonemic awareness tests. On both the LAC test and the phoneme-deletion task, the adolescent NRD readers in this study were markedly below 100% correct on average, and there was considerable variability among scores within reading-ability groups. Collapsing across Grades 8 through 12 for the combined NRD–H and NRD–L groups, on the LAC test, 31% of scores were 94% correct or better, 23% were 83% to 89% correct, 19% were 72% to 78% correct, 18% were 50% to 67% correct, and 9% were below 50% correct; on the phoneme-deletion task, 45% were 90% correct or better, 30% were 80% to 88% correct, 16% were 70% to 78% correct, 5% were 50% to 68% correct, and 4% were below 50% correct. In short, as in Study 1, although many normal readers did quite well on these measures, a sizable proportion of the sample did not, even though it might be argued that the instructions and procedures for both tasks should have disambiguated, to some degree, any confusion that adolescents may have had in Study 1 as to how finely the stimuli should be segmented. Although identifying the segment to be removed on the phoneme-deletion task and letting blocks represent phonemes on the LAC test may have clarified the task demands and perhaps led to somewhat higher average levels of accuracy (this is hard to say, given the other differences from study to study), these procedures did not substantially reduce the wide variations in performance among normal readers. Further evidence pertaining to this issue is provided in Study 3.

The two phonemic awareness measures in Study 2 were highly intercorrelated at all ages (*rs* = .66 to 75), suggesting that, despite their differences, the LAC test and the phoneme-deletion task were largely tapping a common dimension of metaphonological skill. Reading scores also correlated well with those for the LAC test (*rs* = .55 to .69) and the phoneme-deletion task (*rs* = .70 to .72). Despite the larger average differences between good and poor readers in Study 2 compared to Study 1, it is noteworthy that, in both studies and within all age groups in Study 2, there were some disabled readers who earned unexpectedly high scores on the phonemic awareness measures as well as some good readers whose scores were lower—sometimes astonishingly lower—than expected. Clearly, the results of both studies indicate that other factors contribute to variation in word-recognition skill at all ages.

In sum, the results of Study 2 suggest that the developmental course of phonemic awareness is better described as asymptotic than as an inverted-U function. Better readers appeared to reach asymptotic levels somewhat earlier (by about Grade 7) than did poorer readers. As in Study 1 and in the research of Moats (1994) and Scholes (1993), a nontrivial number of good readers made more than a few errors on such tasks in Grades 7 through 12. In Study 3, we explored further the question of why such variability in performance is seen for mature readers on phonemic awareness tests.

STUDY 3

The main purpose of Study 3 was to examine in detail the ways that well-educated adults segment words when they are explicitly instructed to consider how the sounds are represented by letters. The English spelling system, being graphophonemic, uses letters to specify phoneme-size subunits in words. Instructing adults to break words into the speech sounds that correspond to letters should clarify the size of the units they are being asked to identify. We expected that this disambiguation of the segmentation task would enable adults to exhibit more competence in phonemic segmentation than has been observed in Studies 1 and 2 using strictly oral tasks.

According to Ehri (1992), the phoneme-symbolizing function of letters explains how information about sounds and letters is retained in memory and used to read and spell words. The units acquired by readers to bond spellings to their pronunciations can be considered "graphophonemic" units (GPUs). Beginning readers are thought to match up spellings of individual words to their pronunciations by distinguishing constituent GPUs (e.g., *lamp* has four GPUs). In Study 3, a task requiring adults to segment words into GPUs was created. If adult readers are accustomed to thinking about letter–sound relations in terms of GPUs, then asking them to focus on the speech elements that are represented by letters in words should pose little difficulty, particularly when word spellings involve one-to-one correspondences ("transparent mappings") between letters and phonemes, as in *lamp*.

Although many English words have transparent spellings, many other words exhibit complexities that make graphophonemic correspondences harder to detect—for example, words containing silent letters or digraphs (two letters representing one phoneme; e.g., *sh, ck*). Typically, beginning readers are taught how to interpret these complexities graphophonemically. When such words are included on oral tests of phonemic segmentation, the participants' knowledge of the spellings has been shown to influence performance (Ehri & Wilce, 1980, 1986; Tunmer & Nesdale, 1982). On the catch trials in Study 1, about 10% to 15% of the adolescents were observed to respond according to the spellings rather than the sounds of the test items, thus illustrating this phenomenon.

