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# Subgrouping of readers based on performance measures: a latent profile analysis

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**Abstract** By using latent profile analysis eight stable and interpretable subgroups of readers were identified. The basis for subgrouping was different performance measures with four aspects of reading in focus: reading of continuous texts, reading of document texts, word reading and reading speed. Participants were 9-year-old Swedish students included in the International Association for the Evaluation of Educational Achievement (IEA) Reading Literacy Study in 1991 ($n = 4{,}184$) and in 2001 ($n = 5{,}099$). The eight subgroups were compared on different background variables, such as gender, language at home, and cultural and socioeconomic factors. It was concluded that latent profile analysis proved to be a feasible methodology. The even performance profiles of good and average readers imply that reading is a skill with a high degree of transfer and generality. Several subgroups of poor readers with more heterogeneous performance patterns could be identified. The three most stable subgroups proved to be comprised of high performers, poor comprehenders and dyslexic students.

**Keywords** Subgroups of readers · Reading disorders · Dyslexia · Poor comprehenders · Latent profile analysis

## Introduction

Reading is a highly valued skill in our society, not only as a source of enjoyment, but also as the foundation of learning. Children, who cannot meet the literacy demands of our schools run a serious risk of failing in academic life and later in working life and in society.

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A large number of children experience great difficulties in acquiring adequate literacy skills. There are several possible reasons for this. Reading is indeed a complex, multidimensional activity, basically consisting of word decoding and comprehension. It also requires vocabulary, syntactic competence, fluency, ability to make inferences, general aptitude and intellectual habits. In a broader perspective on reading, which goes beyond individual information processing, social causes of illiteracy are also recognized. Thus, there is no reason to assume that a group of poor readers constitutes a homogenous group. Their profiles of performance may, in fact, vary considerably.

Two studies will be presented here. One aim of these studies was to examine different patterns of reading performance among 9-year-old Swedish students. In a first step subgrouping of performance profiles was conducted by latent profile analysis. A variety of reading tasks and reading materials were used. As a second step the profiles were related to different background variables indicating social, economic and cultural factors in order to interpret and validate the profiles.

Another aim was to investigate latent profile analysis as a method to conduct subtype analysis.

## Subtyping

Many investigations have been carried out to find homogenous subtypes of readers. A large proportion of these studies were case studies, although far from all (see for example Doehring and Hoshko 1977; and for reviews see Morris et al., 1998 or Stanovich, Siegel, & Gottardo, 1997). Mainly, the classifications have been based on previously identified poor readers and with normal readers as control groups. However, Satz and Morris (1981) used cluster analysis in their search for reading disabled children in a school population of 11-year-old boys. They identified nine subgroups, of which two were reading disabled. Based on language and perceptual variables these two subgroups were subjected to further subtyping. Five subtypes emerged, including between 10 and 27 students each. The subtypes were defined as a global language impairment type, a specific language type, global and perceptually impaired, visual-perceptual-motor impaired and one subgroup was an unexpected learning disabled subtype, as their performances on the perceptual and language tasks were average to superior. Morris et al. (1998) classified students with disabilities in reading, math, or both; children without disabilities, children with full-scale IQ less than 80 and children with ADHD. Nine subgroups were identified, of which seven were reading disabled. The majority of these children exhibited impaired phonological awareness across subgroups. These two studies (Morris et al., 1998; Satz & Morris, 1981) were thus based on broader samples than merely students with reading disabilities. Yet, they were not based on representative samples.

When a representative sample is used no a priori assumptions about reading difficulties hamper the possibility of identifying various subtypes, which is essential for a classification study (Morris et al., 1998). In contrast to previous studies, the present studies include representative large samples ($n = 4{,}184$, $n = 5{,}099$) of

Swedish 9-year-old students. Also, profiles of good and average readers can be potentially identified.

Rather than addressing all kinds of readers, previous subtyping studies have commonly focused on the concept and definition of dyslexia. Different cognitive approaches have been used. The classification studies have concerned, for example, the double-deficit hypothesis (Wolf & Bowers, 1999; Wolf et al., 2002) where three subgroups are expected: one with a phonological deficit, one with a rapid naming deficit and one with both deficits. Castles & Coltheart (1993) hypothesized that there are two subtypes of dyslexia, phonological dyslexia and surface dyslexia (see for example Manis, Seidenberg, Doi, McBride-Chang, & Petersen, 1996; Sprenger-Charolles, Colé, Lacert, & Serniclaes, 2000; Stanovich, Siegel, & Gottardo, 1997; Wolff, 2009). Several researchers (e.g. Stanovich & Siegel, 1994) have challenged the discrepancy hypothesis, which claims that a dyslexia diagnosis should be based on a discrepancy between IQ and reading performance. Thereby they question the validity of subtypes of poor readers based on IQ-scores. A few studies (e.g. Catts, Hogan, & Fey, 2003) have been based on the Simple View of Reading (Gough & Tunmer, 1986), which also is an essential point of departure in the present studies and which is described below. The dyslexic profile is a key profile of poor reading insofar that it has been the target of intense research within neuropsychology and psychology for many years. In this paper some extra attention will consequently be given to this critical subgroup, even though data do not allow for further subtyping of the dyslexic profile.

## Theoretical framework

The theoretical framework in the present studies is based firstly on theories of components of reading, secondly on theories of dyslexia and thirdly on the impact of family background including language. A fourth part of the framework concerns reading as a general skill over and above specific reading tasks.

### The Simple View of Reading

The Simple View of Reading is a model proposed by Gough and Tunmer (1986). Notwithstanding that reading is a complex process the authors argue that reading holds two components (in themselves complex) of equal importance: decoding and linguistic comprehension. This view is expressed in the equation $R = D \times L$, where R represents reading, D represents decoding and L represents linguistic comprehension. Thus, reading is a product of the ability to accurately and fluently identify the words in print and of general language comprehension ability. The values of the two factors range from 0 to 1, which implies that if any of the components is 0, then reading will be 0, that is both decoding and linguistic comprehension are necessary components but not sufficient.

According to the Simple View of Reading poor reading can derive from at least three conditions:

1. deficient decoding skills only,
2. deficient comprehension skills only,
3. a combination of deficient decoding and comprehension skills.

Several studies (e.g. Aaron, Joshi, Gooden, & Bentum, 2008; Catts, Hogan, & Fey, 2003; Hoover & Gough, 1990) support the idea that decoding and comprehension are dissociable skills. Apart from graphic-based information reading comprehension also involves the same ability as listening comprehension (Hoover & Gough, 1990). A discrepancy between the ability to understand narrative texts and the ability to decode words can tell us something about comprehension skills. Poor word decoding and still normal or good reading comprehension (connected prose) may depend on strong general language skills, an ability to use semantic clues in compensatory strategies, whereas poor reading comprehension with normal or good word decoding may either be a sign of poor vocabulary or poor higher order cognitive skills. Tasks with non-continuous texts (henceforth document tasks), such as reading of maps, charts etc., require very little decoding and can also indicate proficiency in higher order cognitive functioning.

## Dyslexia

As mentioned dyslexia has been the target of intense research within neuropsychology and psychology for many years. According to an abundance of evidence the underlying primary cause of dyslexia is a deficit in the phonological system (e.g. Frith, 1997; Lundberg, 1999; Ramus, 2006; Snowling, 2000; Stanovich, 1988), and its core manifestation is slow and error prone word decoding and spelling (Høien & Lundberg, 2000). Hence, impaired speed is an important obstacle for the dyslexic reader. Especially in transparent orthographies speed is more critical than accuracy (Frith, Wimmer, & Landerl, 1998; Landerl, 2001.) As the Swedish orthography is rather transparent, many dyslexic individuals manage to read and understand texts, but at a much slower pace than other readers. The problems are often unexpected given levels of performance on other abilities, such as comprehension.

