ASSESSMENT OF 3.5-YEAR OLD'S EMERGING PHONOLOGICAL AWARENESS IN A COMPUTER-ANIMATION CONTEXT

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3.5-VUOTIAIDEN VARHAISEN FONOLOGISEN TIETOISUUDEN ARVIOINTI TIETOKONEANIMAATIO KONTEKSTISSA

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Neljä uutta fonologisen tietoisuuden tehtävää luotiin arvioimaan 3.5 –vuotiaiden lasten varhaista fonologista tietoisuutta. Tehtävät esitettiin osana tietokoneanimaatiota. Tutkittavina oli 91 verrokkiryhmään kuuluvaa lasta Jyväskylän yliopistossa toteutettavasta pitkittäistutkimuksesta, jossa seurataan lasten kielen kehitystä ja dysleksiariskin periytymistä (Jyväskylä Longitudinal Study of Dyslexia). Tulokset osoittivat, että silloin kun tehtävät esitetään motivoivassa tutkimuskontekstissa, lapset kykenevät jo huomattavasti ennen kouluikää tunnistamaan sanan tai sanan osan, yhdistelemään tai jatkamaan ääneyhdistelmiä. Sellaiset ärsykkeiden piirteet kuten ääneyhdistelmien koko, sijainti ja merkityksellisyys vaikuttivat tehtävissä suoritutumiseen. Aikaisempien tutkimusten tapaan tämäkin tutkimus osoitti, että tämän ikäiset lapset hallitsevat paremmin sana- ja tavutason kuin äännetason erittelyä vaativia tehtäviä. Neljän tehtävän keksinäissuhteiden tarkasteluun pohjaava rakenneanalyysi osoitti fonologisen tietoisuuden jakautuvan varhaiseen äänteelliseen segmentaatioon ja synteesiin. Tehtäviä ja saatuja tuloksia arvioidaan suhteessa Gombert'n ja Metsalan esittämiin fonologisen tietoisuuden kehittymisen teoreettisiin malleihin.

Avainsanat : 3.5-vuotiaat lapset, varhainen fonologinen tietoisuus, tietokoneanimaatio

CONTENTS

ABSTRACT

ASSESSMENT OF 3.5-YEAR OLD'S EMERGING PHONOLOGICAL
AWARENESS IN A COMPUTER-ANIMATION CONTEXT [1]

Puolakanaho, A, Poikkeus, A-M., Ahonen, T., Tolvanen, A., & Lyytinen, H.

Four computer animated tasks were created to explore emerging phonological awareness among 3.5-year-old children (n = 91). Our findings indicated that already at this young age children are able to master tasks demanding identification of word-size and phonological units, blending and continuation of phonological units when the tasks are presented in a motivating assessment context. Features of the stimuli such as unit size, position, and meaningfulness had an effect on the children's performance in the tasks. In line with earlier findings indicating a clear developmental progression according to unit size, children showed higher mastery in manipulation of word-size and syllabic-size units than phoneme level units. Structural analysis suggested a model with two latent factors based on the operational features of the tasks: the emerging segmentation and blending skills. Current theoretical models of early development of phonological awareness skills by Gombert and Metsala are discussed. The first part of the two-part study to be submitted into international journal in the near future.

Keywords: 3.5- year old children, emerging phonological awareness, computer animation

1. INTRODUCTION

The relationship between phonological awareness skills manifested by children at the school entry, and the acquisition of literacy is widely documented (Bryant, Bradley, MacLean, & Crossland, 1989; Wagner, & Torgesen 1987; Liberman, Shankweiler, Fischer, & Carter 1974). The strongest support for the important role of phonological awareness as a precursor of literacy skills has come from intervention studies (e.g., Ball & Blachman, 1991; Bradley & Bryant, 1985; Brady, Fowler, Stone, & Winbury, 1994; Byrne, & Fielding-Barnsley, 1991, 1993; Korkman & Peltomaa, 1993; Lundberg, Frost, & Petersen, 1988; Schneider, Kuespert, Roth, Vise, & Marx, 1997). At the reading acquisition phase, causal analyses of links between phonological awareness and alphabetic skills are problematic because of the reciprocal development of these skills (Burgess & Lonigan, 1998; Morais, 1991; Vellutino, Scanlon, & Chen 1995; Wagner, Torgesen, & Rashotte, 1994; see also Holopainen, Ahonen, Tolvanen, & Lyytinen, 2000). Assessments carried out before direct exposure to reading instruction are, thus, valuable. Recently, predictive links between phonological awareness assessed between three and four years of age and subsequent reading skills have been documented (e.g., Chaney, 1992, 1998; Lonigan, Burgess, Anthony, & Barker 1998), and the mechanisms behind the early development of phonological awareness have been of increasing interest (e.g., Goswami, 2000b; Metsala & Walley, 1998; Metsala, 1999). The present investigation employed four computer-animated tasks to investigate the construct of emerging phonological awareness, and to analyse the impact of both task type and linguistic complexity of the stimuli on 3.5-year-old children's performance in the tasks.