Tunmer and Nesdale (1982) hypothesized that spellings influence phonemic awareness because participants think about letters rather than sounds while doing such tasks. Ehri and Wilce (1980, 1986) have argued, however, that the effect of orthography on metaphonological judgments has more to do with participants' interpreting letters as symbols for sounds than with their merely disregarding sounds in favor of letters. For example, they found that participants were likely to segment *pitch* into four sounds (/p/-/I/-/t/-/č/) but *rich* into only three (/r/-/I/-/č/) and suggested that, when participants learned to read and spell these words, the presence of the ambiguous letter *t* led them to find a corresponding phoneme (i.e., the tongue tapping the roof of the mouth) in the pronunciation of *pitch* but not in *rich*, which lacks a *t* in its spelling. They also pointed out that segmentation was not entirely spelling based, because participants did not assign separate segments for *c* and *h* in the two words.

In Study 3, a graphophonemic segmentation task was given to adults. It included some words with one-to-one letter–phoneme correspondences, which we expected adults to segment with high accuracy. We also included words with less transparent mapping relations in order to assess adults' judgments regarding more complex stimuli. We selected college students enrolled in teacher education programs for this study. Although such students might be expected to be more sensitive than average to the graphophonemic structure of English, Moats (1994) and others have voiced concern that the metaphonological abilities of some reading teachers may be inadequate.

Method

Participants. The 46 adults (42 women, 4 men) in Study 3 were native English-speaking college students enrolled in teacher education courses at two private colleges in the eastern United States. Most had already earned an undergraduate or master's degree. Mean age was 24.9 years ($SD = 4.1$ years).

Measures. A questionnaire[4] followed by a paper-and-pencil graphophonemic segmentation task was administered during approximately 20 min of class time. The instructions for the graphophonemic task, printed at the top of the form, were:

> Beginning readers and spellers are taught to sound out the letters in written words and to write letters for the sounds in words. Say the following words to yourself. Look at the letters. Determine which letter or letters correspond to sounds in the words, and underline or circle each. In the blank following the word, record the number of sounds you detect. Examples are as follows:
>
> DOG 3 SHIP 3 SKATE 4 THROUGH 3

Below this, the 19 test words were listed in a column, typed in lowercase to show them in their standard form. Next to each word was printed the same word in capital letters with ¼-in. spaces between letters, followed by a blank for recording the number of sounds. Above the column was a reminder to underline the sounds and record how many there were for each word.

[4]The questionnaire concerned participants' backgrounds and opinions about literacy instruction. Three pages of questions required students to describe their experiences in the field of reading and their familiarity with theories and practices in teaching reading, to define terms such as *dyslexia* and *sight word reading*, to rate the importance of various characteristics and capabilities as predictors and as facilitators of reading acquisition, and to describe how to respond to students' oral reading errors and how to read students' invented spellings. Much of this information is irrelevant to this study and is not considered here.

Four of the test words had transparent mappings between their letters and phonemes (*fold, bulb, lens, pistol*). The remainder included words with silent letters (e.g., *w* and *e* in *write*), words with digraphs (e.g., *ch*), word pairs whose spellings represent similar sounds differently (e.g., *wants–once*), and other words with complex or ambiguous relations between phonemes and letters. The 19 words were ordered on the test as follows: *socks, wants, listen, friends, family, bulb, sweat, chocolate, fold, catch, write, mix, lamb, bowl, soften, lens, sword, pistol, once.*

As in the examples, participants were expected to draw a mark beneath each single-letter or multiple-letter portion of the word that represented a single phoneme and to leave unmarked any letters that did not represent a phoneme of the spoken word (i.e., silent letters). The first column of Table 2 lists the segmentation(s) considered acceptable for each word. Responses were scored flexibly to take account of the alternative ways of analyzing some of the items graphophonemically, as follows. The boldface letters in the following items can be interpreted as silent letters and could thus be left appropriately unmarked: *lamb, socks–socks, friends, once, sweat, sword, write, listen, soften, chocolate.* The boldface letters in the following items can be treated as digraphs and could thus be appropriately marked as a single unit: *bowl, lamb, socks, friends, sweat, once, catch–catch, chocolate.* Finally, the boldface letters in the following items can be viewed as "ambiguous" and could thus be appropriately marked or left unmarked: *friends, wants, catch, bowl, family, chocolate.*