Although dyslexia is constitutionally based it does not preclude the possibility that environmental factors might influence the manifest reading performance. Thus, early preventive measures and strong family support may decrease the manifest problems. However, the relationship between socioeconomic factors and manifest dyslexic problems is assumed to be rather weak (Lundberg & Olofsson, 1981; Samuelsson & Lundberg, 2003), which generally is not true for the relation between SES and reading performance (see below). Thus, we shall not expect dyslexic students' cultural and socioeconomic circumstances to be markedly deviant from the normal pattern. One could conceive of a dyslexic child with a very supportive home environment where the dyslexic problems are identified early in pre-school and preventive measures are taken including language stimulation, phonological awareness training and continuous parental support during the first school years. The dyslexic problems of this child might not even be identified in school. Thus, the fact that we are focusing on a biologically based disturbance does not preclude the operation of environmental factors to modify the expression of the constitutional

problems. However, phonological problems seem to be consistent up into adulthood (Svensson & Jacobsson, 2005; Wilson & Lesaux, 2001; Wolff & Lundberg, 2003), and even in compensated dyslexics (Paulesu et al., 1996).

### Family background variables

Researchers have repeatedly demonstrated the relationship between SES and reading performance (Snow, Burns, & Griffin, 1998), especially when it comes to reading comprehension (Olson, Forsberg, & Wise, 1994; Samuelsson & Lundberg, 2003). Thus, reading literacy performance is far from just a function of instruction that takes place at school. Coleman and his associates (1966), for example, showed in studies during the 1960s that family background plays an even more important role than school characteristics in determining student performance. Or more drastically expressed, he reached the conclusion that schooling does not make much of a difference. Later, after having examined the results of 9-year-olds and 14-year-olds in the so-called IEA six-area study, Coleman (1975) concluded that reading achievement is more influenced by home background than the two other subjects, math and science, involved in the study.

According to Bourdieu (1997) capital can present itself in three fundamental guises: *economic capital, cultural capital* and *social capital*. Economic capital is directly convertible into money, but could also be institutionalized in the form of property rights. Cultural capital can exist in an 'objectified state' in the form of cultural goods like pictures, dictionaries and books, whereas social capital is made up of social obligations, or 'connections'. The different forms of capital interact with each other, and if a person possesses one form of capital it can offer an opportunity to assimilate another form of capital. Bourdieu considers further that social hierarchies can be transformed into academic hierarchies. Cultural capital plays an important role, and might provide a theoretical explanation of the unequal scholastic achievement of children.

Some researchers have acknowledged the importance of multilingualism and reading performance. However, bilingualism is not an impediment per se in developing language skills; it may even enhance skills in both languages (Abu-Rabia & Siegel, 2002; Yelland, Pollard, & Mercuri, 1993). Furthermore, some research suggests that multilingualism enhances automatization in rapid naming speed (Bialystok, 1988; Everatt, Smythe, Adams, & Ocampo, 2000; Frederickson & Frith, 1998; Miller Guron, 2004), which is supposed to be a reading related skill (Wolf & Bowers, 1999; Wolf et al., 2002).

Above, it was hypothesized that dyslexic students would have phonological problems, but not necessarily comprehension problems. The opposite pattern is expected from bilingual students. In a study by Fredriksson (2002) immigrant children in grade 3 in Sweden had poorer average reading test scores (although not all subgroups of immigrant children) than Swedish students. The difference on comprehension scores was higher than on word decoding scores. Their poor reading may rather be due to poor semantic and syntactic competence of their second language (Frederickson & Frith, 1998). In this context it is important to recognize that second language learners are neither expected to have less nor more

phonological processing deficits resulting in poor reading in both languages than monolingual students (Da Fontoura & Siegel, 1995).

In a study by Frederickson and Frith (1998) students (aged 10–12 years) with Sylheti as their first language participated. They were poor readers but exhibited normal phonological skills for their age, as opposed to a majority of monolingual students with specific learning difficulties. This study as well as studies by Miller Guron and Lundberg (2003) and Muter and Diethelm (2001) suggest that phonological awareness skills, underlying reading performance, can be assessed in students' second language, i.e. phonological awareness skills for different languages do not have to be learned separately (Yelland, Pollard, & Mercuri, 1993). Frederickson and Frith also demonstrated that reading impaired second language learners performed better on single word reading than text reading and their reading comprehension was significantly lower than their accuracy. Their monolingual peers with specific reading difficulties (overlapping with dyslexia) performed better on text reading than single word reading. This is in line with the assumption that poor word decoding is based on poor phonological processing ability (e.g. Frith, 1999; Høien & Lundberg, 2000). Thus, high semantic knowledge is not necessary for developing word decoding skills, and dyslexic students can compensate their poor word decoding ability by using their superior semantic knowledge.

Besides an increased probability of impaired reading comprehension due to poor semantic and syntactic competence, immigrant children in Sweden often come from families with low socioeconomic status. Their parents are less educated and the underdeveloped cultural capital further undermines the children's reading performance.

## Generality of reading proficiency

Reading is obviously not a biologically given ability like walking or talking, but rather a skill developed within a specific cultural and historical context. This implies to some educators that reading is a culturally relative phenomenon, a situated or domain specific cognitive skill.

In a study by Peterson (as cited in Gough, 1995) 135 naval reservists were assessed on reading comprehension, listening comprehension and word decoding in two domains, baseball and computers. The reservists' background knowledge about the two subjects was also measured. For both listening and reading comprehension the correlation across the domains was rather low, i.e. comprehension was relative to the domain. The correlation of word decoding performance, on the other hand, was very high across the domains, and appeared to be independent of the reader's background knowledge. Peterson's conclusion from the study was that reading comprises two skills, comprehension and decoding.

In Peterson's study the domains were very specific with high demands on certain very different knowledge structures. Someone who, for example, has high knowledge about computers need not be very familiar with baseball and vice versa. Yet, as word decoding does not seem to be domain dependent, one could conceive that a reader who is good at reading one text presumably in many cases

will be good at reading another text, on the condition that the contextual bias is not too high. A critical issue is thus the transferability or generality of reading skills among the majority of students. However, as literacy skills can be decomposed into subskills, which to a varying extent are influenced by environmental factors, we can presumably expect subgroups of poor readers with different problems resulting in more heterogeneous performance patterns.

### Hypothesized subgroups

Based on the assumptions above five main potential subgroups are hypothesized:

1. *Good and average readers* are expected to be a large group with a rather even and a generally high or normal performance profile across several types of reading tasks, as it is assumed here that reading is not a very domain specific skill for this kind of readers, especially with reading tasks deliberately designed to minimize cultural bias.
2. *Garden variety poor readers* are comprised of students from poor socioeconomic backgrounds and with insufficient literacy encouragement. They might exhibit generally low scores on all tasks, due to limited exposure to reading material and lack of reading practice. Exceptionally low scores on tasks towards the end of a test session might indicate lack of motivation. These individuals are often referred to as garden-variety poor readers (Catts, Hogan, & Fey, 2003; Gough & Tunmer, 1986; Stanovich, 1991).
3. *Bilingual students* is another expected subgroup of poor readers. There is no reason to believe that bilingualism inhibits word reading proficiency, it may even be the opposite (Abu-Rabia & Siegel, 2002). Their exposure to continuous texts might be limited, but their word decoding is expected to be rather normal. Yet, poor vocabulary might cause additional problems. Therefore they might manage tasks with a minimum of text, such as the document tasks, better than tasks dealing with continuous texts. In other words, they might have average scores on word recognition, low scores on continuous texts but slightly higher scores on document tasks.
4. *Students with hyperlexic features* are students with limited general cognitive capacity, as for example reflected in poor document reading. As word decoding and IQ are not very strongly related (Høien & Lundberg, 2000) they might not have pronounced problems with word decoding itself but rather with reading comprehension. Thus, one would expect a subgroup with normal or close to normal word recognition, but low scores on both documents and continuous text. Recently individuals with these characteristics have been referred to as hyperlexic (Catts, Hogan, & Fey, 2003), even though this term traditionally has been reserved for very extreme cases. Around 10% of all children are estimated to be found in this group (Nation & Snowling, 1997).
5. *Dyslexic students* have impaired word-decoding ability but are supposed to have normal comprehension. This implies that they may not manage to accomplish the last items of the reading comprehension tasks within time restrictions, which are imposed for administrative reasons. It also implies that

they will perform well below average on speeded word recognition tasks, do better on tasks with continuous text due to efficient use of contextual cues in word identification and even better on document tasks as such tasks require comparatively little reading. However, one risk involved is the fact that deficient reading comprehension occurs as a secondary problem as a consequence of very poor word decoding.

