

Phonemic awareness and learning to read: a longitudinal and  
quasi-experimental study.

by

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#### Abstract

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Clear effects of the training program were found on phonemic awareness tasks in grade 1 and on spelling in grade 2. More subtle effects were found on reading and spelling of simple words in grade 1. No effect was found on rapid silent word decoding. The LISREL analysis was interpreted in favour of a model with phonemic awareness effecting phonological processing which in turn is essential for the early reading development.

The results were interpreted as supporting an interactive-compensatory limited capacity model of reading. Phonemic awareness helps the child to understand the alphabetical principle and ensures the development of an effective system for representing written language. Trained children find it easier to learn spelling-sound relations.

Key words: Phonemic Awareness, Phonemic Awareness Training, Reading Acquisition, Causal Modeling, Reading Readiness, Metaphonology

The dissertation consists of a summary and the following studies:

Lundberg, I., Olofsson, Å., & Wall, S. (1980). Reading and spelling skills in the first school years predicted from phonemic awareness skills in kindergarten. Scandinavian Journal of Psychology, 21, 159-173.

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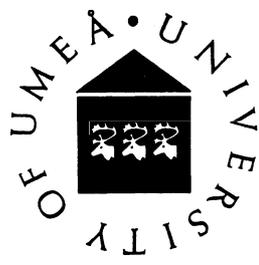
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1985

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Åke Olofsson

## INTRODUCTION

The transmission of literacy to the succeeding generation is of paramount importance. To most human beings reading acquisition seems to be a quite unnatural task, demanding considerable amounts of effort and time. Reading and writing evolved late in human history and, in comparison to oral language learning, late also in the development of the individual. It seems as if every literate society has to deliberately teach reading and writing to the next generation. The more natural language activities of speaking and listening, on the contrary, seem to fully develop without explicit teaching (Lieberman, Lieberman, Mattingly, & Shankweiler, 1980).

Different orthographies map different aspects of speech (e.g., syllables, morphemes, phonemes) but they all require the learner's awareness to the relevant aspects. Alphabetic languages, carrying information mainly about phonemes, seem to put especially high demands on the learner (Gough & Hillinger, 1980; Lieberman, 1973). The development of an orthography representing the phonemic segments of a language seems also to have taken place only once in the history of humankind (Gelb, 1963). In a sense, the difficulties in the ontogenetic development of phonemic segmentation ability seem to have a phylogenetic parallel (Gleitman & Rozin, 1977).

There may be several reasons for the difficulties in attending to and handling speech segments of phoneme size. One involves the abstract nature of phonetic structure and the other involves the meta-cognitive nature of the task of directing attention to the formal aspects of speech.

The first refers to the abstract and non-physical nature of phonemes. The phonetic segments cannot be handled in isolation and have different appearances in different contexts with the information about the segments overlapping to a considerable degree (Lieberman, Cooper, Shankweiler, & Studdert-Kennedy, 1967; Savin & Bever, 1970). For example, the word **bok** (Swedish for book), which has three phonological segments and three orthographic segments, is acoustically one unit. The information about each phonetic segment is so encoded into the acoustic unit that it is impossible to divide the unit into three parts each containing information about only one phonetic segment. Neither is it possible to begin with three prerecorded sounds for **b**, **o** and **k** and concatenate them to form the word **bok**. The same phonological segment will, due to the overlapping, have different acoustic realisations when appearing in different words together with different other segments. Many segments, especially consonants, are impossible to pronounce in isolation.

The meta-cognitive aspect refers to the fact that in ordinary language use these units never have to be attended to. Speech perception is deeply biologically rooted and the analysis of the meaning differentiating segments is done unattended. The words are perceived holistically and attention is normally only directed to meaning. The attention shift from content to form put specific cognitive demands on the individual (Lundberg, 1978).

A person's awareness about various formal aspects of language may be revealed in several ways. At the highest and most sophisticated level, for which the term consciousness may be used, the content of awareness can be directly verbally reported. At the lowest level, access to the object of awareness may be manifested through sorting or classification, for example deciding which of three words have the same initial sound. At the intermediate level "the content of awareness may be characterized as a model of the world capable of simulating future events, anticipating present events, and thereby formulating appropriate actions." (Yates, 1985, p. 249). Awareness of the phoneme thus implies the ability to handle phonemes in such tasks as blending, substitution, deletion and segmentation (see Lewkowicz, 1980, for a review of the most commonly used tasks). For such tasks in the present investigation the term "phonemic awareness" will be used. Originally, the term "linguistic awareness", coined by Mattingly (1972), in a more general way was intended to refer to whatever type of linguistic unit the orthography under consideration was mapping. For English and Swedish the orthography can be said to tap morphophonemic aspect of the language. However, the basic idea of the alphabet is phonemic representation and this may be especially true for the words used in the initial stages of reading acquisition. Other researchers have used terms like phonological awareness, phonetic analysis, sound blending and sound segmentation, but according to the tasks used the distinction is not of any critical importance. In any case the problems of invariance and segmentation of phonological information is recognized. The concept of phoneme is here treated as an abstract linguistic element rather than a specific speech sound.