Results and Discussion

The mean number of words segmented appropriately into GPUs by the 46 adults was 7.6 ($SD = 5.2$), indicating that, on average, fewer than half of the 19 words were segmented according to graphophonemic criteria. As in Studies 1 and 2, scores were extremely variable, ranging from 0 to 18 correct, with considerable negative skewness in the distribution. Three or fewer items were correctly segmented by 24% of the adults, 4 to 7 by 30%, 8 to 11 by 20%, 12 to 15 by 17%, and 16 to 18 by just 9%. Table 2 provides a summary of the adults' responses. Correct segmentations and their frequencies are shown in the left-hand column, and errors are shown in the two right-hand columns. (In interpreting error frequencies, note that more than one error type often occurred within a single response.)

The first three words listed in Table 2 are the items that most closely resemble the stimuli used in the oral phonemic awareness tasks in Studies 1 and 2 and others (Calfee et al., 1973; Lindamood, 1994; Scholes, 1993)—namely, CVCC monosyllables with graphophonemically transparent spellings (*lens, fold, bulb*). Contrary to our expectations that adults would perform almost perfectly in segmenting such words when given the disambiguating information afforded by the graphophonemic

TABLE 2
Acceptable Segmentations of Words Into Graphophonemic Units (GPUs) and Erroneous Responses by 46 Adults (Study 3)

Acceptable Segmentations: Number of GPUs		% Correct	Errors: Marked as Representing One Sound	Errors: Other Errors
fold—4		50		
F O L D	(23)		FO (2), OL (5), LD (10), FOL (1), OLD (1), FOLD (2)	Unmarked: 0 (1), L (1)
lens—4		48		
L E N S	(22)		LE(5), EN (10), NS (9)	Unmarked: E (2), S (1)
bulb—4		37		
B U L B	(17)		BU (3), UL (9), LB (8), BUL (2), ULB (1), BULB (3)	Unmarked: U (2), L (1)
mix—3 or 4		74		
M I X	(34)		MI (2), IX (8), MIX (2)	
M I X _	(0)			
socks—4		70		
S O CK S	(26)		SO (3), OC (1), OCK (1), KS (2), CKS (8), OCKS (1), SOCKS (1)	
S O C K S	(5)			
S O C K S	(1)			
bowl—3 or 4		67		
B O W L	(7)		BO (4), BOW (2), WL (10), BOWL (1)	Unmarked: O (1), L (1)
B O W L	(14)			
B OW L	(10)			
catch—3 or 4		65		
C A T CH	(13)		CA (5), AT (4), CAT (4)	Digraph split: CIH (2), TCIH (2)
C A TCH	(11)			
C A T CH	(6)			
once—3 or 4		43		
O N C E	(13)		ON (12), NCE (2), ONCE (4)	Silent letter marked: E (3) Unmarked: O (2), N (1) No response (2)
O N CE	(7)			
_ O N C E	(0)			
wants—4 or 5		39		
W A N T S	(16)		WA (7), AN (5), NT (2), TS (15), WAN (3), ANT (1), NTS (3), WANTS (1)	Unmarked: N (1), S (1)
W A N T S	(2)			
sweat—4		39		
S W E A T	(7)		SW (22), WE (1), WEA (3), AT (2), SWE (1), EAT (5)	Unmarked: T (1)
S W EA T	(11)			Unmarked: T (1)
lamb—3		35		
L A M B	(16)		LA (3), AM (5), MB (15), AMB (1), LAMB (3)	Silent letter marked: B (5) Unmarked:A (1)

(*Continued*)

TABLE 2
(Continued)