The two studies to be presented here are each conducted in two phases: The first phase with the purpose of finding subgroups of students with different reading performance profiles, and the second phase with the purpose of comparing subgroups according to different background variables.

## Method

The Swedish data from the IEA Reading Literacy Studies, carried out by The International Association for the Evaluation of Educational Achievement (IEA) in 1991 and 2001 formed the bases of the subgroup analysis to be reported here. Some background information about these reading literacy studies will follow.

The major aim of the IEA Reading Literacy study was to determine the average level of reading performance among 9-year-old students (and 14-year-old students in 1991) in 32 and 35 school systems respectively. Other aims were to describe voluntary reading activities, to identify explanatory background variables in home, society and school. Further aims were to produce valid international tests and questionnaires and to provide national baseline data in order to observe changes and patterns over time. The present studies will only concern 9-year-old Swedish students.

### The IEA Reading Literacy study in 1991 (RL 1991)

According to IEA Reading Literacy is defined as: "… the ability to understand and use those written language forms required by society and/or valued by the individual." (Elley, 1992, p. 3) On the basis of this definition the reading literacy tasks in RL 1991 were composed of three kinds of reading material: narrative prose, expository prose and documents, and the major stress was placed on comprehension. *The narrative texts* ranged from short fables to stories of more than 700 words. *The expository texts* included factual information or opinions described and explained in continuous texts, for example a short description of an animal or a more lengthy text on how to determine the age of a tree. *The documents* included charts, tables, maps, graphs, lists or sets of instructions organized in such a way that students had to search, locate and process selected facts rather than read every word of a text. The test items were in multiple-choice format.

Low performance on reading comprehension can be due to slow and/or inaccurate word decoding for some students. Therefore, a speeded word recognition test with highly familiar words was added to the battery. Slow word decoding or dysfluent reading could also be revealed in the so-called end-of-

booklet effect (Yang & Gustafsson, 2004), which is the unexpectedly low performance on tasks at the very end of a test booklet, because of the existing time limit. Although the test was not speeded (except for the word recognition test), a certain time constraint was imposed for administrative reasons. Another aspect of the end-of-booklet effect could simply be lack of motivation. For whatever reason 11.3% of the students in RL 1991 and 11.5% of the students in RL 2001 never reached the end-of booklet passage included in the studies to be presented here.

In order to identify explanatory background variables questionnaires were administered to each student (about voluntary reading activities, about their homes and about their school circumstances), to their teachers (educational background, instructional policies and beliefs) and to their school principals (school circumstances and policies).

### The IEA Reading Literacy study in 2001 (RL 2001)

In 2001 IEA carried out another large-scale international literacy survey, PIRLS (Program for International Reading Literacy Survey). About one-third of the sample (RL 2001) was a national follow-up study (the 10-Year Trend Study) of the RL 1991 study. The majority of the students in RL 2001 were 9-years-old (all of them third graders), and they received exactly the same narrative, expository and documents tasks, the same word decoding task and the same student's questionnaire as the students in the RL 1991 study. In the RL 2001 study teacher ratings of student performance and a parent questionnaire were also included in the assessment battery. Both the student and parent questionnaires included background information, which offered a possibility to identify economic and cultural capital. However, this information has to be interpreted with caution, as the variance of an observed variable can always be decomposed into different sources of variance (Yang, 2003). This means, for example, that having a piano in the home could indicate both cultural and economic capital.

The student questionnaire also asked how often Swedish is spoken at home. It may not on an individual level, but on a group level be an indication of bilingualism. In 2001, 12.7% of the Swedish 9-years-old students (Statistics Sweden) had immigrant background, i.e. they or their parents were born outside Sweden (including returning Swedish families living temporarily outside the country). The samples in the present studies were representative of Swedish 9-year-old students, and the responses to the student questionnaire were rather convergent with the immigrant rate; 9.3% (1991) and 9.6% (2001) of the samples respectively stated that they never, almost never or only sometimes spoke Swedish at home.

RL 2001 was used as the basis for the subgroup analysis to be reported in Study 1. Study 2 was essentially a cross-validation of study 1 and was based on RL 1991. Thus, the basis for subgrouping consisted of a word recognition task, narrative and expository texts indicating comprehension of connected prose and document tasks indicating more general cognitive processing.

## Study 1

### Participants

The 9-year-old students participating in this study were part of the IEA Reading Literacy study in 2001. A total of 5,099 Swedish students were included in the analysis, 2,579 (50.6%) were boys and 2,520 (49.4%) were girls. They were selected on the basis of having valid data for both test booklets A and B.

### Instruments

The theoretical framework presented above was the starting point for the selection of aspects of reading performance to be analyzed. The first aspect was comprehension of *connected prose*, comprising both narrative and expository texts. Earlier analyses on the IEA Reading Literacy battery (Balke, 1995; Gustafsson & Rosén, 2004) have demonstrated that narrative and expository prose form only one factor. The second aspect was *document reading*. The third aspect was *word reading*, as embodied in the word recognition task. The fourth aspect was *reading speed*, revealed in the word recognition task and by the end-of-booklet effect. The end-of-booklet effect comprises both word reading speed and fluency, i.e. continuous reading speed. These four aspects make it possible to identify the hypothesized subgroups. It should be recognized though that the end-of-booklet effect could indicate lack of motivation.

As it was a representative sample of students high correlations between the reading tasks were expected due to the assumption of a general reading factor (Balke, 1995; Gustafsson & Rosén, 2003). However, although performance scores in the total sample were significantly correlated (Pearson's $r$ ranging from 0.237 to 0.525), the putative obtained profiles of poor readers were expected to depict a different pattern of correlations among tasks.

The tests were divided into booklets A and B administered on two separate occasions. The time restriction was 35 min for booklet A and 40 min for booklet B. The following tasks were included in the present study.

*The word recognition test* included 40 items. Highly familiar words were presented, and the task was to mark the matching picture out of four options. The time limit was 90 s. The word recognition test was administered in booklet A.

*Connected prose* consisted of two narrative and two expository texts ranging in length from 181 to 432 words. These texts were selected from a total of four narrative and five expository texts in the battery. Two texts in the present study presented factual information and two texts presented fiction. Each passage was followed by four to six multiple-choice questions. One narrative and one expository text were administered in booklet A, and one narrative and one expository text in booklet B.

*Documents* consisted of five passages of information in the form of maps, tables, graphs etc. In the RL 2001 study a total of six passages were included. The students were required to search for information or to follow instructions. Each passage was followed by 3–5 five multiple-choice questions. Two of the selected passages were administered in booklet A and three passages in booklet B.

**Table 1** Tasks, Cronbach's alpha and number of test items in each task classified on four aspects

| Task | Alpha | Connected prose | Documents | Word reading | Speed |
|---|---|---|---|---|---|
| The Walrus (ewlr) | 0.88 | 6 items | | | Fluency |
| The bird and the elephant (nbird) | 0.60 | 5 items | | | |
| A shark makes friend (nshk) | 0.61 | 5 items | | | |
| Marmots (emrm) | 0.62 | 4 items | | | |
| Island (disl) | 0.58 | | 4 items | | |
| Maria's timetable (dmra) | 0.41 | | 3 items | | |
| Empty bottles (dbtt) | 0.66 | | 4 items | | |
| Buses (dbus) | 0.62 | | 4 items | | |
| Temperature (dtmp) | 0.59 | | 5 items | | |
| Word recognition (word) | | | | 40 items | Word |

*Abbreviations* in brackets

The selection of tasks was made with the intention of obtaining passages varying in content and length. The 10 tasks selected are shown in Table 1. The total test scores of the RL-study indicated high validity and reliability (see Elley, 1994). The reliability coefficient for each passage is, however, rather low (Table 1) due to the small number of items. The surprisingly high reliability for the passage The Walrus may be caused, and inflated, by the speed factor involved (Gustafsson & Rosén, 2003).