The roots of phonological awareness, and the source of individual differences in these skills have lately been extensively discussed (Chaney, 1998; Lonigan et al., 1998). The central features of of emerging phonological awareness two theoretical accounts are graphically presented in Figure 1. The first view, outlined by Gombert (1992), centers on the stage-like developmental progression in reflection ability. The proponents of the second view, Metsala and Walley (Metsala, 1999; Metsala & Walley, 1998), state that development of phonological awareness is intimately linked with the gradual restructuring of lexical items from more holistic to segmental representations. Our conceptualization of early phonological awareness skills and their operationalization in the tasks that we developed are based on Gombert's theoretical account as well as on early empirical findings from studies conducted among preschoolers and toddlers (e.g., Bryant, Bradley, MacLean, & Crossland, 1989; Chaney, 1992; Liberman et al., 1974; Lundberg, et al, 1988; Wagner & Torgesen, 1987). Furthermore, the recent formulation of the lexical restructuring model by Metsala and Walley (Metsala, 1999; Metsala & Walley, 1998) has critically influenced our current understanding on the mechanisms and forces behind the reading-related phonological processes. We believe that the complementary models presented in Figure 1 provide a useful basis for creating
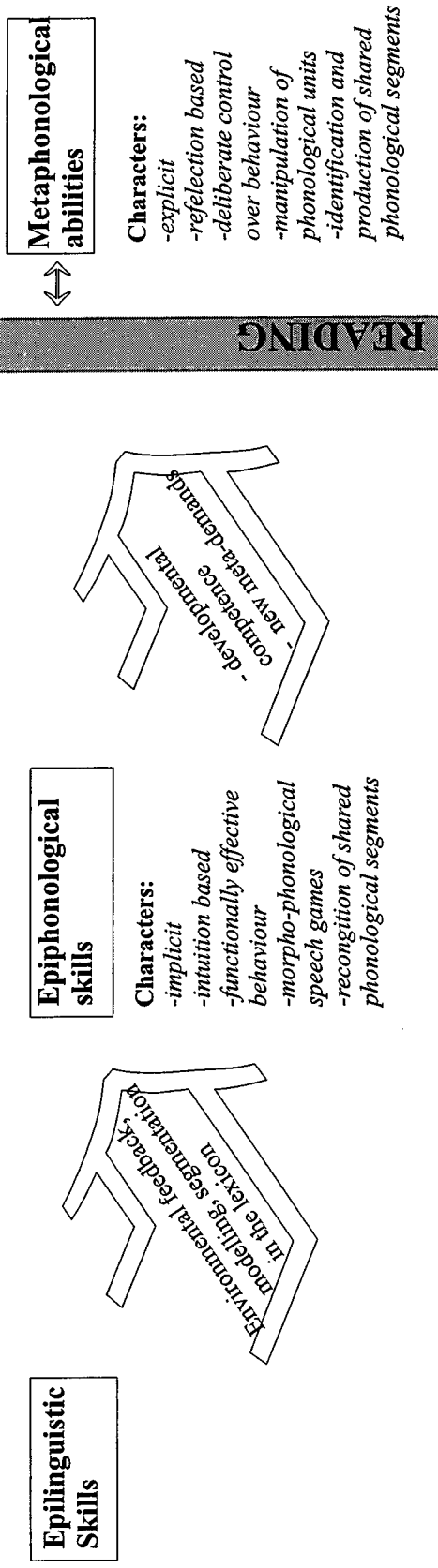
assessment contexts, and for conceptualizing the individual variation in children's phonological awareness skills.