Acceptable Segmentations: Number of GPUs		% Correct	Errors: Marked as Representing One Sound	Errors: Other Errors
sword—4		26		
S W O R D	(12)		SW (25), OR (10), RD (10)	Silent letter marked: W (3) Unmarked: O (3), R (1), D (1)
friends—5 or 6		24		
F R IE N D S	(5)		FR (23), EN (10), ND (6), DS (9), FRI (2), IEN (2), END (5), ENDS (2), IENDS (1)	Unmarked: E (1)
F R I E N D S	(3)			
F R I E N D S	(2)			
F R IE N D S	(1)			
write—3		22		
W R I T E	(10)		WR (22), RI (1), WRI (4), IT (3), ITE (4), TE (8), WRITE (1)	Silent letter marked: W (1), E (3)
family—5 or 6		33		
F A M I L Y	(12)		FA (4), AM (8), MI (7), IL (5), LY (19), FAM (5)	Unmarked: A (1), Y (3) No Response (1)
F A M I L Y	(3)			
pistol—6		26		
P I S T O L	(12)		PI (6), IS (4), ST (6), TO (4), OL (11), PIS (6), TOL (7), STOL (2)	Unmarked: S (1), O (8), L (1)
chocolate—6 or 7		22		
CH O C O L A T E	(9)		OC (4), CO (7), OL (2), LA (4), AT (1), ATE (4), TE (5), CHOC (3), OCO (2), COL (2), LAT (5), LATE (6), CHOCOLATE (1)	Silent letter marked: E (2) Unmarked: O (2), A (3), L (1) Digraph split: CIH (3)
CH O C O L A T E	(1)			
soften—5		17		
S O F T E N	(8)		SO (6), OF (6), OFT (1), FT (8), FTE (1), EN (17), TEN (9), SOF (3), SOFT (1)	Silent letter marked: T (1) Unmarked: F (1), E (5), N (2)
listen—5		15		
L I S T E N	(7)		LI (6), IS (3), ST (10), TE (1), EN (15), TEN (9), LIS (9), STEN (1)	Silent letter marked: T (3) Unmarked: E (4), N (1)

Note. Numbers within parentheses are response frequencies.

task, success ranged only from 37% to 50% ($M = 45\%$). Inspection of the errors on these words revealed that adults typically marked multiple (usually two) GPUs as representing a single phoneme; two adjacent graphemes were conjointly marked 44% of the time, and three or more were treated in that manner 7% of the time. Failing to mark a GPU entirely was a less frequent error (6%). These results are thus highly consistent with the level of accuracy and the preponderance of undercounting errors on the segmentation tasks in Studies 1 and 2. In short, instructing adults to break words into the speech sounds that correspond to letters did not serve successfully to clarify the size of the units into which words should be segmented.

The remainder of Table 2 lists responses to the 11 other monosyllabic words and the 5 polysyllabic items, each in descending order of accuracy. These items with less transparent spellings were included not only to be sure that adults were discriminating GPUs rather than simply marking single letters but also to examine adults' judgments about ambiguous letters, silent letters, and digraphs. It is clear, first, that adults were not simply marking letters without considering the sounds of the words. It was very rare, for instance, for the two letters of a digraph to be marked separately, which occurred on average in only 5% of responses to these 4 items. This confirms that participants were paying attention to sounds, as instructed.

Adults were also clearly influenced by the spellings of the words, as has been observed in previous research. No adult looked beyond the spellings to indicate that *mix* contained four phonemes (/mIks/), despite the fact that many identified four units in *socks* (/saks/); likewise, *once* and *wants* were treated quite differently. Also, ambiguous letters in words were more commonly marked as phonemic (i.e., underlined separately) than as silent (i.e., left unmarked) by the adults who segmented these words correctly (24% vs. 11% of the time, respectively, on average over the 6 items). Truly silent letters were left unmarked far more often and were marked as separate units only 4% of the time. These findings support Ehri and Wilce's (1980, 1986) notion that the presence of an ambiguous letter can lead participants to perceive an otherwise unnoticed phoneme in the pronunciation of the word.

As was seen for the transparent items, however, the predominant error on all words was marking two or more GPUs as a single unit. Two adjacent graphemes were conjoined 47% of the time in both monosyllabic and polysyllabic words, whereas combinations of three or more were less often treated as a unit (7% to 10%). Consonant clusters were more likely to be dealt with in this manner in initial position (49%) than in final position (22%). (It is interesting that the initial letter pairs of *sword* and *write,* which represent only one phoneme, were marked as a unit at a similar rate, 51%, suggesting that their orthographic similarity to true consonant clusters influenced adults to combine them rather than leave one letter unmarked as silent; in comparison, other silent letters were conjoined with adjacent graphemes at a lower rate, 18%.) In polysyllabic words, combining GPUs into larger units was a more frequent error in unstressed syllables (52%) than in stressed syllables (33%).

Although almost all possible combinations of adjacent letters were marked, a majority of such combinations occurred within, rather than between, structural elements of words. In polysyllabic words, combinations that crossed the boundary between two syllables were quite rare (9%). Likewise, within syllables, violations of the onset-rime division were infrequent (9%), excluding the rare instances in which the entire syllable was treated as a single unit (3%). Thus, although adults typically did not adhere strictly to a phonemic, an onset-rime (or onset-vowel-coda), or a syllabic level of analysis, they nevertheless respected divisions between such components and rarely identified units that straddled the boundaries between them.