Thus, four narrative and expository texts indicating comprehension of connected prose, five document tasks indicating more general cognitive processing, and one word recognition task formed the empirical basis for identifying subgroups of readers The measures were selected for the purpose to reveal performance in reading comprehension and in tasks with other cognitive demands than reading (i.e. tapping linguistic comprehension). Comparisons between variables may also indicate speed and word recognition problems. Thus, based on the theoretical assumptions presented above concerning the relationship between comprehension, decoding and speed for different categories of readers, these measures make it possible to identify the hypothesized subgroups.

The theoretical framework also concerns socioeconomic and cultural home background variables. This information was mainly taken from the parent questionnaire (number of books at home, parents' highest educational level, parents' highest professional level and household income) and from the student questionnaire (gender and language at home). Number of books at home was a composite score of children's books and of the additional number of books at home.

The study was conducted in two phases. In the first phase subgroups or profiles were identified, and in the second phase the relations between different profiles and different patterns of background variables were examined.

## Method of analysis

In traditional multivariate analyses the focus is on relation among variables. An alternative approach is to focus on individuals and examine similarities and

differences between individuals when a number of variables have been taken into account. Thus, the focus is on configurations, patterns or profiles of variables defining subgroups of individuals. There are several techniques for identifying or confirming the existence of subgroups. Cluster analysis is a general term for a family of procedures to create classifications. Most methods of cluster analysis are case-centred analyses, in contrast to factor analysis, which is variable-centred (Croll, 1986). Cluster analysis is a multivariate statistical procedure with the general aim to identify groups of cases or entities called clusters, which are homogenous internally regarding the variables in question. The variables representing the measured characteristics should be of a limited number and clearly interpretable (Rapkin & Luke, 1993).

The method used in this study is latent profile analysis, which is a statistically sophisticated kind of cluster analysis. The particular method used here has been developed by Muthén and Muthén (2001) and implemented in the Mplus program, which was used under the STREAMS 2.5 modelling environment (Gustafsson & Stahl, 2001). Latent profile analysis allows specification of models with categorical latent variables using continuous manifest variables as indicators. Usually it is assumed that the variables are independent within latent classes. If they are associated it is termed "conditional dependence" or "local dependence", and the model must be modified to account for this. One advantage of latent profile analysis is that the fit of the model can be assessed.

Raw data as well as standardized data can be used in Mplus. However, standardized values will facilitate an interpretation of the profiles from a theoretical point of view. Therefore, as a first step all students' scores for the nine passages and for word recognition were standardized into *z*-scores. Thus, continuous manifest variables were used in order to get a number of unobserved categorical latent variables. The latent variables represent the profiles. Each student was not only classified into a certain profile by Mplus but a probability for belonging to each profile was also estimated.

The model fit was assessed by so-called information criteria. The best-fitting model is obtained when the Sample-Size BIC (the Bayesian Information Criterion) value is as low as possible combined with as high an Entropy as possible. The BIC value is a log-likelihood measure used for model selection. It does not require any a priori profile information. Entropy is a measure of disorder in a given dispersion. When an individual has a high estimated probability for belonging to one profile and low probabilities for belonging to the remaining profiles the entropy will be high. To determine the number of profiles the two methods were combined with a "scree"-type test where levelling-off points of the curves for the Entropy and Sample-Size Adjusted BIC values for models with a different number of profiles were found.

## Results

First, the procedure for establishing the number of profiles will be described. Then, the obtained latent profiles will be presented along with the results of the comparison of background variables between the profiles. A short description and

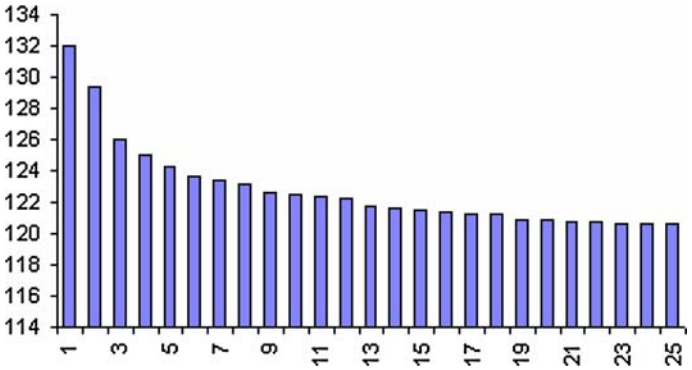


**Fig. 1** The Sample-Size Adjusted BIC values for a 2-profile model until a 26-profile model. Bar 1 is a 2-profile model, i.e. bar 13 is the 14-profile model

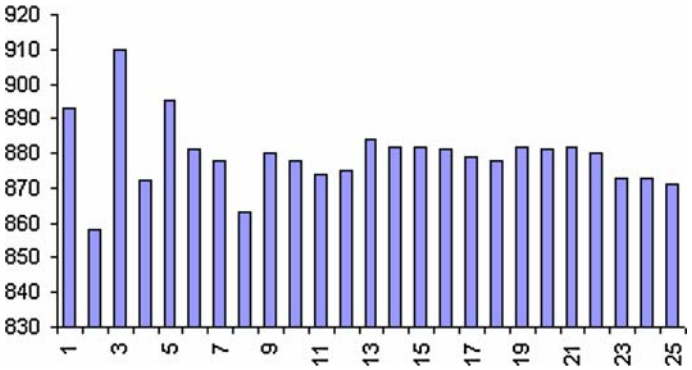


**Fig. 2** The Entropy values for a 2-profile model until a 26-profile model. Bar 1 is a 2-profile model, i.e. bar 13 is the 14-profile model

interpretation of each profile with respect to patterns of reading performance as well as background variables will follow.

Figure 1 shows the Sample-Size Adjusted BIC values, and Fig. 2 shows the Entropy, for the 2-profile model up to the 26-profile model.

The Sample-Size Adjusted BIC value decreased until a 26-profile model was obtained. However, the Entropy did not continuously increase, and some profiles comprised less than 40 individuals. Theoretically there were no particular reasons for a 26-profile model. When scrutinizing the profiles, in addition to weighing the Sample-Size Adjusted BIC value and the Entropy, a 14-profile model was selected as the best fitting model (Sample-Size Adjusted BIC = 121774.089; Entropy = 0.884.). The Sample-Size Adjusted BIC value and the Entropy were fairly consistent against varying start values.

A subjective judgement concerning the face validity of profiles was also made. Some of the 14 profiles exhibited rather trivial differences, e.g. low performance on one document task instead of another similar document task. This resulted in a

**Table 2** Average latent profile probabilities for most likely latent profile membership

| Profiles | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Probability | 0.917 | 0.856[a] | 0.824[a] | 0.876 | 0.954[a] | 0.903[a] | 0.897 | 0.962 |

[a] Mean probabilities for collapsed profiles

reduction into eight final profiles derived from the 14-profile model. The average latent profile probability for each profile is presented in Table 2. The probabilities were estimated by Mplus, indicating the reliability in the classification when utilizing all available information. Each profile was also given a probability for belonging to all other profiles. For example, Profile 8 had the probability of .000 for belonging to Profiles 1–4 and 6, whereas they had the probabilities of .007 and .028 (derived from two profiles merged into one) for Profile 5 and .003 for belonging to Profile 7. As shown in Table 2 the average probabilities for belonging to each profile in the 8-profile model were high, ranging from .824 to .962, indicating stability.

The eight profiles are shown in Fig. 3.

One-way between-groups multivariate analysis of variance (MANOVA) was performed to investigate profile differences in background variables. Six dependent variables were used: Gender, language at home, number of books at home, parents' highest educational level, parents' highest professional level and household income. Each profile versus the remaining group of students was successively taken to be the independent variable. The results are presented in Tables 2, 3, 4, 5, 6, 7. Assumption testing was conducted with no serious violations noted.

## Brief description of the eight profiles

Each profile is characterized with a label. These labels are tentatively assigned based on face validity. The labels have to be interpreted with caution, of course, as some of the background data, for example, is indicated by only one variable. The background variables were analysed for each profile relative to the remaining group of students (Tables 3–8).