The core of Gombert's (1992) theoretical analysis is the outlining of a developmental continuum from primary linguistic skills *(epilinguistic skills)* to implicit *(epiphonological skills)*, and finally to explicit skills in dealing with phonological aspects of speech *(metaphonological skills)*. The critical shift from epiphonological skills to an explicit capacity to intentionally manipulate phonological elements takes place from five years onwards in the face of new demands, usually induced by the exposure to the alphabetic code and reading instruction. Children at the level of epiphonological skills typically engage in morpho-phonological speech games. This level of skills is tapped by tasks that require recognition of shared phonological segments, but do not necessarily require conscious awareness of elementary speech units. Tasks assessing metaphonological awareness, on the other hand, typically include both identification and production of shared phonological segments, thus, they require explicit phonological knowledge. Gombert's model suggests that 3.5-year-old children are at an interesting age in which there is high variation in the size and composition of the lexicon which may subsequently lead to wide variation in the mastery of epiphonological skills; some children are likely to manifest relatively high reflection ability while some children may still be at the early stage of transition into epiphonological awareness. In the present study a set of tasks were created which aimed at tapping the variation in the epiphonological skills of this age.
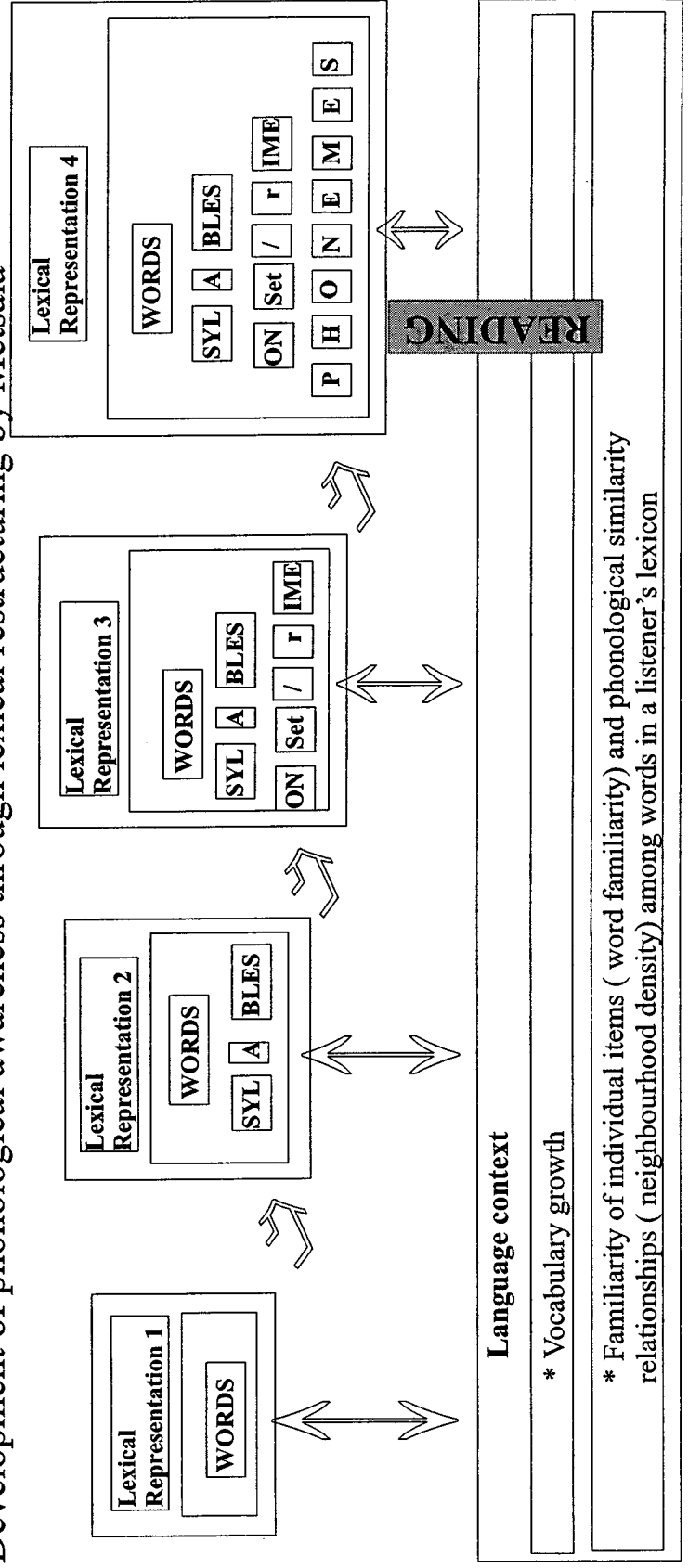
In the course of linguistic development percepto-motor functional speech units in the lexicon need to be changed in order to express phonologically and meaningfully rich speech. Several researchers assume that this process involves a gradual restructuring of lexical items from more holistic word-like forms into segmental representations, e.g., from words and syllables into phonemes. This segmentation hypothesis has explicitly been presented by Fowler (1991), for instance, and extended by Metsala and Walley (Metsala, 1999; Metsala & Walley, 1998) in their lexical restructuring model. Metsala and Walley suggest that the process through which a child develops an ability to manipulate sublexical phonological units is driven by the child's language experience, and it reflects both quantitative and qualitative features related to vocabulary growth (see Figure 1). Their account provides an opposing view to those which place metacognitive abilities, such as decentering, as the motor behind phonological awareness (Metsala, 1999). The lexical restructuring model assumes that at differents points of development children have access to different sized phonological units. Thus, items of varying segmental unit sizes are needed in the assessment of phonological awareness. Metsala and Walley also point out the need to pay attention to familiarity of individual items which suggests the relevance of studying the effects of word

Figure 1: Emergence of phonological awareness in two theoretical models

Developmental continuum of phonological awareness by Gombert

Epilinguistic
Skills

Epiphonological
skills

Characters:
-implicit
-intuition based
-functionally effective behaviour
-morpho-phonological speech games
-recognition of shared phonological segments

Metaphonological abilities

Characters:
-explicit
-reflection based
-deliberate control over behaviour
-manipulation of phonological units
-identification and production of shared phonological segments

READING

- Environmental feedback, modelling, segmentation in the lexicon
- developmental competence - new meta-demands

Development of phonological awareness through lexical restructuring by Metsala

Lexical Representation 1

WORDS

Lexical Representation 2

WORDS

SYL A BLES

Lexical Representation 3

WORDS

SYL A BLES

ON Set / r IME

Lexical Representation 4

WORDS

SYL A BLES

ON Set / r IME

P H O N E M E S

READING

Language context

* Vocabulary growth

* Familiarity of individual items (word familiarity) and phonological similarity relationships (neighbourhood density) among words in a listener's lexicon

familiarity (e.g. familial meaningful words vs. non-words) and item-specific features (e.g., position of target units within a word) on phonological awareness performance.