A number of empirical findings support the presented approach to reading acquisition. Strong relationships are found between tasks measuring phonemic awareness and reading ability (Rozin & Gleitman, 1977, Zifcak, 1981) reading acquisition rate (Goldstein, 1976; Liberman, 1973) and dyslexia (Lundberg, 1982; Snowling, 1980; Wallach, Wallach, Dozier &

Kaplan, 1977). The intention of the present series of studies was to further elucidate the relationships between phonemic awareness and reading acquisition considering both methodological and substantial questions.

Awareness of other formal aspects of language -- that may go together with phonemic awareness under the concept of language awareness -- like that of syntax and pragmatics are not considered in the present investigation. A system for classification of language awareness tasks can be found in Torneus (1983).

#### DEVELOPMENT OF LINGUISTIC AWARENESS

The child shows a gradual development toward increasing awareness about the formal aspects of the spoken language (Lundberg & Tornéus, 1978; Nesdale, Herriman, & Tunmer, 1984) with the child first discovering the word, then the syllables and last the smaller phonemic units (e.g., Fox & Routh, 1975). This development tends to show a remarkable spurt at around six years of age when most children become aware of the phonemic units of speech (Liberman, 1973).

Thus, linguistic awareness could be a function of some general cognitive development (Bruce, 1964). The fundamental changes around age six, the development of concrete operations and decentering, may cause the rapid development of phonemic awareness observed at school-start (Watson, 1974). Different aspects of language awareness -- of which phonemic awareness is one -- may be viewed as a function of a more general capability of metacognition (e.g., Tunmer & Bowey, 1984, p. 151). Although it seems possible that a certain minimum level of cognitive development is required for the development of phonemic awareness additional factors are also needed since the illiterate adults in the study of Morais, Cary, Alegria & Bertelson (1979) did not spontaneously acquire phonemic segmentation ability. Several recent reviews have concluded that general cognitive development is not an important precursor of language awareness (e.g., Content, 1985; Pratt & Grieve, 1984).

Alternatively, linguistic awareness, the ability to make language itself to the object for thought, may develop as an extension of the early grammatical language development (Mattingly, 1972, 1984). The functional aspect of this development is that "the speaker-hearer can use his awareness to control, quite consciously, his linguistic activity" (Mattingly, 1972, p. 140). Such activities are present in many forms of abstract thinking and of course in such language based socio-cultural activities as

versification and secret languages. Thus, the two theoretical approaches, a linguistic and a cognitive-developmental, to language awareness development are to some extent interwoven (as indeed language and thought). (Cf. Donaldson, 1978, ch. 8).

However, reading instruction and reading activity is perhaps the most striking candidate as a causal agent behind the rapid development of language awareness at the age of school-start (Alegria, Pignot & Morais, 1982). It seems as if learning to read involves learning about the phonetic structure. The child himself has to learn about the phonetic structure when taught to read and write, and most reading methods also provide the child with some form of instruction about the speech sounds and their relationship to letters. Type of reading instruction has an effect on the development of phonemic awareness with a more phonics-oriented method leading to an earlier development of phonemic awareness (Alegria et al., 1982).

Gough & Hillinger (1980) describe learning to read as a task of breaking the cipher, or the code, relating written and spoken language. In order to do this the child must (1) recognize the letters (the units of the cipher) (2) know the phonemic segments of the spoken words (3) understand that his task is to unravel the correspondences between these two types of units and finally (4) the child must have enough data to solve this problem (i.e. have experienced enough pairs of written and spoken words from which to figure out the cipher). They also stress that the rules relating written and spoken words are very complex and to a great extent unknown, so we simply cannot give the child the cipher, but only provide a starting point and data.

But, there are good readers of environmental print who seems to lack letter-sound (or reading) ability (Masonhemier, Drum, & Ehri, 1984) indicating that experience with print alone does not necessarily lead to phonemic awareness and reading acquisition (Ehri & Wilce, 1985).

To summarise, the development of linguistic awareness may be explained in three different ways; (1) as a function of general cognitive development and, more specifically, related to metacognitive development, (2) as a continuation of normal language development and (3) as a result of schooling or reading instruction.

The two first explanations emphasize the developmental aspect of phonemic awareness and may be of more importance for the early stages of the development of linguistic awareness. The third explanation undoubtedly

raises the question of causality: Is it possible to train phonemic awareness and what will the effect be on reading acquisition ?

Some studies have demonstrated positive effects of the inclusion of phonemic awareness training in reading programs (e.g., Bradley & Bryant, 1983; Skjelfjord, 1976; Williams, 1980) and demonstrated specific short-term effects of phonemic awareness training on the initial reading acquisition (Fox & Routh, 1984; Treiman & Baron, 1983) and also demonstrated the effect of phonemic awareness training in grade 1 on spelling performance (Tornéus, 1984).