To summarize, the ability to segment words into graphophonemic units was examined in a group of adults who were teacher education students and hence were expected to be sensitive to letter–sound correspondences within words. Although an orthographic scaffold was provided to clarify the segmentation task, the results did not alter the picture of performance yielded by Studies 1 and 2. We still observed lower than expected accuracy and wide variation in scores. A minority (26%) of the adults were able to segment more than half of the words into GPUs, indicating that the task was not obscure or impossible. Their correct segmentations suggested that spellings influenced their analyses of ambiguous sounds in words, and their error patterns did not suggest that adults marked individual letters and ignored sounds. Instead, they exhibited a strong tendency to treat two (or occasionally more) graphemes as a single unit (representing a single phoneme). Such combinations did not occur haphazardly, however, but instead respected phonological structural divisions within syllables and words. It may be that adults' analyses of the items into units larger than GPUs derive from the way they were taught to read and spell when growing up, or it may reflect a process of consolidating GPUs into larger "chunks" from years of experience in reading and writing these sequences (Ehri, 1994, 1995).

GENERAL DISCUSSION

In three studies, we explored various facets of the phonemic awareness skills of individuals beyond the initial stages of learning to read. In Study 1, we observed wide variability and unexpectedly low group averages on phoneme-deletion and -counting tasks by eighth graders with good past and present reading skills, particularly when full segmental analysis (i.e., splitting consonant clusters) was required. Almost all of their errors involved segmenting words into units larger than a single phoneme. We also observed slow and effortful responding on these tasks by many participants, even for some who produced correct responses.

In Study 2, the cross-sectional age functions from Grades 2 through 12 clearly indicated that mean performance on phonemic awareness tests reaches its highest level by Grade 7 for good readers and somewhat later for other students. Whereas scores of above-average readers in Calfee et al.'s (1973) earlier study had appeared to decline from Grade 7 onward, in this study they instead looked asymptotic. These data imply, therefore, that the accuracy levels of the eighth graders in Study 1 probably represent the highest degree of phonemic awareness that they will attain. The results of Study 2 also suggest that accuracy on phonemic awareness tasks by good readers may be slightly increased when the instructions make clear that a phonemic level of analysis is called for but that a nontrivial number of mature readers continue to make errors in segmenting and manipulating phonemic segments in words. Together, the results of Studies 1 and 2 are consistent with several other recent descriptions of rather unimpressive performance by nondisabled adolescent and adult readers on tests of phonemic sensitivity (Lindamood, 1994; Moats, 1994; Scholes, 1993; Shankweiler, Lundquist, Dreyer, & Dickinson, in press).

Study 3 was designed to explore further whether skilled adult readers might make errors on phonemic awareness tasks because the instructions fail to make clear the size of the segments that ought to be deleted or manipulated. We drew attention to the alphabetic principle by providing spellings of the words to be analyzed and by asking the participants to mark how letters correspond to phonemes in the words. Contrary to our expectations, performance was as variable on this graphophonemic measure as on the oral metaphonological measures used in Studies 1 and 2. Even when there was a one-to-one correspondence between letters and phonemes of a word (e.g., in *fold*), many adults segmented the word inappropriately, as in Study 1.

Analyses of the errors of these teachers-in-training revealed a strong tendency, analogous to the response patterns in Studies 1 and 2, for adults to mark as a single unit several letters that represented two (or occasionally three) phonemes. Consonant clusters and unstressed syllables were treated as single units particularly often, but combinations that spanned syllabic or onset-rime boundaries were rarely marked in this manner. These error patterns indicate that the adults were not segmenting words in a haphazard manner but were systematically affected by the relative cohesiveness of various phoneme combinations (Treiman, 1992).

In sum, despite efforts to clarify the level of analysis to be used by providing participants with an orthographic context in which to make judgments about phonemic structure, there was considerable variability in the accuracy of segmentation both within and between individuals. These Study 3 findings are consistent with the findings for purely oral tasks in Studies 1 and 2. Together, they suggest that misunderstanding of the level of segmentation required on tests of phonemic awareness does not fully explain why so many adolescents and adults do not achieve near-perfect scores on these tests. Likewise, sheer carelessness does not appear to be an adequate explanation for the unexpectedly inaccurate and variable performance by good readers on phonemic awareness tests, given that error patterns were quite systematic in Studies 1 and 3 and given the examiners' observations about the effortfulness of participants in Study 1.