*Profile 1* was the largest group comprising 42.8% of the students. It was a high performing group with an even profile, performing around 0.5 SD above the mean on all tasks, which indicates the operation of a general reading ability factor. There was no significant gender imbalance between this group and the remaining students. In all other respects there were highly significant differences. Most pronounced was the advantage of this group in relation to the remaining group concerning the number of books at home. Also, these students more often spoke Swedish at home, their parents were more highly educated, held higher professions, and they earned more money.

*Tentative label*: High performers with favourable social background.

*Profile 2* was the second largest group comprising 20.7% of the students. It was an average performing group. These students performed slightly better on documents than on connected prose. Word decoding and end-of-booklet scores were just above average. Thus, the performance profile was rather even in this group

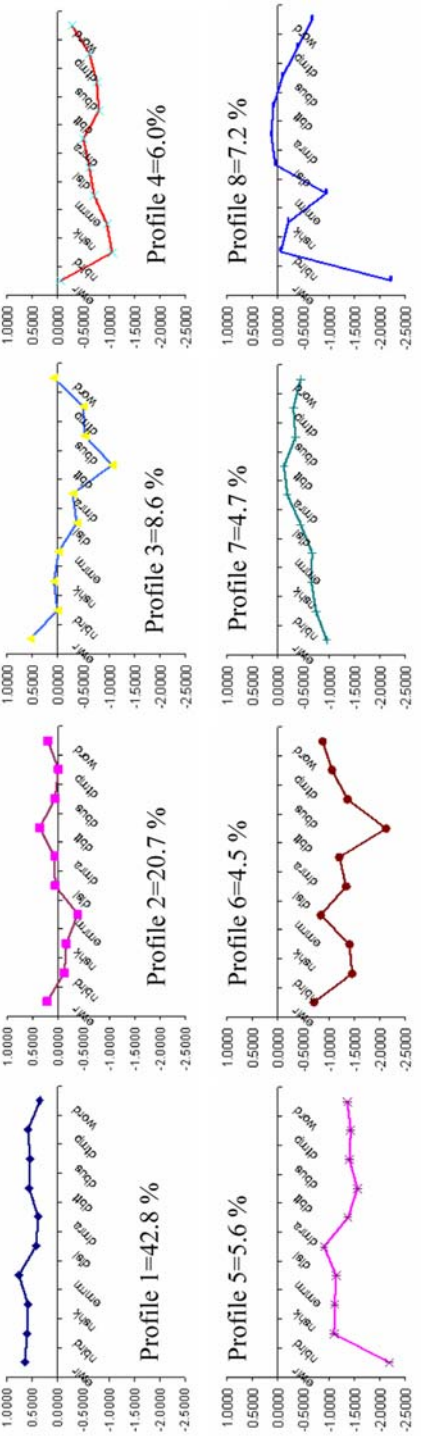


**Fig. 3** Eight profiles of reading performance. On the *x*-axis are the 10 performance variables, and on the *y*-axis are the *z*-scores of performance. For example, Profile 1 is a high performing group with an even profile. Profile 8 seems to be a typical dyslexia group with impaired word recognition, reasonable reading comprehension and good cognitive skills (documents)

**Table 3** A comparison between each profile and the remaining group on gender

| Profile | Boys (%) | Girls (%) | *F* |
|---|---|---|---|
| 1 | 49.5 | 50.5 | 0.96 |
| 2 | 50.6 | 49.4 | 0.02 |
| 3 | 43.3 | 56.7 | 10.21* |
| 4 | 54.6 | 45.4 | 0.80 |
| 5 | 57.4 | 42.6 | 4.50 |
| 6 | 56.8 | 43.2 | 3.76 |
| 7 | 54.5 | 45.5 | 0.65 |
| 8 | 50.4 | 49.6 | 0.10 |

* $p \leq .008$

**Table 4** How often Swedish is spoken at home (total mean = 2.88)

| Profile | *M* | SD | *F* |
|---|---|---|---|
| 1 | 2.95 | 0.26 | 65.74* |
| 2 | 2.87 | 0.41 | 5.40 |
| 3 | 2.89 | 0.40 | 0.20 |
| 4 | 2.80 | 0.49 | 15.56* |
| 5 | 2.84 | 0.47 | 6.69 |
| 6 | 2.78 | 0.52 | 17.50* |
| 7 | 2.80 | 0.52 | 14.10* |
| 8 | 2.91 | 0.33 | 0.27 |

* $p \leq .008$

**Table 5** Number of books at home (total mean = 7.79)

| Profile | *M* | SD | *F* |
|---|---|---|---|
| 1 | 8.29 | 1.69 | 192.72* |
| 2 | 7.69 | 1.93 | 7.06* |
| 3 | 7.63 | 1.93 | 4.72 |
| 4 | 6.90 | 2.18 | 57.26* |
| 5 | 7.29 | 1.94 | 19.80* |
| 6 | 6.79 | 2.36 | 53.87* |
| 7 | 7.34 | 2.04 | 13.37* |
| 8 | 7.76 | 1.78 | 0.53 |

* $p \leq .008$

**Table 6** Parental highest education (total mean = 5.40)

| Profile | *M* | SD | *F* |
|---|---|---|---|
| 1 | 5.85 | 1.97 | 158.54* |
| 2 | 5.29 | 2.01 | 4.23 |
| 3 | 5.12 | 2.04 | 8.20* |
| 4 | 4.87 | 1.93 | 17.32* |
| 5 | 4.78 | 1.97 | 23.57* |
| 6 | 4.76 | 2.07 | 18.50* |
| 7 | 4.94 | 1.93 | 10.98* |
| 8 | 5.00 | 1.91 | 13.83* |

* $p \leq .008$

**Table 7** Parental highest occupation (total mean = 2.13)

| Profile | *M* | SD | *F* |
|---|---|---|---|
| 1 | 2.29 | 0.75 | 122.01* |
| 2 | 2.09 | 0.80 | 3.53 |
| 3 | 2.05 | 0.80 | 4.57 |
| 4 | 1.91 | 0.77 | 19.54* |
| 5 | 1.95 | 0.77 | 13.26* |
| 6 | 1.85 | 0.81 | 23.08* |
| 7 | 1.94 | 0.80 | 12.17* |
| 8 | 2.04 | 0.79 | 5.06 |

* $p \leq .008$

**Table 8** Household income (total mean = 3.90)

| Profile | *M* | SD | *F* |
|---|---|---|---|
| 1 | 4.16 | 1.50 | 79.57* |
| 2 | 3.85 | 1.51 | 3.06 |
| 3 | 3.86 | 1.47 | 0.81 |
| 4 | 3.63 | 1.59 | 9.42* |
| 5 | 3.60 | 1.44 | 11.03* |
| 6 | 3.33 | 1.64 | 27.67* |
| 7 | 3.58 | 1.36 | 10.21* |
| 8 | 3.83 | 1.48 | 1.37 |

* $p \leq .008$

too. Apart from the number of books at home, to their disadvantage, there was no significant difference on any other background variable.

*Tentative label*: Average performers.

*Profile 3* comprised 8.6% of the students. They performed poorly on document tasks, but performed around average on connected prose and word decoding. Significantly more girls than boys were members of this group, and their parents were less educated than the remaining group. No other significant differences were observed.

*Tentative label*: Poor document readers, predominantly girls.

*Profile 4* comprised 6.0% of the students. They had average performance scores on word decoding and on end-of-booklet. On both connected prose and documents their performance scores were well below the mean (around 1 SD). There was no gender imbalance in this group. The students less often spoke Swedish at home, their parents were less educated, had lower professions and earned less money. The most pronounced significant difference was that this group had fewer books at home.

*Tentative label*: Average word decoders with poor comprehension (hyperlexic features).

*Profile 5* comprised 5.6% of the students. They performed around 1 SD below the mean on all tasks but the end-of-booklet task, where their scores were more than

2 SD below the mean. There was no gender imbalance and they spoke Swedish as often at home as the remaining group. Their parents were significantly less educated, had lower professions, earned less money and they had fewer books at home.

