



Spelling problemse in Danish

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Spelling Problems in Danish

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Resume af afhandlingen

Afhandlingen beskriver udvalgte staveproblemer hos danske børn. Et af formålene var at undersøge hvordan staveudviklingen påvirkes af det forhold at dansk er en 'dyb' ortografi, hvor stavemåder ikke altid kan forudsiges ud fra den enkelte lyd. Resultaterne viser at danske børn har betydelige problemer med uforudsigelige stavemåder - det gælder både ordspecifikke stavemåder, stavemåder der afhænger af den lydlige sammenhæng (fx brugen af fordoblet konsonant efter kort vokal) og grammatisk bestemte stavemåder (fx nutidsverber på *-rer*). Tilmed helt forudsigelige stavemåder (konsonantgrupper) lader til at give særlige problemer i dansk.

Et andet formål var at undersøge sammenhængen mellem sproglig opmærksomhed og stavefærdigheder hos større børn. Der viste sig klare sammenhænge mellem opmærksomhed på vokallængde og hyppigheden af fordoblingsfejl og mellem opmærksomhed på grammatiske kategorier og hyppigheden af grammatiske stavefejl. Sproglig opmærksomhed ser ud til også hos større børn at være afgørende for udviklingen af stavefærdighed.

Samlet set peger afhandlingen på at det er vigtigt at skelne mellem staveproblemer på forskellige sproglige niveauer hvis man skal hjælpe børn med at overvinde de særlige vanskeligheder i dansk ortografi.

Abstract

The dissertation describes selected spelling problems in Danish children. One purpose was to examine how the development of spelling competence is influenced by the fact that Danish is a 'deep' orthography where spellings are not always predictable from isolated sound segments. The results indicate that Danish children have considerable problems with unpredictable spellings - both with respect to word-specific spellings, spellings that are sensitive to the phonological context (e.g. the use of consonant doublets after short vowels) and grammatically defined spellings (e.g. present tense verbs in *-rer*). Even entirely predictable spellings (consonant clusters) seem to be a source specific problems in Danish.

A second purpose was to examine the relation between linguistic awareness and spelling skills in older children. Strong links were found between awareness of vowel quantity and the frequency of doubling errors and between awareness of grammatical categories and the frequency of grammatical spelling errors. Linguistic awareness appears to be essential even to the spelling development of older children.

Overall, the dissertation suggests that it is important to distinguish between spelling problems at different linguistic levels in order to help children to overcome the specific difficulties of Danish orthography.

List of studies

Study 1

HOLGER JUUL & BALDUR SIGURÐSSON

Orthography as a handicap? A direct comparison of spelling acquisition in Danish and Icelandic. Manuscript to appear in *Scandinavian Journal of Psychology*

Study 2

HOLGER JUUL

Knowledge of context sensitive spellings as a component of spelling competence: Evidence from Danish. Manuscript to appear in *Applied Psycholinguistics*

Study 3

HOLGER JUUL

Phonemic quantity awareness and the consonant doublet problem. Manuscript submitted for publication

Study 4

HOLGER JUUL & CARSTEN ELBRO

The links between grammar and spelling: A cognitive hurdle in deep orthographies? Manuscript to appear in *Reading & Writing: An Interdisciplinary Journal*

Study 5

HOLGER JUUL

Grammatical awareness and the spelling of inflectional morphemes in Danish. Manuscript to appear in *International Journal of Applied Linguistics*

Introduction to the dissertation

The present dissertation consists of five studies which deal with spelling problems* in Danish. The dissertation addresses two main hypotheses:

- 1) The acquisition of spelling competence in Danish is difficult because Danish is a ‘deep’ orthography.
- 2) Some of the most persistent spelling problems in Danish are associated with a lack of linguistic awareness.

The five studies are intended as a contribution to the field of applied linguistics and, more specifically, to the field of reading research (which includes research on spelling). In a recent paper Keith Stanovich (2003) described a style of science which characterises many leading reading researchers. In their attempt to understand the psychological processes that underlie the act of reading (and spelling), says Stanovich, these researchers are biased towards analytic reductionism rather than holism, and they are concerned with probabilistic predictions and explanations rather than with individual cases.

This is very much the style of science that I try to do! I do not intend to describe all aspects of the lives of the children studied which may in one way or another affect their development of spelling competence. And I am not trying to understand each and every spelling error in each and every participant in the studies presented. I am merely trying to find out whether it is *likely* that the development of spelling competence is affected by the specific nature of Danish orthography. And I am trying to find out whether it is *likely* that linguistic awareness in an individual is associated with his/her development of spelling competence. This is not to deny the complexity of the children and their environments. As Stanovich puts it, “the analytic stance is a calculated gamble.”

Stanovich also points out a gap between the goals of researchers and the goals of teachers. Teachers have a natural desire to help every child in their classroom. Probabilistic answers may seem inadequate if you want to know why one particular child finds it hard to spell, or if you want to know what caused some particular spelling error. It is an important point, however, that this inadequacy does not mean that probabilistic answers are wrong, or that they cannot be helpful in

* The misspelling *problemse* in the title of the dissertation is inspired by Kemp and Bryant’s (2003) paper on the plural *-s* problem in English.

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deciding how to tackle the problems of teaching spelling. The present dissertation does not have an answer to everything one might want to know about spelling in Danish - very far from, I am afraid! - and it has little to say about the effects of specific teaching methods on spelling development. However, the findings presented do have some important implications for the teaching of spelling. I return to this issue in the perspectives section of this introduction.

Below, I first specify my definitions of spelling and spelling problems. These definitions are based on considerations of the general nature of writing systems. The nature of Danish orthography in particular is discussed in order to approach the range of spelling problems one can expect to find in Danish spellers. Then, in the sections that follow, I present the main hypotheses in more detail as well as the methods used to test them. Finally, summaries of the five studies and a discussion of the perspectives of the findings are provided.

On spelling problems in general - and in Danish

Writing as a representation of spoken language

Being able to spell is to be able to represent spoken language by written symbols in a conventional way. This is the definition of spelling competence on which the present dissertation is based. 'Spelling problems' will be defined accordingly as problems with the use of conventional representations of spoken language.

On this definition, written language is secondary to spoken language. There are other ways of approaching written language, of course. It is perfectly legitimate to describe writing systems as semiotic systems in their own right, without reference to speech (Carney, 1994; Harris, 1995; Venezky, 1999). Another possibility is to describe writing as a parallel to spoken language where the content side of morphemes is shared in the spoken and written modality, but where the expression side differs: phonology in the case of spoken language, orthography in the case of writing (Spang-Hanssen, 1974). However, there can be no doubt that people do use written language to represent speech. Indeed, full writing systems - defined by DeFrancis (1989) as writing systems which permit the expression of 'any and all thought' - are *always* linked to a spoken language (Perfetti, 2003).