Different conclusions have been presented in the existing literature concerning the underlying structure of phonological awareness. In some studies a single unitary factor has been found to account for variance in skills tapped by different phonological awareness tasks (Stahl & Murray, 1994; 1998). When several latent factors have emerged they have sometimes been interpreted to represent different levels of *linguistic complexity*, i.e., manipulation of segments of decreasing size such as words, syllables, onset/rhyme or phonemes (Høien, Lundberg, Stanovich, & Bjaalid, 1995; Lundberg, et al, 1988), and sometimes different *operational demands*, such as analysis and synthesis of phonological units (Wagner et al., 1994; see also Yopp, 1988 and Carillo, 1994). No information is yet available on the structure of phonological awareness in the very early years.

Studies of phonological awareness skills prior to preschool-age have utilized tasks such as phoneme recognition and judgement, and auditory discrimination at age two (Thomas & Senechal, 1998), blending and initial phoneme isolation (identification and naming) (Metsala, 1999) as well as elision of segments between 3 and 4 years of age (Lonigan, Burgess, Anthony, & Barker, 1998); judgement of adequacy and correction of misarticulated phonemes, phonological play, identification of initial sounds (/m/ or not /m/), judging words as rhyming or not, and phoneme synthesis at the average age of 3.8 years (Chaney, 1992, 1994, 1998). Thus, several types of tasks have successfully been employed to assess phonological awareness in young children and to predict reading (for general discussion on diversity of the phonological awareness tasks see Elbro, 1996 or Gallagher, 1995). However, sometimes a somewhat inconsistent pattern of results has emerged which may reflect differences in task demands. In some studies rhyme production and rhyme/alliteration detection have significantly predicted subsequent reading (Bradley & Bryant, 1983; Bryant et al, 1990; Lonigan et al., 1998; MacLean, Bryant, & Bradley, 1987), whereas sometimes rhyming has failed to predict any significant variance in reading (Chaney, 1998).

The developmental progression in the child's access to different sized phonological units is clearly evident in the findings of Lonigan et al. (1998) as well as those of Wood and Terrell (1998). In their cross-sectional study of 3 and 4 year-old children Lonigan et al (1998) found a substantial increase in phonological awareness tasks performance by age. In the blending task, 3-year-olds mastered 39% of the word-, 25% of the syllable- and 21% of the phoneme-level item, whereas corresponding rates for the 4-year-olds were 82%, 70%, and 50%, respectively. Also in the elision task, mastery varied consistently by the segment size. In a similar fashion Wood and Terrell (1998)

showed that 4-year-old children had higher success rates in tasks involving segmentation of sentences (84%) or syllables (68%) than in those involving segmentation at the level of onset/rimes (20%) or phonemes (13%). A corresponding decreasing mastery by decreasing unit size emerged also in the blending task: syllables (65%), onset/rimes (17%), and phonemes (7%). These developmental patterns suggest that the level of phonological skills that young children manifest in the tasks depends both on the operations required by the task, and the linguistic complexity of the stimuli. A young child with emerging phonological awareness may be able to manifest mastery in the tasks only when the operations are at an optimal level, i.e., identification or blending of phonological units, (c.f., Gombert, 1992), and when the linguistic demands are low enough, i.e., targets at the level of words, syllables or onset/rimes (c.f., Fowler, 1991; Metsala, 1999; Metsala & Walley, 1998).

2. RESEARCH PROBLEMS

The purpose of this study was to investigate the mastery of 3.5-year-old children in four computer-animated phonological awareness tasks. Our *first goal* involved analysing the psychometric characteristics of the tasks. In the assessment of young children it is critical to set task demands as optimal, for instance, by employing a forced-choice procedure with visually presented stimuli, and by using motivational aids which appeal to the child's imagination. A multimedia program in which this kind of test format can easily be incorporated was used to provide a standard assessment context. Of the task types presented in the literature, we developed age- and language-adapted modifications: Identification of words and syllabic segments, Blending of syllables and phonemes, and Continuation of phonological units. *Secondly,* the effects of stimulus features on children's performance were explored. Based on earlier studies (e.g., Lonigan et al, 1998; Wood & Terrell, 1998) showing a clear developmental progression in phonological segment accessibility, we expected that a majority of the 3.5-year-olds would manifest mastery in identifying or blending word- and syllable -level targets, but only a minority would respond accurately to stimuli presented at the phoneme –level. Nonword targets were expected to be more difficult than targets involving real words. Of interest was also the effect of the target position within a word (initial vs. final). The *third goal* involved the investigation of the underlying structure of phonological awareness. A latent factor modelling with multiple concurrent measures was employed in line with Wagner et al. (1994) who suggested that operational features of the task are critical in the construct of phonological awareness at preschool age.