*Tentative label*: Generally poor and slow readers with poor cultural and socioeconomic background, garden-variety poor readers.

*Profile 6* comprised 4.5% of the students. The end-of-booklet scores and the word decoding scores were between 0.5 and 1 SD below the mean. Their performance scores on connected prose and documents were in general below this level, with a marked dip on the document passage "Empty bottles" to more than 2 SD below the mean. There was no gender imbalance in this group. Compared to the remaining group there were significant differences on all other background variables. They less often spoke Swedish at home, their parents were less educated, had lower professions, earned less money and, above all, they had fewer books at home.

*Tentative label*: Generally poor readers, less deficient on word decoding and from poor cultural and socioeconomic background, garden-variety poor readers.

*Profile 7* comprised 4.7% of the students. This group exhibited low performance on connected prose, around 0.5–1 SD below the mean, and more average performance, between 0 and 0.5 SD below the mean, on documents and word decoding. There was no gender imbalance in this group. On all other background variables there were significant differences compared to the remaining group. They spoke Swedish at home less often, their parents were less educated, had lower professions, earned less money, and they had fewer books at home.

*Tentative label*: Particularly poor on connected prose, possibly due to limited language skills.

*Profile 8* comprised 7.2% of the students. The average result on the end-of-booklet task in this group was more than 2 SD below the mean, and their word decoding was about 0.7 SD below the mean. They performed about average on connected prose with the exception of the passage "Marmots". The results on documents were slightly better than on connected prose. They performed just above the mean on four out of five tasks. They did not differ significantly from the remaining group on background variables, except for parents' educational level, which was lower in this group.

*Tentative label*: A dyslexic group.

## Subgroup stability

If we are to have confidence in these results there has also to be a considerable invariance in highly separate and distinct profiles when different numbers of profiles are specified. It seems like the dyslexia profile is such a distinct profile. This performance profile was distinguished already in a 4-profiles solution. However, in this profile there were an additional 157 students, who were distributed into other profiles (5–7) of poor readers in later steps of the analysis, and were thus not present in the 8-profiles solution. The high performing profile (Profile 1) and the poor comprehenders with hyperlexic features (Profile 4) were also identified already in

the 4-profiles solution. The fourth and remaining profile in this model was a group of generally poor readers. Thus, the latent profile analysis appears to have provided stable profiles of reading performance, especially of high performing students, poor comprehenders and dyslexic students.

Latent profile analysis has certain advantages compared to ordinary cluster analysis. The fit of the model is assessed, and the latent profiles obtained may well be used in further statistical calculations. Yet, it would further validate the procedures of latent profile analysis if the results could be replicated in a traditional cluster analysis. With focus on the dyslexia profile a K-means cluster analysis was conducted, as this method is suitable for large samples (SPSS, 1999). In an 8-cluster solution a cluster of 454 students with a dyslexic profile arose, 338 (74%) of these students were identical with the students identified in the dyslexia profile in the 8-profiles model of latent profile analysis. Thus, in addition to the dyslexia profile proving to be a very robust profile (identified already in the 4-profiles model of latent profile analysis), the finding by latent profile analysis was rather consistent with the finding by K-means cluster analysis. The concordant memberships across different clustering methods indicate internal validity.

Eight interpretable profiles were identified among more than 5,000 students in Study 1. The fact that they could be predicted theoretically validates the assumption of the profiles and the procedures to identify them, at least to some extent. However, the most important and convincing way to validate the finding of these profiles of performance is to explore the possibility of replicating the results in another large sample. As RL 2001 is a repeat study of RL 1991 it was very natural to turn to the older data. Thus, Study 2 was conducted with the intention of replicating Study 1.

## Study 2

### Participants

The sample consisted of 4,184 9-year-old students from the IEA Reading Literacy study in 1991, 2105 (50.3%) were boys and 2079 (49.7%) were girls. They were selected on the basis of having valid data for both booklets A and B.

### Instruments

The same 10 tasks as in Study 1 were included in the analysis and the same four aspects were considered (see Table 1). The first aspect was *word reading* assessed by the word recognition task. The second aspect was *connected prose*, the third aspect was *documents*, and the fourth aspect was *reading speed*, revealed in the word recognition task and by the end-of-booklet effect.

As a second step the profiles were compared on some background variables. In RL 1991 there was no parent questionnaire. Therefore the observed background variables on which the profiles were compared were reduced, in comparison to Study 1. Three different background variables were included, and information was

taken from the student questionnaire (*gender, number of books at home and language at home*).

The same methods of analysis were applied as in Study 1.

## Results

A short description of the profiles obtained in relation to reading patterns and background variables will follow. Then the profiles in Study 1 and Study 2 will be compared. Figure 4 shows the Sample-Size Adjusted BIC values, and Fig. 5 shows the Entropy, for the 2-profile model up to the 16-profile model. The Sample-Size Adjusted BIC value decreased up to a 16-profile model. Some profiles proved to be very sensitive to different start values and the Entropy measure did not continuously increase.

When scrutinizing the profiles, and weighing the Sample-Size Adjusted BIC value and the Entropy, an 8-profile model was identified as the best fitting model (Sample-Size Adjusted BIC = 98894.391; Entropy = 0.883.). The Sample-Size Adjusted BIC value and the Entropy were consistent when start values were varied. The eight profiles are shown in Fig. 6.

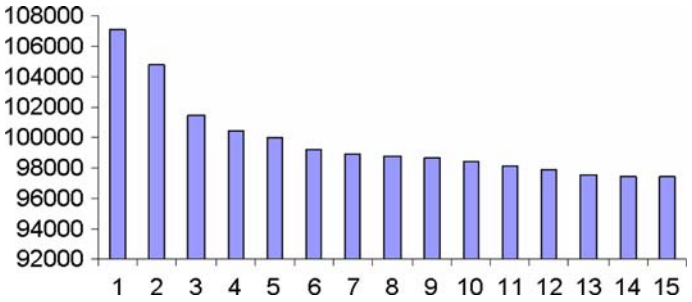


**Fig. 4** The Sample-Size Adjusted BIC values for a 2-profile model until a 16-profile model. Bar 1 is a 2-profile model, i.e. bar 7 is the 8-profile model

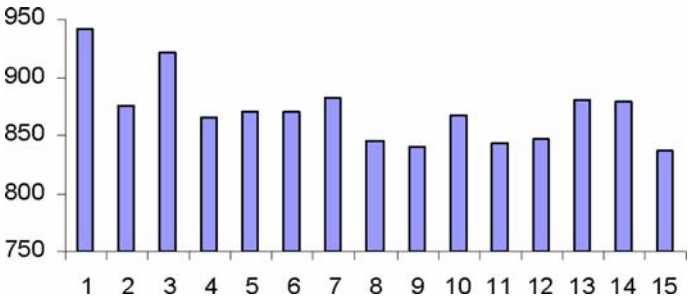


**Fig. 5** The Entropy values for a 2-profile model until a 16-profile model. Bar 1 is a 2-profile model, i.e. bar 7 is the 8-profile model