It is worth noting that in his classification of writing systems, Sampson (1985) does include a distinction between 'semasiographic' and 'glottographic' writing, where semasiographic writing is writing which does convey a message in a conventional way, but which - in contrast to glottographic writing - does not correspond to any particular wording of a spoken language utterance. For instance, a road sign can convey a message for which no particular phrasing in any particular spoken language can be considered correct. Equally correct 'readings' of road sign

could be 'no left turn', 'do not turn left', 'you shouldn't make a left turn here, mate' etc.

However, DeFrancis (1989) very amusingly demonstrated that Sampson's most elaborate specimen of semasiographic writing, a 'letter' sent by a young girl of the Yukaghir tribe of north-eastern Siberia, was really not at all a letter in the conventional sense of this word. Had it been a genuine letter, then anybody familiar with the conventions of Yukaghir writing should be able to decode the message from the visual symbols alone. Apparently this was not the case. All full writing systems are glottographic in nature: They represent spoken language.

How is spoken language represented by writing?

What, then, are the elements of spoken languages which competent writers/spellers are able to represent? The answer to this question depends on the specific writing system considered. A standard distinction among writing systems is between phonographic writing systems, in which the basic unit of representation is a phonological unit, such as the phoneme or the syllable, and logographic writing systems in which the basic unit of representation is a meaningful unit, such as the word or the morpheme (Sampson, 1985).

From the point of view of normal language users, however, *all* writing systems are logographic. What would a writer want to write, and what would a reader want to read, if not meaningful elements of spoken language making up meaningful utterances? What distinguishes writing systems from each other are the *ways* in which meaningful elements are represented by written symbols. It is a commonplace in linguistics that meaningful elements of spoken language can be described as signs having a content side (the meaning) and an expression side (the pronunciation). In principle, these signs can be represented in three different ways. The first option is to represent the content side, the second is to represent the expression side, and the third is to represent the sign as such.

The first option can be illustrated by symbols such as ♂ and ♀ which can be said to represent the semantic features 'male' and 'female'. In principle, combinations of such semantic symbols could be used to represent morphemes, but in practice writing systems do not exploit this option much. Chinese writing is famous for having semantic determinatives, but no writing system is based exclusively on semantic symbols.

The second option, the phonographic option goes without introduction. Phonographic writing can be subclassified according to the basic unit of representation, primarily syllables (syllabic writing) or phonemes (alphabetic writing). Danish orthography is an alphabetic writing system.

The third option is to represent the linguistic sign (the word or morpheme) as such. The 'logographic' symbol \$, for instance, can be said to represent the word 'dollar'. Neither the meaning nor the pronunciation of the word is represented

directly. The same can be said of the basic numerals. The numeral symbol 3 represents the word '*three*', but it neither represents the meaning nor the pronunciation of that word.

Curiously, classifications of writing systems tend to conflate the first and the third options under the heading of 'logographic' or 'morphemic' writing (see DeFrancis (1989) for a survey of classificational schemes). However, there can be no doubt that the second option, phonographic writing, is far more important than the other two. First of all, phonographic writing is *productive*. Any word can be represented, whether the spelling is known in advance or not. By contrast, logographic symbols have to be learned in advance. If one does not know that '*dollar*' can be represented by the symbol \$, then there is no chance of guessing. Secondly, the analysis of any new word is a fairly straightforward matter, once the principles of phonological analysis are understood. By contrast, it is probably impossible to devise a system of semantic analysis which can be applied in a similar straightforward manner to any word whatsoever. Finally, phonographic writing, and especially alphabetic writing, is economical because a fairly limited number of written symbols suffices to represent the spoken language inventory of phonological units.

Given these advantages of phonographic writing it should perhaps not come as a surprise that all the major writing systems of the world can be said to be phonographic at least in part (DeFrancis, 1989; Mattingly, 1992). According to some scholars, even Chinese, the standard example of a 'logographic' writing system, is better described as a phonographic (syllabic) writing system (see DeFrancis, 1989, for a discussion of Chinese).

What is represented in alphabetic writing systems?

The important point in the present context, of course, is that Danish orthography is an alphabetic writing system. This seems to suggest that spelling in Danish is primarily a question of representing phonemes. However, matters are rather more complicated, and this is why the three representational options of writing systems were worth spelling out.

In alphabetic writing systems the spelling of a word can be related to its phonemic structure (its expression side), but this does not mean that the phoneme is the *only* unit that spellers can represent. It is a logical possibility, for instance, to ignore the phonemic level and to write alphabetic words as logographs. Representing phonological units is *practical*, for the reasons described above, but it is rarely an end in itself. Representing phonology serves a communicative purpose indirectly, as a means of representing words. Indeed, the orthographic word (defined as a sequence of letters between spaces which usually corresponds to a spoken word) is a basic orthographic unit as well as the letter (defined as an indivisible visual character which usually corresponds to a phoneme).

It is also important to note that alphabetic writing systems are standardised at the level of the word, not at the level of the phoneme. When pronunciations of a word vary, there is a conflict between the word level and the phonological level: At what level should the representation be consistent? In such conflicts the word level usually ‘wins out’. Even people who do not pronounce the *H*’s of *Henry Higgins* have to write them. Thus, although spellings can be said to represent information about the phonemic structure of words, an orthography is not a sound script like the International Phonetic Alphabet which is used to record *exact* pronunciations. It is possible, of course, to represent variations in the pronunciation of a word orthographically, but orthographies have many shortcomings in this respect.

In short, alphabetic writing systems represent words as well as phonemes, and the use an alphabetic orthography can, in principle, be a matter of representing words as much as a matter of representing phonemes. From the start, then, it seems useful to make a distinction between lexical spelling knowledge (i.e., knowledge of the way specific words are represented in writing) and phonological spelling knowledge (i.e., knowledge of the way phonological units are represented in writing). Whether and to what extent spellers rely on one or the other kind of spelling knowledge is an empirical question.

What spellers in Danish and other alphabetic writing systems definitely do *not* represent is meaning. It is important to make this point because it is sometimes claimed that cases where morphemes are spelled in a consistent way in spite of changes in pronunciation – cf. English *dogs/cats*, *heal/health*, *paradigm/paradigmatic*, etc. - are examples of spellings that represent a *meaning* layer of information (e.g. Templeton & Morris, 2000). This claim is, at best, confusing. The identification of a morpheme does require that its meaning be identified, but the consistent representation of morphemes in writing does not involve the representation of semantic features.