3. METHOD

3.1. Subjects

The performance of 91 children (41 girls and 50 boys) was assessed. This subsample is part of a prospective investigation (JLD; The Jyväskylä Longitudinal Study of Dyslexia) on early language development and precursors of reading skills (see Lyytinen, Leinonen, Nikula, Aro, & Leiwo, 1995). Altogether 214 families participate in this follow-up (selection procedure in more detail in Leinonen, Müller, Leppänen, Aro, Ahonen, & Lyytinen (in press). Half of the children are from families with at least one dyslexic parent and a familial background of reading difficulties (at risk group), and the other half are from families in which parents and their close relatives do not have reading or writing difficulties (control group). The two groups of parents were matched with respect to educational level. The educational distribution of the parents was representative of the Finnish population. The children of the present study belong to the control group.

3.2. Procedure

3.2.1. Computer animation program

The tasks were administered using a computer program *Heps-Kups Land* created especially for this purpose. All task instructions and individual test items were embedded in an interactional animation story. The child was familiarized with two main animation characters, Maka and Popo, who lead him or her through a series of adventures involving other animation characters. Children received visual and auditory rewards (e.g., invisible object turning visible) for answering questions or responding to requests as they proceeded from one subtest to the next one. The child proceeded by pressing touch screen items or by answering questions orally. An animation character called Outo-Orvelo, which was always positioned in one corner of the screen, summarized and clarified the events of the animation to the child, gave general instructions, and corrective feedback when needed. An experimenter sat by the child and monitored the testing situation, and coded the responses which were given orally. Administration of the four tasks analysed in this paper took approximately 15 minutes.

All animation characters had different human voices which were recorded using a high quality audio recorder. Voice recordings were transformed into digital form and saved as sound files. The sounds were stabilized using the Sound Blaster programme. The sounds were presented to the child at normal talking level (around 75 dB) via headphones. A small minority of the children (less than 10%) refused to use the headphones. In these cases sounds were presented through loudspeakers. The responses given by the child via pressing the touch screen items were recorded automatically in a data file by the program, and responses which require the child to give an answer orally were coded on line by the experimenter. All speech production of the child was recorded into sound files.

In the majority of the tasks the target units consisted of naturally produced words or word segments, however, in the Word-level and Syllable-level identifcation tasks half of the target units were cut artificially from the initial words. Since no differences emerged in the distributions of correct responses between naturally produced and artificially cut word segments, these two types of stimuli were combined in the analyses.

3.2.2. Phonological awareness tasks

The subtasks analysed in this paper were completed in the following fixed order: Word-level segment identification (WI), Syllable-level segment identification (SI), Synthesis of phonological units (SY) and Continuation of phonological units (CO). The results of the pilots for three 4.5 year olds' phonological awareness tasks are reported in a note below. [1]

1. Word-level segment identification (8 items). Three pictures depicting tangible objects were shown on the computer screen one after another, and the name of the object was presented immediately after the visual object was seen on the screen. The child's task was to identify the object which contained the requested part of a compound word. The child responded by touching

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[1] At 3.5 years the following three tasks which will be employed in the next assessment phase at 4.5 years were piloted: *Say just a little bit* (see e.g., Fox & Routh, 1975), *Rhyme Oddity,* and *Alliteration Oddity* (see e.g., Bradley & Bryant, 1983). The means of the pilot data indicated that these tasks were rather difficult, and some close to the floor level at this age, for instance, in the first task only 6.7% of the children receive the maximum score. Say just a little bit (n = 91) M = 1.2, SD = 2.5; Rhyme oddity (n = 16) M = 3.1 (chance level 2.6), SD = 1.2; Alliteration oddity (n = 16) M = 2.4, SD = 1.1 (chance level 2.6) (maximum score was 8 in each tasks).

one of the three pictures on the screen. For example in Item 2 involving the set *lentokone* (aeroplane) - *soutuvene* (rowing boat) - *polkupyörä* (bicycle) the child is asked: In which picture can you hear the sound *kone* (plane)?. Two practice items were administered for each child, and a third practice followed automatically if the child failed the first two.

2. Syllable-level segment identification (8 items). The task was similar to the word-level segment identification task in all other respects except that the target units consisted of sub-word elements. In two items a two-syllabic unit was used, and in six items the target unit consisted of one syllable. For example in Item 3 consisting the of set *makkara* (sausage) - *kurkku* (cucumber) - *porkkana* (carrot), the child was asked to identify the syllable *pork-* (carr-). No practice items were given as the procedure was exactly the same as in the previous task.

3. Synthesis of phonological units ('Secret Words', 12 items). Segments of varying size (750 msec pause between each segment) were presented to the child, and the child was asked to produce the intended animal name (e.g., What is: *ka-me-li* (camel)?). One test item consisted of a compound word (*virta-hepo* = hippopotamus), eight items required synthesis of syllables (e.g., *per-ho-nen* = butterfly), and three items required synthesis of syllables and phonemes (e.g., *aa-s-i* = donkey). Only a response containing the right assembled form was coded as correct. The principle of assembly was reinforced in the two practice items.

4. Continuation of phonological units ('Mysterious Steps', 8 items). The child was given the first syllable of "secret" words, and asked to guess how the words continue (e.g., What could this be: *ma-*?). In some of the items the syllable easily elicits a word known by most children (e.g. *veit-* -> *veitsi* (knife) whereas in others the syllable could present the beginning of many words. A picture of common object starting with the requested syllable was shown on the screen as a reward after each item. There were two practice items. Items were chosen so that they easily provided the beginning of a meaningful word in the vocabularies of 3,5 year-old children. Only continuations which were meaningful words were coded as correct.