However, due to the effects of the learning-to-read process (Gough & Hillinger, 1980) and emerging knowledge of orthography (Ehri, 1984; Ehri & Wilce, 1980, 1985; Valtin, 1984) on the development of phonemic awareness the conceptual significance of phonemic awareness training with readers may not be clear. One way to clarify this is to study pre-readers.

The general aim of the present series of studies was to shed some further light on the relationship between phonemic awareness and reading acquisition. Besides focusing on the substantial questions of how and when to train phonemic awareness the studies engaged in methodological questions in developmental psychology.

The vast majority of studies done on phonemic awareness and reading are correlational and hence do not provide sufficient tests of causal hypothesis. The properly controlled training studies are mostly of short term nature and often use highly specific dependent variables and specific

**Table 1.** General design. Studies 2, 3, 4 and 5 draw on the same cohort of children. Study 1<sup>a</sup> is a follow-up from Study 1 and is reported in the present summary.

Study	N	Children	Method
1	200-143	Kindergarten - grade 2	Path analysis
1 <sup>a</sup>	119	grade 3	- " -
-----			
2	95	Kindergarten	Field experiment
3	83	- " - - grade 1	Program evaluation
4	48	- " - - grade 2	- " -
5	48	Kind. - grade 1 - grade 2	LISREL analysis

samples resulting in poor construct and external validity. The present study used both a longitudinal-correlational method and a quasi-experimental method. The general design of the study is presented in Table 1.

The aim of the first study (Lundberg, Olofsson & Wall, 1980) was to further elucidate the relationship between learning to read, different aspects of linguistic awareness and measures of cognitive ability and finally to extend previous correlational findings by estimating the predictive power of linguistic awareness through a longitudinal study

#### STUDY 1: A CAUSAL MODEL FOR READING ACQUISITION

A rather broad variety of metalinguistic tasks were used. The linguistic unit of analysis was varied by using both syllables and phonemes in all tasks. Further, the cognitive requirement was varied by placing different demands on the operations to be carried out with the units and different demands on working memory.

The postulated model assumed that metalinguistic skills are dependent on previous development of general intelligence and decentering and that metalinguistic skills cause differences in development of reading and spelling skills. The direct influence of cognitive abilities was postulated to be minor. 200 children were tested in kindergarten whereof 143 were identified one year later in grade 1 and 133 two years later in grade 2. The dependent variables included teacher ratings of reading and spelling, as well as silent word decoding tests, spelling tests and ratings of language production and understanding.

The quantitative implications of the postulated model were worked out by path analysis. For each dependent variable an OLS multiple regression analysis was computed using all prior causal variables as predictors.

The results revealed a clear superiority in predictive power for the phonemic tasks. The cognitive and perceptual tasks influenced reading and spelling almost exclusively in an indirect way mediated by the phonemic awareness tasks. Totally, about 50% of the variance in reading and spelling ability was accounted for. The best single predictor was found to be a task demanding the segmentation of two and three-syllabic words into phonemes, then the reversal of the order of the segments and pronunciation of the new "reversed" word. Nearly as good a predictor was a task allowing the child to analyse picture-presented three-phoneme words into phonemes by concretely representing the phonemes with pegs on a board. This task was designed to minimize the working-memory load and other extraneous

cognitive requirements. The same pattern was found in a separate analysis applied on children with no preschool reading ability. Here the phoneme reversal task showed less importance and the analysis and synthesis tasks with concrete representations more importance.

Table 2 presents previous unpublished results from a follow up in grade 3 of the same sample as in Study 1. The same path model as in Study 1 was estimated using test-results in grade 3 as dependent variables. The predictive power of the kindergarten tests are, as expected, slightly lower, but for the kindergarten test measuring analysis of concretely represented phonemes (ANPHONC) the predictive power is not attenuated from grade 1 to 3. This reflects the validity of ANPHONC as a measurement of stable and genuine individual differences related to reading acquisition. The power of Sex as a significant predictor of grade 3 spelling skill may reflect the girls higher sensitivity to linguistic norms, a finding not uncommon in sociolinguistics (cf. Olofsson, 1985a). The total amount of variance explained after three years is very high.

**Table 2.** Comparison of path coefficients (standardized regression coefficients) for the path models in Lundberg et al. (1980) and the same models using grade 3 data as dependent variables.  $N > 114$

	Dependent variables									
	OS400 <sup>a</sup>		RATEREAD <sup>a</sup>		SPELLING <sup>b</sup>		RATEWRITE <sup>a</sup>		BASICS <sup>a</sup>	
ANPHONRE	.56	.31	.36	.36	.31	.38	.40	.45	.50	.43
ANPHONC			.20	.24			.21	.25	.30	.30
SYNPHONC					.24	.18				
SYNPHOND			.23	.08						
SEX <sup>c</sup>	-.17	-.14	-.04	-.04	-.14	-.22	-.05	-.19		
R <sup>2</sup>	.39	.16	.50	.40	.43	.39	.33	.49	.54	.45

Note. For simplicity the complete set of predictor variables for OS400, RateRead and Spelling are not reported. The omitted variables all had lower coefficients than the included variables.