Possible spelling problems in Danish

As argued in the preceding section, both lexical and phonological spelling knowledge are potentially important to users of alphabetic writing systems. However, the relative importance of the two may differ from one orthography to the other, because orthographies differ with respect to the consistency with which phonemes are represented in writing. Some orthographies are classified as ‘shallow’ (or ‘regular’ or ‘transparent’) because spellings tend to be very consistent - and thus predictable - at the level of the phoneme. In such orthographies - Finnish, for instance - lexical spelling knowledge may still be useful, but to the extent that spellings are predictable from standard pronunciations, it is not strictly necessary. By contrast, Danish can be classified as a ‘deep’ (or ‘irregular’ or ‘opaque’) orthography, because spellings are often inconsistent - and thus not entirely predictable - at the level of the phoneme. The same is true of English, which is

without doubt the language most often studied in reading research. In orthographies like Danish and English lexical spelling knowledge is often necessary if one is to spell correctly.

As a consequence, it seems especially important to assess the degree to which spellers have problems with the representation of words when the object of study is a deep orthography. It must be pointed out that the need for lexical spelling knowledge in deep orthographies does not mean that spellings have to be learned as logographs. Usually, the greater part of a word is predictable from phonology, while only certain aspects of its spelling are word-specific. A case in point is the use of singleton vs. doublet consonant spellings for intervocalic consonants after short unstressed vowels in Danish. For instance, a singleton *l* is used in the word *salat* ‘salad’ (pronounced with stress on the second syllable) while a doublet *ll* is used in the word *fallit* ‘bankrupt’ (also stressed on the second syllable). The only way of learning the correct spellings of these words is to learn whether the medial /l/ of each particular word should be spelled with or without a doublet. Apart from the spelling of the medial /l/, however, the spellings of these words are phonemically straightforward. Thus, although phonological spelling knowledge is not sufficient if one is to spell correctly, it may still be most useful.

Another characteristic of the deep Danish orthography is that the spellings of particular phonemes can be sensitive to the phonological context. This means that inconsistencies at the level of the phoneme can be reduced or even eliminated if the context of the phoneme is considered. As demonstrated above, the spelling of intervocalic consonant phonemes is inconsistent, as they can be represented either by a singleton consonant or a doublet. However, when consonants follow a *stressed* vowel, the use of singleton consonants vs. doublets is largely predictable: Doublet spellings apply after short vowels only.

Exploiting this context sensitivity of spellings requires spellers to consider units larger than single phoneme. Spellers in shallow orthographies, where spellings are predictable at the level of the phoneme, may be able to represent larger units, too, of course. But to spellers in deep orthographies this ability may be especially useful, or even necessary. Thus, it seems important to assess the degree to which spellers in deep orthographies have problems with the conventional representation of units larger than the single phoneme.

Yet another important characteristic of Danish orthography is the fact that spellings tend to be consistent at the level of the morpheme, even when the pronunciation varies (i.e., in cases of allomorphy) - cf. the English examples such as *heal/health* referred to above. In other words, the morpheme level tends to win out in cases of conflict with the phoneme level. For instance, the Danish morpheme corresponding to English ‘bake’ is consistently spelled *bag* in the infinitive *bage* ‘bake’, the past participle *bagt* ‘baked’ and in the compound word *bagværk* ‘pastry’, although the pronunciation varies: In the three words cited, the letter *g* represents three

different phonemes, viz. /j/, /k/ and /v/ (Grønnum, 1998). Shallow orthographies tend to be consistent at the level of the phoneme, rather than at the level of the morpheme. In Finnish, for instance, different phonemes have different spellings, even when this leads to morpheme level inconsistency.

As a consequence, morpheme level spelling knowledge may be especially useful, or even necessary for spellers in a deep orthography such as Danish. Thus, it seems important to assess the degree to which Danish spellers have problems with the representation of morphemes.

It should be noted that, originally, the notion of orthographic depth refers to a distinction between ‘deep’ phonology and ‘surface’ phonology (Sampson, 1985), where deep phonology is a rather abstract, morphophonemic level of phonological representation. For instance, the *g*’s of the Danish words *bage*, *bagt* and *bagværk* can be said to represent the same morphophoneme /g/ from which the surface phonemes /j/, /k/ and /v/ (corresponding more closely to the actual pronunciations) can be derived through a set of ordered rules (Grønnum, 1998). Thus, the phonemic correspondences of the letter *g* are consistent at the level of ‘deep’ phonology, although they are inconsistent at the level of ‘surface’ phonology. However, only *some* surface phonology inconsistencies are accounted for by a more abstract phonological analysis, and the notion of orthographic depth is often used in a broader sense simply as a label for orthographies with many inconsistencies at the level of the (surface) phoneme. I use the term in this broader sense.

Summing up, spelling problems in Danish can, in principle, be problems with the conventional representation of spoken language units at various linguistic levels. These include isolated phonemes, phonemes in a particular context, morphemes, and words.

The main hypotheses

The acquisition of spelling competence in Danish is difficult because Danish is a ‘deep’ orthography

As explained in the introduction to Study 1, differences between deep and shallow orthographies are interesting for several reasons. Understanding how specific orthographic features affect the acquisition of literacy skills is theoretically interesting; it can give us important information about what reading and spelling are all about. Such an understanding is also of practical relevance. In the early 1990’s a cross-national evaluation of educational achievement with respect to children’s reading abilities came as a shock to the Danish public because it indicated that Danish children were much poorer readers than children in the other Nordic countries (Elley, 1992). In interpreting such a result it is important to know whether the task of becoming literate is similar across orthographies. Is it possible that the

acquisition of literacy skills is *intrinsically* more difficult in Danish? The present dissertation seeks an answer to this question with respect to spelling. Identifying specific problems in learning to spell in Danish is also relevant to instruction, of course. If certain aspects of literacy acquisition require special attention in a Danish context, it is certainly important that we know what these aspects are.

The present dissertation deals with the issue of orthographic depth in a number of ways. One way was simply to assess the extent to which Danish spellers have problems with the representation of spoken language units at linguistic levels which are more important in deep orthographies than in shallow orthographies. For instance, Study 4 and 5 assess Danish students' problems with the representation of inflectional morphemes. In shallow orthographies the spellings of inflectional morphemes are predictable at the phonemic level, and thus morpheme level spelling knowledge is not so important - whereas in Danish morpheme level spelling knowledge is often essential to correct spelling. To the extent that problems with the spelling of inflectional morphemes persist in Danish spellers, spelling in Danish can be said to be more difficult than spelling in a shallow orthography, simply because spellers in shallow orthographies do not have to deal with such problems.