3.3. Data analysis

Missing values which emerged towards the end of the testing session (e.g., due to tiredness and inattention) were substituted with regression estimates. The substitution involved less than 6% of the tasks. No statistically significant differences emerged between boys and girls, and, thus, their data are combined in the analyses.

4. RESULTS

4.1. Descriptive statistics

Means, standard deviations, and mean percentages of accuracy for Word-level segment identification (WI), Syllable-level segment identification (SI), Synthesis of phonological units (SY), and Continuation of phonological units (CO) are presented in Table 1. The descriptive statistics indicate variation in the scores for each task. The identification tasks which involved a forced choice response were completed above chance level (chance level criterion for both WI and SI was 2.6). A negatively skewed distribution indicating high mastery among the children emerged especially for WI. The non-parametric Friedman Test indicated that there were differences between the tasks in the mean percentage of accuracy (χ^2 (3)= 30.5; p= .000). Pairwise comparisons using Wilcoxon Signed Ranks Test showed that children manifested higher mastery in the Word-level segment identification than in the three other tasks (p < 001 for each comparison), and the mean percentage of accuracy was higher in the Syllable-level segment identification than in the Synthesis of phonological units (p ≤ 01).

TABLE 1. Means, standard deviations and mean percentages in phonological awareness tasks

				Accuracy		
Tasks	M	SD	Range / Max	Mean %	Proportion of children who had all items correct (%)	Proportion of children at the 50th percentile (%)
1. Word-level segment identification	6.4	1.9	2-8 / 8	79.5	42.9	18.7
2. Syllable –level segment identification	5.5	1.8	0-8 / 8	68.8	9.9	28.6
3. Synthesis of phonological units	7.4	2.6	0-12 / 12	61.7	9.9	27.5
4. Continuation of phonological units	5.1	2.6	0-8 / 8	63.9	24.2	33.0

Internal consistency as assessed by Cronbach's Alpha coefficient was high in three of the tasks: .72 in Word-level segment identification, .83 in Synthesis of phonological units, and .92 in Continuation of phonological units. In Syllable-level segment identification internal consistency was, however, relatively low .56. Poor correlation with the other items were found for items with highest difficulty. These were items in which the children had to make choice between syllabic targets with only one phoneme difference (e.g. naula vs. taulu), or in which the target was short and in the final position (e.g. nukke, possu, nalle). Deleting the four most discrepant items would have increased the reliability (.63), but in the current analyses the complete scales was used to make it more comparable in length to the other tasks.

4.2. Item analysis in terms of linguistic features of the target

Item-level analyses explored the effects of the size of linguistic units on children's performance. The mean percentage of accuracy was 79.5 in the Identification task with word-level targets (WI), whereas mean percentage of accuracy was 68.8 in the Identification task with syllable-level targets (SI). In SI children identified correctly 76.0% of the bi-syllabic items and 68.6% of the mono-syllabic items. Children's performance in the Synthesis task was analysed by dividing the items into three categories representing increasing levels of difficulty: items involving word-, syllable- and phoneme-level targets. An expected trend of decrease in accuracy by decreasing target size was observed.

TABLE 2. Average proportion of accurate responses in Synthesis of phonological units task by different unit size

Unit size	Accuracy (Mean %)
Whole word [a] (e.g., virta-hepo)	73.6
4-syllabic segment [b] (e.g., sar-vi-kuo-no)	67.9
3-syllabic segment [b] (e.g., tii-ke-ri)	65.9
2-syllabic segment [b] (e.g., koi-ra)	70.0
1-syllabic segment	-
Phonemic segment [c] (e.g., aa-s-i)	12.1

Mean based on [a] 1 item, [b] 3 items, [c] 2 items.

The mean percentage of accuracy was 73.6% for blending of word-level items (e.g., virta-hepo), between 65.9% and 70.0% for items with two to four syllables (e.g., koi-ra; tii-ke-ri; pa-pu-kai-ja), and only 12.1% for phoneme-level items (e.g., aa-s-i) (see Table 2). In the Continuation –task stimuli with three phonemes elicited a mean accuracy of 65.9% (e.g., kis-), whereas stimuli with two phonemes elicited only a mean accuracy of 39.6% (e.g., ma-).

Also of interest were the effects that different target positions within words (initial vs. final) and the targets' meaningfulness (meaningful word vs. non-word) have on the children's mastery. In the two identification tasks, the majority of children (80.6%) identified correctly bi-syllabic targets in the initial position (e.g., il-ma-pal-lo, ku-mi-saap-paat), whereas mono-syllabic targets in the final position (e.g., pa-pe-ri; pos-su) were identified correctly by only about half of the children (54.4%) (see Table 3). The effect of the targets' meaningfulness was analysed in items with bi-syllabic targets in the final position. Children identified correctly 77.5% of the targets which were meaningful (e.g., si-li-tys-rau-ta), and 66.5% of the targets which were not meaningful (e.g., lei-pu-ri).