<sup>a</sup>Measured in grade 1 and grade 3.

<sup>b</sup>Measured in grade 2 and grade 3.

<sup>c</sup>This variable was coded as 0 for girls and 1 for boys.

Recent studies using the same path-analytical approach have supported to a great extent the findings in study 1 yielding similar causal ordering and effect estimates of cognitive variables upon phonemic awareness and reading and spelling (e.g., Leong, 1984; Stanovich, Cunningham & Feeman, 1984b). The present study reports a more detailed picture.

It was suggested that the high predictive power of a small set of phonemic awareness tasks -- over 50% of the variance in basic reading and spelling skills -- should not primarily be applied in selecting high-risk cases for intervention. On the contrary, the theoretical clarification gained through the explicitness forced by the use of path analysis implied that a general stimulation of the development of phonemic skills in the kindergarten group should positively affect learning to read and spell in school for all children.

In the literature it is repeated, like a mantra, that findings such as the present ones are correlational and that correlation is not causation. The best way to test the causal power of phonemic awareness is to experimentally manipulate it and evaluate the effects on reading acquisition. A first step may be to investigate if it is possible at all to raise phonemic awareness through training (Lewkowicz, 1980). Many researchers have commented upon the difficulty in instructing children in phonemic awareness tasks (e.g. Rozin & Gleitman, 1977; Savin, 1972; Zhurova, 1973) but there are some studies indicating training effects (e.g., Content, Morais, Alegria & Bertelson, 1982; Farmer, Nixon, & White, 1976; Lewkowicz & Low, 1979; Marsh & Mineo, 1977).

#### STUDY 2: PHONEMIC AWARENESS TRAINING IN KINDERGARTEN

This study evaluated a training program designed to develop phonemic awareness skills through playful activities carried out within ordinary kindergarten groups. The program did not emphasize explicit instruction, but on the contrary, in a playful context stimulated the children to actively construct and develop their own representation of the phonemic aspects of speech. This approach to phonemic awareness training, which contrasts sharply against the method of teaching speech sounds in most phonics based reading programs, is also stressed by Elkonin (1973; see also Downing & Leong, 1982, p. 108).

The three experimental groups had different amounts of phonemic awareness training and one of the control groups participated in a similar program dealing only with non-verbal sounds. Initially, and after about 8

weeks of training, the children were tested with highly equivalent tests measuring the ability to blend concretely represented phonemes into words and to analyse words into their phonemic constituents. This test was an improved version of the analysis and synthesis tasks with concrete representations used in study I. It was chosen as the least reading contaminated and least cognitively loaded phonemic awareness test with predictive validity also among absolute non-readers. This test was also found to drop least in correlation with reading and spelling measures over the years (see also the regression coefficients presented in Table 2).

The analysis was affected by ceiling effects but clear improvement was found for the children with medium and low abilities in the experimental groups with the most structured training. Based on the observations of spontaneous activities, using phonemic segmentation and blending, it was concluded that also the children among the more advanced benefitted from the training program.

No apparent problems were found in the implementation of the exercises or games. The most crucial difficulty for many children was to discover the phoneme and a great deal of the games had to center around tasks of isolating the first phoneme. Despite great individual differences it was possible to carry out exercises and games in a way that all the children enjoyed.

It was concluded that phonemic awareness can be developed in pre-readers outside the context of formal reading instruction. Attention can be directed to the formal aspects of language by appropriate activities encouraging them to approach their language in a playful and creative way.

In Study 2 a tendency towards bimodality in the frequency distributions of scores from the phonemic awareness tests was noted. In addition to the comments on this issue given in Olofsson & Lundberg (1983) I will here elaborate a bit more on that important theme.

Several recent studies also report bimodally distributed scores for tests tapping phonological awareness (e.g., Stanovich, Cunningham & Cramer, 1984a, p. 182; Tunmer & Nesdale, 1982, p. 305). Watson (1984, p. 116) suggests that these findings reflect the effect of seriation ability on phonemic awareness and points to the fact that bimodally distributed scores are common for cognitive measures in the Piagetian research tradition. In the framework of a cognitive-developmental theory of reading acquisition, Marsh, Friedman, Welch, & Desberg (1981, p. 205) interpreted bimodality as indicating a qualitative difference between stages in read-

ing development. Calfee (1977) pointed out that bimodality is characteristic for any variable measuring a single underlying trait. This conclusion was also drawn by Olofsson & Lundberg (1983) who pointed out that the underlying variable could still be normally distributed if only the test items were highly discriminating.

Ehri & Wilce (1979, p. 38) suggested that the bimodal distribution is an effect of the rapid integration of separate subskills that occurs when children grasp the alphabetical principle. The basic understanding of the letter-sound relationship also leads to a rapid transition from none to some reading ability, resulting in the bimodal trend in early reading scores (Ehri & Wilce, 1985; Masonheimer, et al., 1984).