In Study 2, the degree to which spellers had problems with context sensitive and word-specific spellings were directly compared to the degree to which they had problems with spellings that are predictable from phonemes considered in isolation. Again, as spellings in shallow orthographies tend to be predictable, the difficulty of learning to spell in Danish can be inferred if context sensitive and word-specific spellings are more difficult than predictable spellings. The language internal comparison in Study 2 made it possible to ask *how* much easier it was to use predictable spellings.

A cross-linguistic comparison was employed in Study 1. Here, the focus was on the development of phonemic encoding skills in Danish as compared to Icelandic, a more shallow orthography. The hypothesis addressed, was that the inconsistencies of deep orthographies tend to delay the acquisition of phonemic encoding skills. However, problems with phoneme level encoding are not specific to deep orthographies. A direct cross-linguistic comparison was needed to show whether the size of these problems were associated with orthographic depth.

Some of the most persistent spelling problems in Danish are associated with a lack of linguistic awareness

One thing is to establish whether and to what degree Danish children are characterised by certain types of spelling problems. Another thing is to find out what it takes to overcome those problems.

If spelling ability is a matter of representing spoken language units by conventional orthographic units (cf. above), it is natural, in a way, to ask whether spelling problems can be ascribed to insufficient knowledge of either the relevant

spoken language units or the relevant orthographic units. Most children that come to school are quite aware that writing is about putting words on paper. They know about words (a relevant linguistic unit), but they have little knowledge of orthographic units that can be used to represent words. These units often consist of several letters, and usually children know just a few such units when they begin school, e.g. the spelling of their own name. Conversely, children at the beginning of school usually have some knowledge of letters (a relevant orthographic unit), but typically their knowledge of the spoken language units that can be represented by letters (*viz.* phonemes) is limited.

A part of the problem of becoming literate, then, is to make ends meet (Brown & Ellis, 1994). In order to be able to make links between spoken and written language, children need to refine either their knowledge of spoken language units or their knowledge of orthographic units - or both. So a big question is – and has been – whether specific types of knowledge are especially important to the development of literacy skills.

Many studies from the past decades have indicated that awareness of phonemes is particularly important for the development of reading and spelling skills (Caravolas, Hulme, & Snowling, 2001; Scarborough, 1998). This is also the conclusion drawn from studies of Danish children (Elbro, Borstrøm, & Petersen, 1998; Lundberg, Frost, & Petersen, 1988). Children with poor phonemic awareness are at risk for reading and spelling disabilities. The present dissertation asks whether certain specific spelling problems in children beyond the earliest grades are also associated with a lack of linguistic awareness. For instance: Do Danish children who fail to use consonant doublets after stressed short vowels have a poorer awareness of vowels or vowel quantity than children who use doublets correctly? Do Danish children who misspell certain inflectional morphemes have a poorer awareness of grammar than children who spell those inflections correctly? These aspects of linguistic awareness and spelling competence have received relatively little attention in previous studies.

The most important way of studying the relevance of linguistic awareness to spelling development is to ask how measures of linguistic awareness relate to spelling development. Such questions are addressed in Study 3 and 5. The crucial question is, of course, not merely whether linguistic awareness is related to spelling development, but whether this relation is causal. I return to the issue of causality in the next section. In Study 4, the relevance of linguistic awareness to spelling development is studied in a more tentative manner. Here, the question asked was whether measures of spelling development which were hypothesised to depend on the same kind of linguistic awareness (*viz.* grammatical awareness) correlated among themselves.

It should be pointed out that linguistic awareness differences are not necessarily associated with spelling problems. Even in the case of basic phoneme

level encoding skills, spellers may have problems although they do have sufficient knowledge of both phonemes and letters. In order to establish and exploit the links between spoken and written language units, practice is needed, too! Likewise, it is possible that Danish spellers who are perfectly aware of vowel quantity differences continue to have problems with the use of consonant doublets, or that spellers who are quite familiar with grammatical categories continue to have problems with the spelling of inflectional morphemes. Furthermore, from the fact that, in principle, a link between spoken and written language can be made, it does not follow that spellers in real life actually employ that link.

Finally, it should be pointed out that problems with linguistic awareness are unlikely to explain all spelling problems in Danish spellers beyond the earliest grades. Given that even beginners are familiar with words, problems with word-specific spellings can hardly be due to a lack of word awareness. Here, knowledge of the orthographic units - the conventions applying to individual words – are more likely to be the problem than knowledge of the linguistic units.

Methodological considerations

On causal relations

The dissertation is concerned with possible causes of spelling development. The main questions are whether the development of spelling competence in Danish is delayed because Danish is a deep orthography, and whether individual differences in spelling competence can be due to differences in linguistic awareness. In order to demonstrate such causal relationships, the first step is to establish whether spelling competence in Danish is in fact associated with the presumed causal factors. Is there an association between orthographic depth and the development of spelling competence? Is there an association between specific aspects of linguistic awareness and spelling competence? The plausibility of a causal relationship will be reduced, if such associations cannot be observed.

In some cases only this initial step is taken in the present dissertation. And in some cases this initial step may in fact suffice to render a causal relationship plausible. Thus, from the observation that word-specific spellings are a major obstacle to the development of spelling competence, one can conclude that the nature of Danish orthography affects the development of spelling competence, because word-specific spellings are far more common in Danish than in shallow orthographies.

In most cases, however, harder evidence is needed, because associations between factors can be interpreted in several ways. In the direct comparison of Danish and Icelandic in Study 1, an association between spelling competence and orthographic depth was evident. Spelling scores were poorer in the deep Danish

orthography than in the more shallow Icelandic orthography. One way of explaining this relation was to claim that orthographic depth *caused* spelling development to be slower in Danish. Indeed, a causal relationship in the opposite relation could be excluded: It would be meaningless to claim that the relatively poor spelling skills of Danish children caused Danish orthography to be deep. Still, the differences in spelling skills could be due several other factors than orthographic depth, including literacy culture or educational practices.

It was impossible to control all such factors. However, a cross-linguistic spelling age match was employed in order to reduce the range of plausible causes of observed cross-linguistic differences. If differences were found on certain aspects of spelling competence, in spite of the fact that participants matched on other aspects of spelling competence, then one should look for factors that would be likely to affect these other aspects *selectively*. Factors thought to affect spelling development in general would be less plausible. Thus, Study 1 makes the methodological point that careful cross-linguistic matching of samples is a way in which associations can be made more interpretable.