Together, the findings of all three studies, and similar observations by other investigators, challenge the assumption that adolescents and adults with no history of reading disability should possess and display full competence in phonemic awareness. The findings of these studies are quite remarkably consistent, despite differences in the ages and educational levels of the samples, despite diversity in the requirements of the tasks, despite variations in the complexity of the stimuli, and despite differences in the availability of graphemic "scaffolding." From the literature available to date, the only experimental manipulation that appears to materially raise accuracy levels of good readers is providing explicit training with feedback regarding how the stimuli are expected to be segmented. For instance, Scholes (1993) found that, after providing such training, the college students who reached criterion on the training trials were subsequently able to respond very accurately on a phoneme-counting task. (Unfortunately, Scholes did not describe how long it took for these individuals to reach criterion or how many other students were unable to do so.) Similarly, Gombert (1994) reported that, when literate adults did not spontaneously adopt a phonemic level of analysis, their performance could often be substantially improved by providing some explicit training with feedback. From the information available, it is also quite possible that more training was conducted before testing in the two other studies of adults in which very strong performance on phonemic awareness tasks was obtained (Bruck, 1992; Pennington et al., 1990). Taken all together, research on the phonemic awareness capabilities of mature readers suggests that these readers' errors derive not from carelessness or confusion about the task requirements but instead from a flexible metaphonological approach that permits speech to be analyzed into components that are not exclusively phonemic. For some (perhaps most) individuals, this approach to the task is not immutable but rather can be modified through appropriate training. We turn now to some possible explanations for why skilled adult readers do not spontaneously and readily segment words into phoneme-size elements.

One possibility, which we favored at the outset, is that skilled readers attain full phonemic awareness during the early stages of reading acquisition, but their phonemic sensitivity later deteriorates. That is, the decline in scores on the LAC test, evident in Calfee et al.'s (1973) study, had suggested to us that, after decoding skills and phonemic sensitivity are acquired and refined to the point that word recognition is fluent and automatized, there might be little further need for the individual to continue to attend to and manipulate phonemic segments of spoken words, and the ability to do so might atrophy through lack of use. In other words, phonemic awareness might function like other acquired skills—such as solving geometry problems, playing the piano, and juggling—in which competence actually declines through lack of use. If so, however, individual growth curves for phonemic awareness should first rise and then fall, and this trend should also be reflected in group averages as more and more individuals enter the declining phase. We were unable to find any evidence of this pattern in the cross-sectional age curves for the two measures examined in Study 2. Although phonemic sensitivity in a few individuals might truly decline over time, longitudinal data would be needed to confirm this.

Another possibility is that, increasingly over the school years, performance on phonemic awareness tasks may be affected by the emergence or acquisition of competing strategies or habits. Orthographic representations, for instance, become important and useful tools for thinking about spoken and written language. According to Ehri's (1995) phase theory of reading development, beginning readers first learn to interpret graphemes as symbols for phonemes, but, as experience is gained in reading and spelling, graphemes become consolidated into larger orthographic units consisting of commonly occurring letter sequences that stand for larger phonological units. Other research (e.g., Adams, 1990; Santa, Santa, & Smith, 1977) has shown that novice readers may attempt to decode in a grapheme-by-grapheme fashion, but, as decoding improves, children start to perceive print in orthographic "chunks" (e.g., such that *thr–*, *–ing*, etc. are treated as units). As a consequence, children may shift conscious attention from sound-based phonemic segments to larger units (Seymour, 1997). Such syllabic and subsyllabic units may become more familiar and feel more natural to readers than smaller grapho-phonemic units. In time, children may come to rely on these larger chunks not only for analyzing printed words but even for segmenting spoken words when given a conventional phonemic awareness task. Given this interaction between developing phonological and orthographic skills, it might be difficult for many older children and adults to selectively use purely phonemic analyses.