The extent to which the obtained distributions are a function of crude measurement should also be investigated further. If more knowledge about the stages in learning to read and the processes involved could be gathered it would then be possible to refine the observations of the development of early reading skill. Some promising attempts in this direction have been made by Mason (1980), Masonheimer, et al. (1984) and Ehri & Wilce (1985).

The bimodal distributions reflect either non-linear relationships between the observed scores and the underlying traits or truly qualitative or bimodally distributed variables. This issue may be further elucidated within the framework of latent trait theory (Fischer, 1974). As mentioned in Olofsson & Lundberg (1983) the kindergarten phonemic awareness test showed an acceptable fit to the Rash model which uses a logistic function for the relation between the observed score and the underlying trait (Rash, 1960). This line of research deserves further attention since it may offer a solution to the problems of measuring change and comparing change for different levels of ability (Gustafsson, 1979, 1980).

### STUDY 3: EFFECTS ON READING AND SPELLING IN GRADE 1

The long-term effects of the kindergarten training program was evaluated by a follow-up in grade 1. In the middle of the spring semester, 83 out of the original 95 children were identified in 9 different school classes. A broad set of measures was used, capturing phonemic synthesis and analysis ability, reading and spelling of nonsense words, reading and spelling of common words with (for Swedish spelling) more complex or "irregular" spelling-sound relations and a silent word decoding test. Effects of the training program were found on the phonemic awareness

tests, and for the subgroup of children with beginning knowledge about reading and spelling in kindergarten effects were found on reading and spelling of nonsense and "irregular" words. No effects were found on the silent word reading test. The analysis was affected by ceiling effects and unequal control groups. The methodological problems in evaluation of unequal control group designs were discussed and attacked by using blocking and analysis of covariance. Different amounts of adjustment for pre-test results were used in order to bracket the true effect.

The effect on reading and spelling of "irregular" high-frequency words was interpreted as the children not treating these words as sight-words. Instead, the words seemed to be processed on a letter-sound basis. The nonsense word tests were found to deviate from the common pattern by showing a slight superiority for boys. It was argued that these tests were less language related and less conforming to sociolinguistic norms.

The analysis of individual cases indicated that the treated children may, to a greater extent, have avoided failure in reading and spelling. In the experimental groups all the children mastering the phonemic awareness tasks in kindergarten seemed to have acquired satisfactory reading and spelling ability in grade 1. Among the control children with equal kindergarten phonemic awareness there were several with poor development in reading and spelling.

It was concluded that the phonemic awareness training enhanced the children's understanding of the basic relationship between spoken and written language.

#### STUDY 4: EFFECTS ON READING AND SPELLING IN GRADE 2

Further long-term effects of the phonemic awareness training in kindergarten were evaluated in grade 2 by repeating the silent word decoding test and the irregular-word spelling test. The nonsense word spelling test was developed in order to more effectively tap the children's use of more complex spelling-sound rules.

The extremely long post-treatment delay called for several additional measurements with the purpose of control.

The trained children were found to create qualitatively different spellings compared to the untrained children but the groups did not differ on the silent word reading test. The experimental groups made highly rule governed spellings, reflecting a correct phonemic analysis of the spoken words as well as knowledge of spelling sound rules. The untrained children

created more spellings that could not be explained from spelling-sound rules or conventions in Swedish spelling. These spellings rather reflected poor knowledge of spelling-sound rules or poor phonemic analysis ability.

The results were explained in terms of the effect of kindergarten phonemic awareness training on the children's ability to learn spelling-sound rules. The advantage of phonemic awareness training **before** reading instruction was discussed in terms of the child being encouraged to attend to the rich information in the spoken word in structuring speech and developing mental representations for the speech segments.

#### STUDY 5: CAUSAL MODELING WITH LATENT VARIABLES

The latent structure hypothesized to account for the relation between kindergarten phonemic awareness and reading and spelling in the first grades was explicitly formulated and tested using the technique of linear structural relationships (LISREL, see Jöreskog & Sörbom, 1984).

Phonemic awareness in kindergarten was hypothesized to influence phonemic awareness in grade 1 which in turn was thought to enhance the child's understanding of the alphabetical principle and cause more efficient phonological processing in learning to read. This causes an early acquisition of decoding skills with easy and pleasant reading experience which in turn encourages practicing and thus leads to skilled reading with automatic and effortless word recognition (Stanovich, 1980).

The LISREL analysis supported the construct validity of phonemic awareness as it was measured in kindergarten. As to the school tests the discrimination between phonological awareness tests and tests for spelling-sound rule use was questionable. The conclusions in study 3 about the phonological processing of words in the irregular word spelling tests were validated. The LISREL analysis indicated low reliability for the nonsense word reading test. Thus, the structural modeling with latent variables yielded valuable information about the psychometric properties of the variables.

The favoured model conceptualized the silent word decoding tests and the spelling test in grade 2 as indicators of a latent variable for automatic and effortless word processing.

The estimated effects of phonemic awareness on the observed variables in grade 1 and 2 were largely congruent with the results of the quasi-experimental analysis in study 3 and 4.