An even better way of studying causes of spelling development is to employ a longitudinal design and test whether hypothesised causal factors are valid predictors of later spelling development. A variant of this design was employed in Study 3 (Experiment 2), where a dynamic test was used to measure children's potential for learning new spellings. It is argued that such a dynamic test is in fact an observation of spelling development, even if this development takes place within a single test session. As in traditional longitudinal studies, then, it is of interest to examine whether hypothesised causes are valid predictors of this condensed spelling development, i.e. of performances on a dynamic spelling test.

The ultimate test of a causal relation is to conduct a double blinded intervention study, i.e. a study where one observes the effects of manipulating the hypothesised causal factor - as when the effects of various treatments on a disease are studied in the medical sciences. Unfortunately, it was not possible to conduct intervention studies within the budget of the present project. Also, some fundamental obstacles to intervention studies in the field of educational research should be noted. In a double-blinded experiment a treatment hypothesised to have an effect on spelling development - e.g. a training programme of some kind - should be compared to the effects of a dummy treatment - i.e., a formally similar training programme presumed to have no effect on spelling development. Clearly, there is an ethical problem here. It may be acceptable to ask participants in a medical experiment to swallow a pill that has no effect, but it is hardly acceptable to waste hours of children's time on a training programme that is unlikely to do them any good - at least not deliberately!

In the case of the effects of orthographic depth, the orthography itself is analogous to the treatment. Here, it is a fundamental problem that spellers have to

learn their orthographies the way they happen to be - so that the 'treatment' as such cannot be varied. One way out here, is to study language internal effects – as in Study 2 where I compare Danish children's use of spellings which differ with respect to 'orthographic transparency'. Another way out is, suggested at the end of Study 3, is to vary orthographic conventions within an experimental setting. For the sake of a small experiment it may be acceptable to teach children to use fictive orthographies, for instance, and then vary the ways in which these orthographies represent certain spoken language units.

Problems of measurement

Several problems of measurement are addressed in the dissertation, including the measurement of orthographic depth (Study 1) and the measurement of linguistic awareness (Study 3 and 5). Even when it comes to the measurement of spelling skills, the studies are based entirely on newly devised measures. The decision to use newly devised measures of spelling may seem questionable as several previous studies have been concerned with the assessment of spelling skills in Danish children. However, for the present studies measures of some very specific aspects of spelling competence were needed, and, unfortunately, such measures were not available. Furthermore, properly standardised tests of children's general spelling development were not available either.

In the Danish literature on spelling there has been a tendency to focus on formally defined spelling error types – e.g. errors involving the letter *r* (Löb, 1983; Spang-Hanssen, 1974), or omission errors. Many spelling errors in Danish do involve the letter *r*, and many errors are omissions – but to my mind that does not mean that *r*-errors or omission errors form meaningful error categories. Spelling errors are very important data in spelling research, because they indicate that spellers have a problem of some kind. What is of interest in a study of spelling competence, however, are not the errors themselves, but the kind of problems they reflect. Information on the frequency of errors within a category is not very informative if one does not suspect that those errors reflect related problems. This is the problem with formally defined categories such as *r*-errors or omission errors: In spite of the formal similarity of errors within these categories, errors can reflect problems that have little or nothing in common (Juul, 2003).

Another problem of measurement in previous studies is the fact that error frequencies tend to be reported relative to the total number of errors, rather than relative to the number of times the error could have occurred (Kihl, 1988, is an exception). So, typically, one is told, for instance, how many of the errors in a given sample that were doublet errors, but one is not told how often doublets were used correctly (cf. Sandersen, 2003, for a discussion of these alternative measures). Thus, it is often not very clear whether error frequencies reflect the extent to which spellers have problems with doublets as such. If doublet errors are relatively frequent, this

could simply reflect that doublets are a relatively common orthographic structure. Furthermore, when the frequencies of different error types are compared, the results can be very hard to interpret if the error frequencies are based on words that differ with respect to structure or frequency of occurrence. All spelling measures in the present dissertation were based on dictated words (or pseudo-words) in order to make the results easier to interpret. The use of preselected items ensured that the number of times a particular error could occur was known, and that important item properties could be controlled.

Recently, Danielsson (2003) reported a study of reading errors in Swedish children which employed a design similar to the design used to study spelling in Study 3 of the present dissertation. Danielsson distinguished between fully transparent spellings, spellings that were transparent given the graphemic/phonological context, and opaque spellings (corresponding roughly to 'predictable', 'context sensitive' and 'word-specific' spellings in my terminology). In my view, Danielsson's rather surprising finding that Swedish children made few errors on opaque words cannot be taken to indicate that opacity is not a problem for Swedish children for the simple reason that words within the three categories differed with respect to structure and frequency. The opaque words tended to be shorter and more frequent than words in the other categories, and this may explain why errors on opaque words were relatively infrequent.

An important error category in the present dissertation, as in previous studies, are phonemically implausible errors. What is phonemically plausible depends on the pronunciation on which the spelling is based, of course. In the studies presented here, I have generally taken the liberty of assuming that participants were familiar with the standard pronunciations of the words which they were asked to spell and which were used when the words were dictated. This assumption seemed justified because all children lived in the Copenhagen area, the centre of the pronunciations standard in Denmark, and because the pronunciation of Danish is fairly homogeneous even across regions. Even so, the possibility cannot be excluded that some 'phonemically implausible' errors were in fact plausible, given the pronunciations standard favoured by the speller.

A note on the term phoneme itself is called for, too. To most phonologists, phonemes are abstract sound units which should be distinguished from actual pronunciations. For instance, a Danish phonologist might say that the phoneme /d/ - usually rendered in oblique brackets - can be pronounced either as [d] or [ð] - in square brackets - depending on its position in the syllable (Grønnum, 1998). In reading research, however, the level of abstraction tends to be ignored, and it is common to refer to all minimal sound segments as 'phonemes'. In most places, I follow this usage. Thus, for instance I talk about the /ð/ phoneme in Danish, although I agree that the pronunciation [ð] can be described as a manifestation of the abstract phoneme /d/. This has the important consequence that when I talk about

inconsistency at the level of the phoneme, I am in fact referring to the level of a broad phonetic transcription. My reason for adopting this usage of the term is that one cannot take it for granted that spellers have access to abstract phonemes. It may be the case that spellers identify the pronunciations [ð] and [d] as allophones of /d/, in which case they merely have to learn that /d/ is represented in writing by *d*. But it may also be the case that spellers take the sounds that they hear as their input, rather than abstract phonemes.