Furthermore, it is important to emphasize that, in both Studies 1 and 3, many participants used several levels of analysis simultaneously, sometimes segmenting at the level of single phonemes (i.e., on items that were scored as correctly segmented) and sometimes treating larger combinations as single units. This pattern of behavior is consistent with the observation that there are several different levels at which speech can be analyzed, with orthographies varying according to the level they represent (DeFrancis, 1988). Whereas Chinese writing represents speech roughly at the level of the morpheme, and Japanese at the level of the syllable, Italian and Serbo–Croation are almost perfectly phonemic. Although it has been remarked that "each language gets the orthography it deserves," it would seem clear that humans must inherently be endowed with the ability to analyze speech at multiple levels. It would not be at all surprising, therefore, if adults who have learned to read an alphabetic language retain awareness of other levels even as they become able to operate at the level of the phoneme. Indeed, it has long been recognized that the very nature of English orthography demands flexibility by the reader in handling the various levels of structural analysis that are called for.

Even if many adults do become more used to relying on orthographic than on purely phonological knowledge in their representations of words, and even if many good readers can use a variety of different levels to analyze speech, there appears to be a nontrivial proportion of nondisabled readers who almost never segment words into phonemes, but only into larger units, as indicated by their especially low accuracy levels on phonemic awareness tasks. This negatively skewed tail was seen in the score distributions for all of the measures used in our three studies. The consistency of this finding suggests that some individuals manage to become good readers without ever having attained a phonemic level of metaphonological skill. Although an awareness of the segmental nature of speech is undoubtedly very helpful for discovering the alphabetic principle upon which the English writing system is based, a child who has not attained this insight, and who discerns only less fine-grained subsyllabic structural components of speech (e.g., onsets, vowel nuclei, codas), may nevertheless be able to discover and master the many regular correspondences between letter sequences and these subsyllabic units and could thereby progress satisfactorily in decoding skill (Goswami & Bryant, 1990). Many of these letter–sound associations, in fact, would be equivalent to true grapheme–phoneme correspondences, given that so many onsets and codas are singleton consonants, particularly in the kinds of words that appear in texts written for beginning readers. Although a large literature suggests that young children with true phonemic awareness have a distinct advantage in learning to read, it is possible that the attainment of fluent decoding would not be precluded for children with a less fine-grained appreciation of phonological structure.

In this regard, we are reminded of Isabelle Liberman's original conceptualization of phonemic awareness and its relation to reading acquisition (Liberman, 1973; Liberman et al., 1974). In particular, Liberman drew attention to the idea that this level of metaphonological skill is "unnatural." An appreciation of the fact that spoken words consist of sequences of phonemes is not something that children ordinarily develop just from their experience with spoken language. In contrast, most children do more naturally acquire an appreciation of some sublexical units such as word rhymes and onsets (e.g., Brady, Fowler, & Gipstein, 1993; Goswami & Bryant, 1990; Treiman, 1992). Training studies have demonstrated, however, that most children can grasp the notion of the phoneme when their attention is drawn (repeatedly) to the componential nature of speech. Others presumably discover it through repeated experiences with reading and exposure to instruction regarding grapheme–phoneme correspondences. What the adolescent and adult data indicate, however, is that phonemic awareness may not always be necessary for successful reading acquisition. Instead, some individuals may never come to appreciate the existence of phonemes and yet may attain high levels of reading achievement.

The results of these studies carry practical significance. Most important, they underscore the importance of focusing on phonemic awareness in teacher training. The need for this is especially evident in the performance in Study 3 of a sample of teacher education students, many of whom intended to become elementary school teachers with the responsibility of teaching children to read. Moats (1994) previously raised concerns about the phonemic awareness skills of practicing teachers. Similarly, our findings suggest that many education students lack an adequate appreciation of how speech is structured phonemically and of how graphemes correspond to phonemes in English words. Without such an understanding, these students' ability to impart this knowledge to beginning readers is seriously compromised. Clearly, providing the necessary instruction about the phonological and orthographic systems of English needs to be given increased priority in the teacher education curriculum. Fortunately, the recent findings of Gombert (1994) and Scholes (1993) suggest that many adults may be able to attain or more consistently demonstrate phonemic-level segmentation skills if appropriate training is provided.

The goal for reading teachers is not just to strengthen their phonemic awareness skills but also to appreciate and recognize the multiple levels at which their students may be operating. From errors evident in children's reading and spelling, the astute teacher should be able to determine what level(s) of analysis a child is using—whole word, syllable, morpheme, onset-rime, or phoneme. This understanding should allow the teacher to respond more appropriately in helping children attain greater sensitivity to language structure.

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