Some other models were also tested but showed a poorer fit to the data

or non-permissible solutions.

The importance of theory in causal modeling was emphasized. The relationships formulated in the model can be quantified by LISREL but the meaning and nature of these relationships must be well grounded on theory (cf. Olofsson, in press).

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The combination of a quasi-experimental design and structural equation modeling is certainly not a usual strategy in developmental psychology. The power of this approach has been demonstrated in the present series of studies. The weakness of each method was compensated by the strength of the other. It should also be noted that the use of similar tests on two different samples yielded valuable information about the stability of the correlational estimates. This is of greatest importance in the present research area where replication and cross-validation are expensive and time-consuming (Cf. Lundberg, 1985).

#### CONCLUDING COMMENTS

Two main conclusions may be drawn from this series of studies. First, phonemic awareness in kindergarten is a good predictor of success in reading acquisition. Second, systematic training in phonemic awareness prior to reading instruction seems to decrease the risk for failure in learning to read and to enhance the learning of spelling-sound relations. This is, in fact, further evidence for the relevance of phonemic awareness in learning to read.

It must also be noted that a considerable proportion of the Swedish pre-schoolers show high levels of phonemic awareness in the spring before school-start. Further, several of these children did not show any sign of reading ability.

These findings seem to support a developmental theory of linguistic awareness, where it is seen as a distinct part of the language and cognitive abilities that develop under middle childhood. However, it might well be that this awareness only develops under certain conditions. The relative late school-start in Sweden ensures that a great proportion of the pre-readers have a rather high level of cognitive development. An even more important condition (Olofsson, 1985a) may be inferred from the indication of a variable, related to peer-group, affecting phonemic awareness. Share, Jorm, Maclean & Matthews (1984) found that phonemic awareness among peers was a very good predictor of a child's reading acquisition. They

suggested that "phonemically aware children somehow teach these skills to their peers, which when acquired, facilitate reading acquisition" (p. 1322). This theory of peer-influence or socio-cultural activity, is also compatible with the spontaneous phonemic play observed in Study 2.

#### REFERENCES

- Alegria, J., Pignot, E., & Morais, J. (1982). Phonetic analysis of speech and memory codes in beginning readers. Memory & Cognition, 10, 451-456.
- Bradley, L., & Bryant, P. E. (1983). Categorizing sounds and learning to read - a causal connection. Nature, 301, 419-421.
- Bruce, D. J. (1964). The analysis of word sounds by young children. The British Journal of Educational Psychology, 34, 158-170.
- Calfee, R. C. (1977). Assessment of independent reading skills: Basic research and practical applications. In A. S. Reber & D. L. Scarborough (Eds.), Toward a psychology of reading (pp. 289-323). Hillsdale, NJ: Lawrence Erlbaum.
- Content, A. (1985). Le developpement de l'habilete d'analyse phonetique de la parole The development of phonetic analysis ability. L'Annee Psychologique, 85, 73-99.
- Content, A., Morais, J., Alegria, J., & Bertelson, P. (1982). Accelerating the development of phonetic segmentation skills in kindergartners. Cahiers de Psychologie Cognitive, 2, 259-269.
- Donaldson, M. (1978). Children's Minds. Glasgow: Fontana.
- Downing, J. & Leong, C. K. (1982). Psychology of reading. New York: Macmillan.
- Ehri, L. C. (1984). How orthography alters spoken language competencies in children learning to read and spell. In J. Downing & R. Valtin (Eds.), Language awareness and learning to read (pp. 119-147). New York: Springer.
- Ehri, L. C. & Wilce, L. G. (1979). The mnemonic value of orthography among beginning readers. Journal of Educational Psychology, 71, 26-40.
- Ehri, L. C., & Wilce, L. S. (1980). The influence of orthography on readers' conceptualization of the phonemic structure of words. Applied Psycholinguistics, 1, 371-385.
- Ehri, L. C. & Wilce, L. S. (1985). Movement into reading: Is the first stage of printed word learning visual or phonetic? Reading Research Quarterly, 20, 163-179.
- Elkonin, D. B. (1973). U.S.S.R. In J. Downing (Ed.), Comparative Read-