This is especially important when the phonemic analysis of a sound segment is ambiguous. For instance, in an abstract (morphophonemic) analysis of Danish, the sound [ʌ] can be analysed as a manifestation of either /ə/ (spelled *e*) or /ər/ (spelled *er*; cf. Grønnum, 1998, for more information on Danish phonology). If spellers have access to these abstract phonemes, then the inconsistent spelling of [ʌ] (as either *e* or *er*) should pose no problem. As shown in Study 4 and 5, Danish spellers do have very persistent problems with this inconsistency, suggesting that the abstract phonemic analysis is not available to them as input to the spelling process.

A final problem for the measurement of specific spelling skills is the phenomenon of overgeneralisations, i.e., the phenomenon that a spelling which applies under certain conditions is used even where these conditions are not met. Controlling for such overgeneralisations is often very important. For instance, if Danish spellers use consonant doublets for *all* consonants in intervocalic position, one should not conclude that they master the doubling rule (the regularity that intervocalic consonants are doubled in writing if they follow *short* vowel, but usually not otherwise). For this reason measures of the frequency of overgeneralisations were often included in the studies of the present dissertation. Furthermore, combined measures of correctly used and overgeneralised spellings were often computed. In several cases I report the correlations (phi coefficients) between the spelling produced (e.g. doublet vs. singleton spelling of an intervocalic consonant) on the one hand, and the type of item to be spelled (e.g. condition for using a doublet fulfilled vs. not fulfilled) on the other hand. In this way, a measure which takes account of the tendency to overgeneralise is obtained.*

Summaries of the studies

This section presents the five studies of the dissertation in outline. An overview of the studies is provided in Table 1.

* I thank Carsten Elbro and Peter Allerup for suggesting this approach to the overgeneralisation problem to me.

The first question addressed in the dissertation is whether spelling development in the ‘deep’ Danish orthography is slower than in the more ‘shallow’ Icelandic orthography (Study 1). A comparison of Danish and Icelandic is a good opportunity to study the effects of orthographic depth, because the spoken and written languages are in many ways quite similar. However, as the study demonstrates, they differ with respect to orthographic depth; the relations between sounds and letters are far more irregular in Danish. The hypothesis in Study 1 was that this difference affects the speed with which specific aspects of spelling competence is acquired.

Parallel versions of a pseudo-word spelling task were administered to Danish and Icelandic children (primarily 3rd and 4th graders). The focus of attention were performances with word medial consonant doublets and word initial consonant clusters. Although these structures occur with approximately the same frequency in the two orthographies, Danish children were outperformed on both structures. In the case of consonant doublets this was expected, because the doubling rule is more complex in Danish. Doublets in Danish are context sensitive (reflecting that a preceding stressed vowel is short rather than long). Icelandic doublets also occur after short vowels, but, unlike Danish doublets, they usually correspond to consonants that are phonetically long.

In the case of consonant clusters the cross-linguistic difference was more surprising, because the spellings of consonant clusters are phonemically straightforward in both languages. This difference suggests that the development of basic phoneme level encoding skills is delayed in deep orthographies. This interpretation is consistent with data on spelling development in German- and English-speaking children (Wimmer & Landerl, 1997).

Study 2 and 3 follow up on Danish children’s problems with context sensitive consonant doublets. In Study 2, the phenomenon of context sensitivity is in focus. Context sensitivity means that spelling ambiguities at the level of the phoneme can be reduced or even eliminated if spellers take account of the phonological context. Context sensitivity is not confined to medial doublets – vowel spellings are often context sensitive, too, for instance – and it is found also in other orthographies - e.g. English (cf. Kessler & Treiman, 2001).

Study 2 asked whether Danish children rely on the phonological context when they spell words. Words items were used in order to allow a comparison of performances on context sensitive spellings and word-specific spellings (i.e., spellings that are specific to particular words because they cannot be predicted from phonology). Evidently, pseudo-words cannot be used to study word-specific knowledge. Participants were children from grades 4 to 6. If children rely exclusively on word-specific spelling knowledge when spellings are ambiguous at the level of the phoneme, then errors should be as frequent for context sensitive spellings as for word-specific spellings – given that the comparison is based on otherwise similar

Table 1. Overview of the studies

Study & Design	Focus	Participants	Spelling error focus	Background variables
Study 1. Cross-linguistic comparison	Effects of orthographic depth on spelling development	115 Danish students from grades 2, 3, 4 and 6 and 77 Icelandic students from grades 3 and 4.	Consonant cluster reductions. Doublet errors	Orthography (Danish vs. Icelandic)
Study 2. Within subjects comparison	Context sensitive spelling knowledge	104 students from grades 4, 5 and 6	Errors on context sensitive (vs. predictable and word-specific) spellings	Phonemic encoding skills.
Study 3. Exp. 1: Correlational Exp. 2: 'Condensed longitudinal'	The relation between vowel quantity awareness and knowledge of consonant doublets	Exp. 1: 96 students from grade 4, 5 and 6 (a subset of the Study 2 sample). Exp. 2: 32 students from grade 3*	Doublet errors	Awareness of vowels and vowel quantity. Grapho-phonemic awareness. Visual memory
Study 4. Cross-sectional	The size and nature of the problem with grammatically defined spellings	142 students from grades 4, 6, 8 and 10	Grammatical errors	Grade level. Use of context sensitive spellings. Word reading
Study 5. Correlational	The relation between grammatical awareness and grammatical spelling competence	32 students from grade 6 (a subset of the Study 2 sample)	Grammatical errors	Grammatical awareness. Use of word-specific spellings. Word reading

* These participants were selected from a larger sample of 60 third graders. All other samples were based on intact classes (bilinguals excluded in some cases).

words. The experiment demonstrated that this was *not* the case. Both for consonant doublets and for vowel spellings, errors were less frequent for context sensitive spellings than for word-specific spellings, suggesting that Danish children do rely on the phonological context, at least to some extent. Errors were least frequent, however, for spellings that were predictable at the level of the phoneme. Thus, spelling accuracy varied language internally as a function of orthographic ‘transparency’ (Fischer, Shankweiler, & Liberman, 1985).

Performances on context sensitive doublets and context sensitive vowel spellings were found to correlate, even when performances on word-specific and predictable spellings were controlled. Thus, knowledge of context sensitive spellings appears to be a separate component of spelling competence.