TABLE 3. Average proportion (mean %) of accurate responses by target position in the Word-level Segment Identification (WI) and Syllable-level Segment Identification (SI)

Number of syllables	Target in initial position	Target in final position
2-syllabic targets (e.g., WI: ilmapallo; SI: kameli)	80.6 [a]	73.8 [c]
1-syllabic targets (e.g., WI: yöpuku; SI: paperi)	74.3 [b]	54.4 [d]

Mean based on [a] 3 items, [b] 5 items, [c] 6 items, [d] 2 items.

4.3. Analysis of associations between the phonological awareness tasks using structural modelling

Two-factor model based on operational features of the tasks. In the Word- and Syllable-level identification tasks (WI and SI) the cognitive operation demanded of the child was the same (identifying the requested word/segment from three alternatives presented orally and visually). The tasks differed only with respect to target size, and meaningfulness of the targets (meaningful in WI vs. meaningless in SI). Based on identical operational demands we expected these two tasks to be intercorrelated, and to form a latent *Identification Skills* -factor.

In the Synthesis –task words are blended from segments, and in the Continuation –task a given segment is matched with a word derived from the lexicon and produced as a blended whole word. These tasks, thus, both require a "build up" process. Based on this operational similarity these tasks were expected to form a latent *Blending Skills* -factor.

Alternative models. An alternative two-factor model based on the size of the lexical units that the child is required to manipulate (words vs. smaller phonological units) is suggested by findings on the developmental progression in the child's access to different sized phonological units (Lonigan et al., 1998; Wood & Terrell, 1998), some factor analytic studies (_Høien, et al, 1995; Lundberg et al., 1988), and by assumptions of the lexical restructuring model (Metsala, 1999; Metsala & Walley, 1998). In the alternative model Word-level identification and Continuation of phonological units form the *Lexical Access* – factor tapping the ability to process whole meaningful words. Syllable-level identification and the Synthesis of phonological units form the *Segmental Awareness*-factor tapping the ability to process smaller phonological units. In addition to this two-factor model based on linguistic factors, a single latent factor model combining all four measures will also be tested.

First, the model of two latent factors based on operational features was tested using the LISREL 8.30 (Jöreskog & Sörbom, 1999). Method of estimation was Weighted Least Squares, and input to LISREL was in the form of polychoric correlation matrices. The Chi-Square, Root Mean Square Error of Approximation (RMSEA), Model Aic, Goodness-of-fit Index (GFI), the Standardized Root Mean Squared Residuals (SRMR), and the Non-Normed Fit Index (NNFI) indicated that this model fitted the data well (see Figure 2). All the paths shown in the model were significant.

Neither of the two alternative models received empirical support (statistics for the two-factor model based on linguistic features: Chi-Square $(1) = 5,5$; $p < .05$, Model Aic $= 23.50$; statistics for the single-factor model: Chi-Square $(2) = 6.26$, $p < .04$, Model Aic $= 22.26$).

Figure 2   Lisrel structure model of phonological awareness skills at age 3½ year
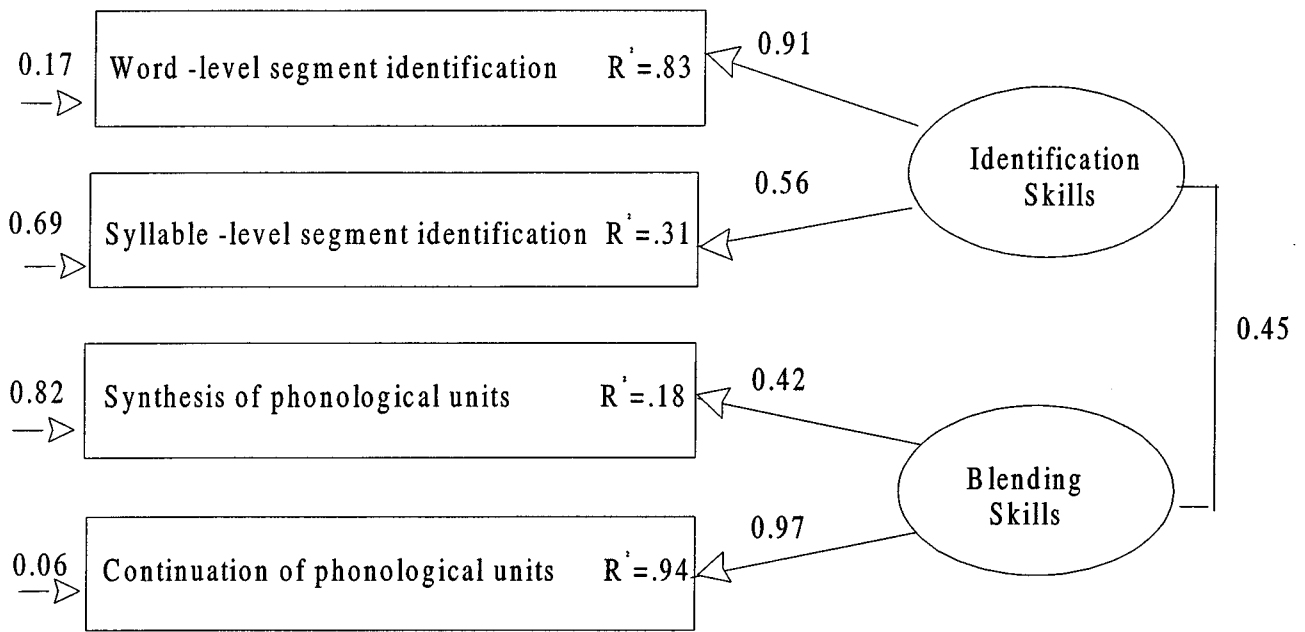
CHI-SQUARE (1)=0.043, P=0.84, RMSEA=0.0, MODEL AIC= 18.04, GFI=1.00, SRMR=0.007,