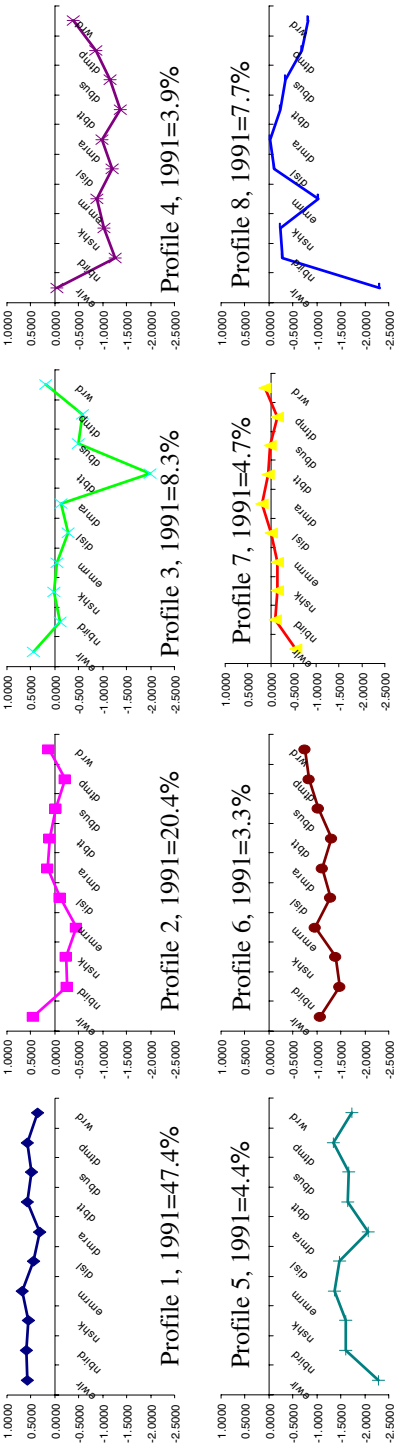


**Fig. 6** Eight profiles of reading performance. On the *x*-axis are the 10 performance variables, and on the *y*-axis are the *z*-scores of performance

**Table 9** A comparison between each profile and the remaining group on gender

| Profile | Boys (%) | Girls (%) | *F* |
|---|---|---|---|
| 1 | 48.5 | 51.5 | 5.15* |
| 2 | 50.0 | 50.0 | 0.01 |
| 3 | 41.8 | 58.2 | 4.69* |
| 4 | 51.1 | 48.9 | 0.04 |
| 5 | 57.7 | 42.3 | 4.38* |
| 6 | 55.1 | 44.9 | 1.27 |
| 7 | 49.7 | 50.3 | 0.06 |
| 8 | 60.1 | 39.9 | 13.30** |

* $p \leq .05$
** $p \leq .001$

**Table 10** How often Swedish is spoken at home (total mean = 2.87)

| Profile | *M* | SD | *F* |
|---|---|---|---|
| 1 | 2.93 | 0.33 | 68.19* |
| 2 | 2.86 | 0.46 | 0.88 |
| 3 | 2.84 | 0.47 | 0.87 |
| 4 | 2.70 | 0.60 | 31.17* |
| 5 | 2.67 | 0.60 | 45.08* |
| 6 | 2.67 | 0.61 | 33.38* |
| 7 | 2.86 | 0.44 | 0.24 |
| 8 | 2.89 | 0.39 | 0.48 |

* $p \leq .001$

**Table 11** Number of books at home (total mean = 5.12)

| Profile | *M* | SD | *F* |
|---|---|---|---|
| 1 | 5.27 | 1.00 | 68.34** |
| 2 | 5.04 | 1.17 | 4.64* |
| 3 | 4.95 | 1.17 | 3.89* |
| 4 | 4.76 | 1.39 | 18.74** |
| 5 | 4.76 | 1.53 | 20.69** |
| 6 | 4.76 | 1.42 | 13.88** |
| 7 | 5.08 | 1.12 | 0.34 |
| 8 | 5.08 | 1.27 | 0.43 |

* $p \leq .05$; ** $p \leq .001$

The profiles were compared on three background variables, *gender, language at home* and *number of books at home*. The results of one-way between-groups multivariate analysis of variance (MANOVA) are presented in Tables 9, 10 and 11.

Brief description of the eight profiles

*Profile 1* was the largest group comprising 47.4% of the students. It was a high performing group with an even profile, performing around 0.5 SD above the mean on all tasks. There were significantly more girls in this profile. Also, these students more often spoke Swedish at home and they had more books at home.

*Tentative label*: High performers with favourable social background.

*Profile 2* was the second largest group comprising 20.4%. It was an average performing group. These students performed slightly better on documents than on connected prose. Word decoding and end-of-booklet scores were just above average. The performance profile was rather even also in this group. Apart from the number of books at home, to their disadvantage, there was no significant difference on any other background variable. They spoke Swedish at home as often as did the remaining group, and there was no gender imbalance.

*Tentative label*: Average performers

*Profile 3* comprised 8.3% of the students. They performed poorly on document tasks, but performed around average on connected prose and word decoding. Significantly more girls than boys were members of this group, and they had fewer books at home. They spoke Swedish at home as often as did the remaining group

*Tentative label*: Poor document readers, predominantly girls.

*Profile 4* comprised 3.9% of the students. They had average performance scores on word decoding and end-of-booklet. On both connected prose and documents their performance scores were well below the mean (around 1–1.5 SD). There was no gender imbalance in this group, but the students less often spoke Swedish at home and they had fewer books at home.

*Tentative label*: Average word decoders with poor comprehension (hyperlexic features).

*Profile 5* comprised 4.4% of the students. They performed around 1.5–2 SD below the mean on all tasks but the end-of-booklet task, where their scores were almost 2.5 SD below the mean. There were significantly more boys than girls in this profile. They spoke Swedish less often at home, and they had fewer books at home.

*Tentative label*: Generally poor and slow readers from poor cultural background, garden-variety poor readers.

*Profile 6* was the smallest profile comprising 3.3% of the students. All their performance scores were between 1 and 1.5 SD below the mean. They spoke Swedish less often at home, and they had fewer books at home.

*Tentative label*: Generally poor readers, less deficient on word decoding and from poor cultural background, garden-variety poor readers.

*Profile 7* comprised 4.7% of the students. It was an average performing group. Their background data did not differ from the remaining group.

*Tentative label*: Average readers, somewhat poor performance on connected prose.

*Profile 8* comprised 7.7% of the students. The average result on the end-of-booklet task in this group was almost 2.5 SD below the mean, and on word decoding it was about 1 SD below the mean. They performed about average on connected prose with the exception of the passage "Marmots". The results on documents were slightly better than on connected prose. There were significantly more boys in this profile. Otherwise they did not differ from the remaining group on the background variables.

*Tentative label*: A dyslexic group.

In Fig. 7 the profiles of reading performance from Study 1 and Study 2 are shown in corresponding pairs of similar performance patterns.

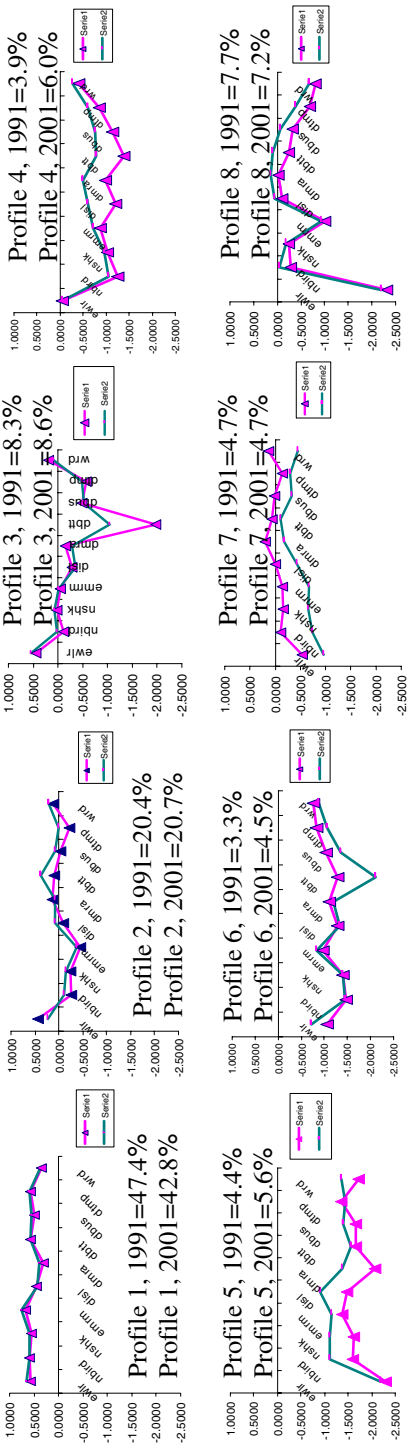


**Fig. 7** A comparison of the eight corresponding profiles of reading performance from RL 1991 and RL 2001

Each profile in Study 2 corresponded well with a profile in Study 1. Only three of the six background variables in Study 1 were included in Study 2. Consequently, differences and similarities could only be examined with respect to these variables. On the whole the profiles in the two studies had the same patterns of background variables. The most pronounced differences were that Profiles 5 and 8 included relatively more boys than girls in study 2, and Profile 1 included more girls than boys.