Study 3 addresses the possibility that problems with context sensitive consonant doublets can be explained by insufficient awareness of vowels and vowel quantity. It is well-known that phonological awareness is an important predictor of spelling development, but it is less clear whether this holds also for the spelling development in children beyond the earliest grades. Furthermore, awareness of phonemic quantity is an aspect of phonological awareness not often studied (Landerl, 2003).

The first of two experiments reported showed that Danish children’s ability to match vowels of identical quantity and quality was related to their use of consonant doublets in a dictation task. This experiment was based on the same sample as Study 2.

The second experiment addressed the possibility that quantity awareness is causally related to acquisition of doublet knowledge. It was shown that ability to categorise vowels as long or short predicted the speed with which correct spellings of pseudo-words (spelled with or without doublets) were learned. Participants in this experiment were third graders who did not master the doubling rule beforehand. This result suggests that awareness of vowel quantity is indeed a facilitating factor when children have to learn new spellings. The results of the experiment also suggested that explicit, rather than implicit, awareness of quantity is needed. A special feature of this experiment was the employment of dynamic testing.

Study 4 and 5 turn to a somewhat different problem of Danish orthography, viz. the use of grammatically defined spellings. Again, parallel problems can be found in English and other deep orthographies (Bryant, Nunes, & Aidinis, 1999). Study 4 suggests that measures of grammatical spelling competence should take account of overgeneralisations (as when the *-ed* of English past tense verbs is used for non-verbs, e.g. the misspelling *sofed* for *soft*). A cross-sectional experiment based on pseudo-words assessed performances on five different grammatical spelling problems, including the ‘classical’ problems in Danish: the present tense *-er* inflection, and the present participle *-ende* inflection. Participants came from grades

4, 6, 8 and 10. The three youngest groups performed below ceiling on all five problems, suggesting that mastery of grammatically defined spellings tends to be achieved at a late point in spelling development. Given the assumption that grammatical spelling competence is based on grammatical awareness (Nunes, Bryant, & Bindman, 1997), performances on the five problems were surprisingly poorly correlated with each other.

Study 5 follow up on the Danish spelling problems with the present tense and present participle inflections. The persistency of these problems was confirmed even though words rather pseudo-words were used as items in a new experiment with sixth graders (a subset of the Study 2 sample). The new experiment also replicated the finding that performances on the two problems were poorly intercorrelated. Nevertheless, a strong correlation between grammatical spelling competence and awareness of grammatical categories was found. These constructs appear to be heterogeneous, however. Correct spelling of the present tense inflection was related most strongly to awareness of inflectional categories, while correct spelling of the present participle inflection was related most strongly to awareness of word class distinction. This is a plausible situation, given that the present tense verbs can be homophonous with infinitives (a different inflection) while present participles can be homophonous with plural definite nouns (a different word class). Thus, specific aspects of grammatical spelling competence seem to require specific types of grammatical awareness. The study introduced group based word oddity tasks as measures of grammatical awareness.

Perspectives

As the summaries above demonstrate, the main hypotheses of the dissertation were confirmed.

First, the acquisition of spelling competence in Danish does appear to be difficult because Danish is a ‘deep’ orthography. It was shown that Danish children have persistent problems with features which distinguish Danish from more shallow orthographies – viz. context sensitive spellings, word-specific spellings and grammatically defined spellings, all of which occur frequently in Danish. Furthermore, Danish children appeared to lag behind their peers in another Nordic country, who learned to spell in a more shallow orthography, even when it came to the acquisition of basic phonemic encoding skills.

Second, as hypothesised, some of the most persistent spelling problems in Danish – problems with the use of consonant doublets after stressed short vowels and with the use of grammatically defined spellings – were found to be associated with a lack of linguistic awareness. The interpretation that linguistic awareness is causally

related to spelling development appeared likely in the case of grammatically defined spellings, and it was strongly supported in the case of consonant doublet problems.

So far, so good. But why are these findings important?

Why study spelling?

SIR,

I am a young Woman and reckoned Pretty, therefore you'll pardon me that I trouble you to decide a Wager between me and a Cousin of mine, who is always contradicting one because he understands *Latin*. Pray, Sir, is Dimple spelt with a single or a double P?

I am, Sir,

Your very Humble Servant,

Betty Saunter

This letter was written to the editor of the *Spectator* in 1711 (I quote it from Carney, 1994: 112). It illustrates the fact that spelling competence - knowledge of the use of consonant doublets included - has a long history as a social marker. Pointing out other people's spelling errors can be a most convenient way of demonstrating one's level of education. To be sure, people like Betty Saunter's cousin are still around!

This raises some fundamental questions about the importance of spelling competence: Is spelling competence primarily important in order to avoid being categorised as uneducated by people who ought to know better? Does it make any sense that children should spend their childhoods trying to overcome spelling problems that have been around for generations? Is it not quite obvious that learning to use written language should be a question of discovering a new way of communicating with other people rather than a question of remembering a lot of intricate orthographic conventions? So why bother about spelling acquisition at all?

Seen in this perspective, the present dissertation may appear to be thoroughly misguided. Instead of trying to *understand* the nature of spelling problems, why not do away with spelling problems once and for all by changing people's attitudes to spelling competence? Instead of teaching correct spellings, why not tell Betty Saunters that she can spell *dimple* with as many *p*'s as she likes to? In fact, the real problem may not be Betty Saunter's cousin, but Betty Saunters herself. Why does she not question the fact that there *is* such a thing as a "correct" spelling? Who in the world, if not ordinary language users – Betty, for instance - should have authority over language use? As Jaffe (2000) puts it: "[...] non-standard orthographies are potentially subversive, because they can expose and thus call into question dominant language ideologies and the social hierarchies in which they are embedded."

I quite agree with that. Learning to use an orthography is not just a matter of learning to represent spoken language. It is also a matter of learning to represent spoken language in a conventional way. It is a kind of linguistic socialisation. Indeed, language users should be made aware that spellings are just like other social conventions: They can be negotiated.

Nevertheless, I do believe that it is important to understand the nature of spelling problems. Orthographic conventions can be negotiated, but they cannot be eliminated. Language users could make things easier for themselves, perhaps, if they favoured the use of simplified spellings, and if they chose to always represent their own pronunciations in writing (Kristiansen, 1999). Interestingly, however, in 1986 when the Danish Language Council introduced the simplified spelling *majonæse* of the French loan word *mayonnaise*, the reaction from the general public was thoroughly negative. In Denmark, as in many other countries, language users tend to come out in favour of spellings standardised at the level of the word, rather than at the level of the phoneme, and they tend to be quite conservative. The prospects of changing these attitudes to spelling are not very positive. From a pragmatic point of view, then, improving instructional practices may be a more feasible way of helping poor spellers. In order to do that, an understanding of the nature of spelling problems is clearly necessary.