5. DISCUSSION

An assessment context reflecting current views on the development of phonological skills was created for investigating phonological awareness at 3.5 years of age. Four tasks representing different operations and linguistic complexity were used: Word-level segment identification (WI), Syllable-level segment identification (SI), Synthesis of phonological units (SY), and Continuation of phonological units (CO). Except for the synthesis task the task types we employed have rarely been used at this early age. Our findings indicated that 3.5-year-old children could easily and enthusiastically follow the instructions presented in a computer-animation context, and they displayed high mastery in all four tasks. Features of the stimuli, such as unit size, position and meaningfulness, however, had an effect on the children's performance. In the analyses of the underlying structure of phonological awareness skills, two distinct although correlated latent factors, based on operational features of the tasks, emerged.

The motivating assessment context, clear and comprehensible instructions, and ample rewarding contributed to a very low refusal rate: over 90 % of the task items were completed by each child. Internal consistency of the tasks was also high. Psychometrically some of the tasks lacked optimal differentiation among children with relatively high mastery. In the easiest of the tasks, Identification of word-sized units, almost 80% of the children identified correctly all items. Our findings of children's mastery in the blending task were in the same range as the percentages presented earlier in the literature (e.g., Lonigan et al., 1998; Wood & Terrell, 1998): Finnish children blended correctly an average of 73% of the word-size targets, and 69% of the syllable-size targets. For diagnostic purposes longer scales with greater number of items in the difficult end of the continuum are recommendable.

In line with previous literature (Lonigan et al., 1998; Wood & Terrel, 1998) we found a developmental progression of phonological manipulation skills from mastery of word-size and syllabic units to phoneme-size units. As suggested by the lexical restructuring theory (Metsala, 1999) items in which targets were meaningless tended to be more difficult for children than items with meaningful targets. Our item-level analyses also showed that stimuli in the initial position were easier for children to identify than those in the final position. In the Finnish language, in which a single word can have over 2000 inflectional forms changing the end of the word-body, initial word-stems carry the most salient meaning, and are, thus, also under heaviest segmentation pressure. Our finding of higher mastery in detecting stimuli in the initial position can be understood also in this language-specific context. As a whole, these findings emphasize the need to take into account all these factors, the size and position of target segment and meaningfulness of the stimuli,

in order to create tasks which optimally differentiate between those children with only emerging skills and those with more advanced manipulation ability.

The LISREL analyses supported a model with two latent factors based on operational features: Identification skills, and Blending Skills. Similar findings emphasizing operational features have been reported by Wagner et al (1993; 1994). The alternative models involving two latent factors based on linguistic features and a single latent factor did not receive empirical support, although the relatively high error variances on some of the variables suggests that each of the four tasks also had unique variance. Our findings suggest that the critical areas of phonology which are under rapid development at this age are blending of segments into meaningful units, and identification of phonological units which preceeds the more explicit segmentation ability. We believe that these task types are the most relevant for evaluation of young children's phonological skills in both research and clinical contexts.

Some researchers argue that children's performance in phonological awareness tasks depends on their level of metacognitive abilities (Gombert, 1992), while others suggests that phonological awareness is tied to lexical restructuring which is driven by qualitative and quantitative changes in vocabulary (Fowler, 1991; Metsala, 1999; Metsala & Walley, 1998, Goswami, 2000). The latter view stresses that performance in phonological awareness tasks reflects the child's developmental stage in segmenting the requested lexical items. Although these views place different phenomena as the core of phonological awareness, the processes that they put forward appear to be interactive rather than contrary to each other: more advanced lexical segmentation may lead to an increasing ability to reflect phonological features of speech, and developmental changes in awareness, on the other hand, might set the stage for further segmentation in lexicon.

Phonological tasks are critically dependent on listening to stimuli, and, thus, researchers of early phonology need to pay careful attention to motivational and attentional aspects in young children's assessment. The computer animation program that was created for this purpose involved a coherent narrative and adaptive reinforcers which encouraged children to engage in play-like manipulation of sounds. This kind of activity resembles spontaneous speech games typical of this age. Our study demonstrates that the playful and rewarding environment of computer animations offers a fruitful method for assessing young children's language skills (more about computer animation in Rieber, 1990a; 1990b). As a whole, the findings of the present study showed that when age-appropriate and motivating tasks are used, as young as 3.5-year-old children do manifest phonological awareness. In our further analyses we intend to study the relations between the

awareness skills tapped by these tasks and other phonological processing skills, and their contribution in the prediction of reading and writing skills.

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