- ing (pp. 551-579). New York: Macmillan.
- Farner, A.R., Nixon, M. & White, R.T. (1976). Sound blending and learning to read: An experimental investigation. British Journal of Educational Psychology, 46, 155-163.
- Fischer, G. H. (1974). Einführung in die Theorie psychologischer Tests. Grundlagen und Anwendungen. Bern: Huber.
- Fox, B., & Routh, D. K. (1975). Analyzing spoken language into words, syllables and phonemes: A developmental study. Journal of Psycholinguistic Research, 4, 331-342
- Fox, B., & Routh, D. K. (1984). Phonemic analysis and synthesis as word attack skills: Revisited. Journal of Educational Psychology, 76, 1059-1064.
- Gelb, I. J. (1963). A study of writing: The foundation of grammatology. (Revised edition). Chicago: University of Chicago Press.
- Gleitman, L. R. & Rozin, P. (1977). The structure and acquisition of reading I: Relations between orthographies and structure of language. In A. S. Reber & D. L. Scarborough (Eds.), Toward a psychology of reading (pp. 1-53). Hillsdale, NJ: Lawrence Erlbaum.
- Goldstein, D. M. (1976). Cognitive-linguistic functioning and learning to read in preschoolers. Journal of Educational Psychology, 68, 680-688.
- Gough, P. B. & Hillinger, M. L. (1980). Learning to read: an unnatural act. Bulletin of the Orton Society, 30, 179-196.
- Gustafsson, J-E. (1979). PML: A computer program for conditional estimation and testing in the Rash model for dichotomous items. Reports from the Institute of Education, University of Göteborg, 85.
- Gustafsson, J-E. (1980). Testing and obtaining fit of data to the rash model. British Journal of Mathematical and Statistical Psychology, 33, 205-233.
- Jöreskog, K. G., & Sörbom, D. (1984). LISREL VI. Mooresville, Ind.: Scientific Software, Inc.
- Leong, C. K. (1984). Cognitive processing, language awareness, and reading in grade 2 and grade 4 children. Contemporary Educational Psychology, 9, 369-383.
- Lewkowicz, N. K. (1980). Phonemic awareness training: What to teach and how to teach it. Journal of Educational Psychology, 72, 686-700.
- Lewkowicz, N. K., & Low, L. Y. (1979). Effects of visual aids and word structure on phonemic segmentation. Contemporary Educational Psychology, 4, 238-252.

- Lieberman, A. M., Cooper, F. S., Shankweiler, D. P., & Studdert-Kennedy, M. (1967). Perception of the speech code. Psychological Review, 74, 431-461.
- Lieberman, I. Y. (1973). Segmentation of the spoken word and reading acquisition. Bulletin of the Orton Society, 23, 65-77.
- Lieberman, I. Y., Liberman, A. M., Mattingly, I. G., & Shankweiler, D. (1980). Orthography and the beginning reader. In J. Kavanagh and R. Venezky (Eds.), Orthography, reading and dyslexia (pp. 137-153). Baltimore, MD.: University Park Press.
- Lundberg, I. (1978). Aspects of linguistic awareness related to reading. In A. Sinclair, R. J. Jarvella & W. J. M. Levelt (Eds.), The child's conception of language (pp. 83-96). Berlin: Springer.
- Lundberg, I. (1982). Linguistic awareness related to dyslexia. In Y. Zotterman (Ed.), Dyslexia. Neuronal, cognitive, & linguistic aspects. Oxford: Pergamon.
- Lundberg, I. (1985). Longitudinal studies of reading and its difficulties in Sweden. In G. E. Mackinnon and T. G. Waller (Eds.), Reading research. Advances in theory and practice (Vol. 4, pp. 65-105). New York: Academic Press.
- Lundberg, I., Olofsson, Å., & Wall, S. (1980). Reading and spelling skills in the first school years predicted from phonemic awareness skills in kindergarten. Scandinavian Journal of Psychology, 21, 159-173.
- Lundberg, I. & Tornéus, M. (1978). Nonreaders' awareness of the basic relationship between spoken and written words. Journal of Experimental Child Psychology, 25, 404-412.
- Marsh, G. & Mineo, R. J. (1977). Training preschool children to recognize phonemes in words. Journal of Educational Psychology, 69, 748-753.
- Marsh, G., Friedman, M., Welch, V., & Desberg, P. (1981). A cognitive-developmental theory of reading acquisition. In G. E. Mackinnon and T. G. Waller (Eds.), Reading research: Advances in theory and practice (Vol. 3, pp. 199-221). New York: Academic Press.
- Mason, J. M. (1980). When do children begin to read: an exploration of four year old children's letter and word reading competencies. Reading Research Quarterly, 15, 203-227.
- Masonheimer, P. E., Drum, P. A., & Ehri, L. C. (1984). Does environmental print identification lead children into word reading? Journal of Reading Behavior, 16, 257-271.
- Mattingly, I. G. (1972). Reading, the linguistic process, and linguistic awareness. In J. F. Kavanagh & I. G. Mattingly (Eds.), Language by ear