## Discussion

The present studies have demonstrated that it is possible to identify stable and interpretable subgroups of readers by using latent profile analysis. Large samples, 9,283 students altogether, were subgrouped on the basis of different performance measures with four aspects in focus: reading of continuous texts, reading of document texts, word reading and reading speed. Eight profiles of reading performance were obtained where good and average readers exhibited even profiles of reading performance whereas poor readers showed more heterogeneous patterns of performance.

The results were based on data from the Swedish part of the IEA Reading Literacy Studies 1991 and 2001. The whole idea of these large international studies is that it is feasible to assess students' literacy skills and compare them across different cultures and languages. These surveys are based on the assumption that it is possible to compare reading ability across countries by minimizing cultural bias in the selection of texts. Others (e.g. Tierney, 1998) claim that assessments should be based on cultural sensitivity and be open-ended, and that there is no way to do prepackaged assessment. According to Tierney and others learning is always situation-specific and of an ongoing constructive nature. However, Gustafsson and Rosén (2003) have identified a general factor of reading performance in both the Swedish RL 2001 and the PIRLS study. Although the RL 2001 study included almost only multiple-choice items, and the PIRLS study had open-ended items the general factor found in each study captured the same ability, *comprehension in reading continuous text*. Other dimensions were documents, reading speed (RL 2001) and constructed response (PIRLS).

The large samples of the RL 1991 and RL 2001 studies offered a unique opportunity to find subgroups of sufficient size, and eight interpretable profiles were identified. Around 65–75% of the samples in the two studies belonged either to a high performing or an average performing profile. They exhibited good literacy skills irrespective of whether it was a task in the domain of documents, connected prose or word recognition. It appears that a characteristic of a good reader is an even profile of good reading, which is not dependent on any specific domain of interest. Thus, these studies support the view that proficiency in reading holds a high degree of generality. However, good reading skills are not always sufficient for the cognitive skills required when processing information about tables, graphs and maps as in document tasks (Gustafsson, 1995).

On the other hand, poor readers do not seem to be a homogeneous group. Profiles 3–7 (7 only in Study 1) and 8 exhibited different patterns of poor reading

performance. Thus, a good reason for subgrouping is to find patterns of poor reading that can form a foundation for educational intervention.

There were more girls than boys in Profile 3 in both studies. This group did well on both word decoding and continuous texts so it is doubtful if they should be labelled poor readers at all. However, they did not reach average performance on document tasks, which require other cognitive skills than fluent reading. The prevalence of more girls than boys in this profile is consistent with other findings (Gustafsson, 1995; Wagemaker, Taube, Munck, Kontogiannopoulou-Polydorides, & Martin, 1996) showing that girls perform worse on document tasks relative to reading of continuous texts, in comparison to boys.

In Profile 4 the students exhibited normal word recognition skills but poor reading comprehension on both connected prose and documents. It may be hypothesized that they were students with poor linguistic comprehension, possibly due to low general comprehension. However, around 20% of the students in this profile never, or only sometimes, spoke Swedish at home. The latter students' poor performance in reading comprehension is likely to be due to poor vocabulary and/or cultural factors.

Students in Profiles 5 and 6 were generally low performers, and the difference in performance scores between them was rather more quantitative than qualitative. Both groups had fewer books at home compared to the remaining group, and they also spoke Swedish less often (the latter is apart from Profile 5 in Study 1). This indicates that their poor performance, at least partly, could be due to limited exposure to text. There were more boys in Profile 5, and the students in this profile were also the most impaired readers. The same pattern of more boys among the poorest readers has been observed in other studies (Høien & Lundberg, 2000). Poor performance on the end-of-booklet task can, apart from deficient reading fluency, also be a sign of lack of motivation. In this case that might be the best interpretation of the dip on the end-of-booklet passage, especially as the tests were taken anonymously.

The overall impression is that Profile 7 in Study 1 and Profile 7 in Study 2 had the same patterns of reading performance even though there was some notable difference in elevation. Their performance profile in Study 1 is in line with the idea that immigrant children do not have to exhibit deficient word recognition skills, but might have impaired vocabulary and have limited exposure to continuous texts. Yet, they might manage short texts, as the document tasks, better than tasks on continuous texts. In Study 2 the students in this profile were average readers with just slightly worse performance on connected prose, but in this profile immigrant children were not overrepresented. The differences in distribution of immigrant students between the samples from RL 1991 and from RL 2001 are likely to be due to the fact that both the quantity of immigrants and the character of immigration to Sweden have changed during these 10 years.

The students in Profile 8 exhibited low performance on the end-of-booklet task together with slow and/or error prone word decoding. This is a core symptom of dyslexia (Lundberg, 1999). They performed around average on connected prose with one exception. The dip on the "Marmots" passage in both studies could be explained by the fact that this passage is close to the end of booklet B, and around

1–1.5% never reached this passage (Gustafsson, Rosén, & Myrberg, 2003). The results on documents were slightly better than on connected prose. This feature of slow and error prone word decoding, combined with sufficient reading comprehension and good cognitive skills (Frith, 1997) when only very limited reading is required seems to fit a dyslexic profile. In line with a dyslexic profile is also the percentage of students (7.2%) included in this profile; a typical frequency of dyslexia reported in many studies is 5–8% (e.g. Lundberg, 1985; Ramus, 2004). In Study 1 there was no gender imbalance in this profile, whereas there were significantly more boys in Study 2, which is in accordance with the common view on dyslexia. In Study 1 (no available data for Study 2) the students' parents were less educated compared to the parents of the remaining group. This is not surprising considering the fact that the phonological deficit in dyslexia is highly inheritable (for a review see Grigorenko, 2001; Ramus, 2006).

To sum up, there were more girls than boys in the highest performing profile, and there were more boys than girls in the lowest performing profile. The best performing profile had a higher number of books at home, and the lower performing profiles had fewer books at home, with the expected exception of the dyslexic profile. Also, the students in the dyslexic profile spoke Swedish at home as often as did the remaining group, in contrast to the other low-performing profiles, who spoke Swedish at home less often.

Five profiles of reading performance were hypothesized in this paper. However, an even more diversified picture emerged in the empirical results. Profile 3 was not expected, even though it nicely fits with the assumption that document tasks require other cognitive skills than connected prose (Gustafsson, 1995). These students had average performance on word decoding and on connected prose, but could not meet the cognitive demands from document tasks. Average performing students, Profile 2, turned out to be a distinct profile, and garden-variety poor readers fell out into two separate profiles (Profiles 5 and 6). Yet, the three most stable profiles were hypothesized, i.e. high performing students, poor comprehenders and dyslexic students.

For a future study it would be desirable to have more variables included, such as measures on motivation and more stable measures on word decoding and fluency. Measures on listening comprehension would contribute with essential information together with the existing measures on word recognition skills. As dyslexia is basically a phonological deficit, tasks measuring phonological abilities would be highly valuable in the efforts to identify a dyslexic profile.

One aim of this study was to explore if latent profile analysis gives stable and interpretable results, as the method has not been used in this context before. In the two studies presented here the eight profiles obtained showed to be interpretable from a theory-based point of view. Above all, the successful cross-validation of profiles of reading performance in Study 1 and Study 2 indicates that latent profile analysis is a relevant tool in this context. Most of the comparable background variables (gender, language at home and number of books at home) were consistent in the corresponding profiles of the two studies. Also, the dispersion of background variables was in accordance with what was hypothesized, thus, validating the obtained profiles.

The following conclusions can be made:

1. Latent profile analysis proved to be a feasible methodology. The results were robust, stable and interpretable.
2. The two largest profiles, good and average readers, showed an even profile of performance implying that reading is a skill with high transfer and generality.
3. Poor readers are not a homogeneous group. Several subgroups of poor readers were identified, an observation with educational implications.

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