- and by eye (pp. 133-147). Cambridge, Mass.: MIT Press.
- Mattingly, I. G. (1984). Reading, linguistic awareness and language acquisition. J. Downing & R. Valtin (Eds.), Language awareness and learning to read (pp. 9-26). New York: Springer-Verlag.
- Morais, J., Cary, L., Alegria, J., & Bertelson, P. (1979). Does awareness of speech as a sequence of phones arise spontaneously? Cognition, 7, 323-331.
- Nesdale, A. R., Herriman, M. L., & Tunmer, W. E. (1984). Phonological awareness in children. In W. E. Tunmer, C. Pratt, & M. L. Herriman (Eds.), Metalinguistic awareness in children (pp. 56-72). New York: Springer.
- Olofsson, Å. (in press). On the role of theory in structural equation modeling. Scandinavian Journal of Psychology.
- Olofsson, Å. (1985a). Effects of phonemic awareness training in kindergarten on the use of spelling-sound rules in grade 2. Manuscript submitted for publication.
- Olofsson, Å. (1985b). Phonemic awareness and learning to read: structural equation modeling with longitudinal data. Manuscript submitted for publication.
- Olofsson, Å., & Lundberg, I. (1983). Can phonemic awareness be trained in kindergarten? Scandinavian Journal of Psychology, 24, 35-44.
- Olofsson, Å., & Lundberg, I. (1985). Evaluation of long-term effects of phonemic awareness training in kindergarten: Illustrations of some methodological problems in evaluation research. Scandinavian Journal of Psychology, 26, 21-34.
- Pratt, C. & Grieve, R. (1984). Metalinguistic awareness and cognitive development. In W. E. Tunmer, C. Pratt, & M. L. Herriman (Eds.), Metalinguistic awareness in children (pp. 128-143). New York: Springer.
- Rash, G. (1960). Probabilistic models for the intelligence and attainment tests. Copenhagen: Teknisk Forlag
- Rozin, P., & Gleitman, L. R. (1977). The structure and acquisition of reading II: The reading process and the acquisition of the alphabetic principle. In A. S. Reber & D. L. Scarborough (Eds.), Toward a psychology of reading (pp. 55-141). Hillsdale, NJ: Earlbaum.
- Savin, H. B. (1972). What the child knows about speech when he starts to learn to read. In J. F. Kavanagh & I. G. Mattingly (Eds.), Language by ear and by eye (pp. 319-326). Cambridge, Mass.: MIT Press.
- Savin, H. B. & Bever, T. G. (1970). The nonperceptual reality of the

- phoneme. Journal of Verbal Learning and Verbal Behavior, 9, 295-302.
- Share, D. L., Jorm, A. F., Maclean, R., & Matthews, R. (1984). Sources of individual differences in reading acquisition. Journal of Educational Psychology, 76, 1309-1324.
- Skjelfjord, V. (1976). Teaching children to segment spoken words as an aid in learning to read. Journal of Learning Disabilities, 9, 297-306.
- Snowling, M. (1980). The development of grapheme-phoneme correspondence in normal and dyslexic readers. Journal of Experimental Child Psychology, 29, 294-305.
- Stanovich, K. E. (1980). Towards an interactive-compensatory model of individual differences in the development of reading fluency. Reading Research Quarterly, 16, 32-71.
- Stanovich, K. E., Cunningham, A. E., & Cramer, B. B. (1984a). Assessing phonological awareness in kindergarten children: Issues of task comparability. Journal of Experimental Child Psychology, 38, 175-190.
- Stanovich, K. E., Cunningham, A. E., & Feeman, D. J. (1984b). Intelligence, cognitive skills, and early reading progress. Reading Research Quarterly, 14, 278-303.
- Tornéus, M. (1983). Rim eller reson - språklig medvetenhet och läsning. Studier av metafonologiska färdigheters betydelse för läs och skrivinläringen. The importance of metaphonological abilities for reading and writing. Stockholm: Psykologiförlaget.
- Tornéus, M. (1984). Phonological awareness and reading: A chicken-and-egg problem? Journal of Educational Psychology, 76, 1346-1358.
- Treiman, R. & Baron, J. (1983). Phonemic-analysis training helps children benefit from spelling-sound rules. Memory & Cognition, 11, 382-389.
- Tunmer, W. E., & Bowey, J. A. (1984). Metalinguistic awareness and reading acquisition. In W. E. Tunmer, C. Pratt, & M. L. Herriman (Eds.), Metalinguistic awareness in children (pp. 144-168). New York: Springer.
- Tunmer, W. E., & Nesdale, A. R. (1982). The effects of digraphs and pseudowords on phonemic segmentation in young children. Applied Psycholinguistics, 3, 299-311.
- Wallach, L., Wallach, M. A., Dozier, M. G., & Kaplan, N. E. (1977). Poor children learning to read do not have trouble with auditory discrimination but do have problem with phoneme recognition. Journal of Educational Psychology, 69, 36-39.
- Valtin, R. (1984). The development of metalinguistic abilities. In J. Downing & R. Valtin (Eds.), Language awareness and learning to read.

New York: Springer-Verlag.

- Watson, A. J. (1984). Cognitive development and units of print in early reading. In J. Downing & R. Valtin (Eds.), Language awareness and learning to read (pp. 93-118). New York: Springer.
- Williams, J. P. (1980). Teaching decoding with an emphasis on phoneme analysis and phoneme blending. Journal of Educational Psychology, 72, 1-15.
- Yates, J. (1985). The content of awareness is a model of the world. Psychological Review, 92, 249-284.
- Zifcak, M. (1981). Phonological awareness and reading acquisition. Contemporary Educational Psychology, 6, 117-126.
- Zhurova, L. E. (1966-1967). The development of analysis of words into their sounds by preschool children. Soviet Psychology and Psychiatry, 2, 17- 27.