The resistance towards spellings that would without doubt be easier to learn, such as the phonemically straightforward *majonæse* in Danish, may seem surprising. Yet, as pointed out in the introduction, what language users want to represent in writing are meaningful units, i.e., words. This being so, it is certainly practical to have a fixed standard at the word level. Right from the time when the Danish orthographic norm came into being (in the 16th century), it has covered a variety of pronunciations, so that speakers of different dialects came to share a loyalty toward a common written language (Rischel, 2002). Although a phonemically transparent orthography is in the interest of the child learning to spell, there are other interests within the linguistic community which appear to be stronger.

The problem of learning the orthographic norm remains, then. This does not mean that all aspects of this norm are equally important, of course. Knowledge of regularities in the relation between spoken and written language are more important than knowledge of word-specific spellings, for the simple reason that word-specific spellings have a limited scope of application. The relative amount of attention paid to different aspects of spelling competence in the present dissertation reflects this fact, I hope.

As Betty Saunter's letter illustrated for English, spelling problems have quite a long history. With respect to Danish, a recent study of spelling errors in letters written by Danish soldiers in the middle of the 19th century demonstrated that difficulties with consonant doublets and grammatically defined spellings were common even then (Sandersen, 2003). In that respect, there is nothing new in the

problems demonstrated in the present dissertation. However, the spelling instruction available to the general public in the middle of the 19th century was scanty indeed. Today, we are obviously much better off - but there is still reason to ask how improvements can be made.

Implications for instruction

First of all, the results of the dissertation suggest that the acquisition of phonemic encoding skills may be more difficult in Danish than in more shallow orthographies such as those used in the other Nordic countries. There is no reason, however, to assume that phonemic encoding skills are less important in Danish than in the other orthographies. Quite generally, children who had problems with the basic relations between phonemes and letters had even greater problems when it came to the more sophisticated aspects of Danish orthography. This was especially clear in Study 2, where the problems with context sensitive spellings and word-specific spellings were most evident among the poorest phoneme level encoders. Thus, the development of phonemic encoding skills, is clearly of prime importance in the early grades. The fact that the development of encoding skills appears to be more difficult in the deep Danish orthography only makes it more important that teachers pay attention to this aspect of spelling development.

If phonemic encoding skills are the first priority, it is logical that the use of conventional spellings at the word level (i.e., the use of ‘correct’ spellings) must be regarded as relatively less important. When spellings that are predictable at the phoneme level are mastered, it will, presumably, be much easier to focus on those aspects of the spelling system that are not so predictable.

A strong warning is called for here, however. Once the traditional instructional focus on correct spellings is abandoned, it can be quite tempting to leave it entirely to the child to decide how words should be spelled. Thus, a recent article in the Danish teacher union’s magazine (Folkeskolen [The Folkeskole] 2003, 7, page 6) described how a teacher encouraged a third grader who wrote *drd* for the *grød* ‘porridge’ (a phonemically implausible spelling). Encouraging children to use written language – and poor spellers not least – is important enough. However, to ensure that other people can read what is written (and what is the purpose of writing if this goal is not achieved?), every word, and every sound of every word, needs to be represented. Sure enough, *some* spellers will discover how the orthography works almost by themselves if only they are encouraged to read and write stories. But, unfortunately, that is not the way things work out for everybody (Graham, 2000). Third graders who leave out the vowel of a one syllable word have a problem, and I see no point in pretending that they do not.

Second, the results of the dissertation suggest that stimulating specific aspects of children’s linguistic awareness could have positive effects on their spelling

development even beyond the earliest grades. The results are not conclusive, but they certainly indicate that one cannot take for it granted that Danish children are aware of vowel quantity and grammatical categories. Children with a limited linguistic awareness are unlikely to benefit from explicit spelling rules referring to vowel quantity or grammatical categories. Furthermore, their chances of implicitly discovering the orthographic regularities pertaining to vowel quantity and grammatical categories may also be poor (cf. Steffler, 2001, on the distinction between implicit and explicit spelling knowledge). As in the case of phonemic awareness in preschoolers, the development of these aspects of linguistic awareness may require a lot of focussed training.

A third implication for instruction is that it may be helpful to focus on very specific skills when a child's spelling development is evaluated. If tests are used, it should be considered what skills exactly they were designed to measure.

Suggestions for future studies

Obviously, the results reported will be more conclusive to the extent that they can be replicated in future studies. Especially, the cognitive status of context sensitive spellings knowledge (Study 2) needs to be further explored. Also, the finding that the development of phonemic encoding skills (especially performances on consonant clusters) is relatively slow in the deep Danish orthography (Study 1) is in need of replication. It would be interesting to follow the spelling development of children in different orthographies over time, preferably from the preschool age. Instructional differences should be paid more attention than in Study 1.

Genuine longitudinal studies – and intervention studies – are also needed to shed more light on the relations between linguistic awareness and spelling development beyond the earliest grades. With respect to linguistic awareness another next step could be to go further backwards! If grammatical awareness is important to the development of spelling competence, for instance, what, then, determines the development of grammatical awareness? Dynamic testing (as used in Study 3) may be a convenient way of approaching the answer to such a question. Thus, the ease with which children can learn to distinguish between, say, nouns and adjectives could be the focus of a dynamic test. If valid predictors of performances on such a test could be identified, it could lead to a better understanding of spelling development - and language learning in general.

Finally, I should like to stress that the present dissertation addresses only a subset of the spelling problems that Danish children have to overcome. No doubt, many important questions have not even been asked yet.

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STUDY 1

Orthography as a handicap? A direct comparison of spelling acquisition in Danish and Icelandic

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Abstract

Spelling of cross-linguistically very similar pseudo-words was compared in 115 Danish and 77 Icelandic children (primarily 3rd and 4th graders). Danish children made more errors than Icelandic children on word medial consonant doublets and on word initial consonant clusters, even when the groups compared were matched on simpler spelling tasks. These results suggest that the acquisition of phonemic encoding skills is slower in 'deep' orthographies such as Danish than in more 'shallow' orthographies such as Icelandic. The effect of orthography was expected for consonant doublets because of the relatively more complex sound-letter correspondences in Danish. For consonant clusters, however, sound-letter correspondences are perfectly regular in both languages. The study thus points to the conclusion that even the mastery of regular sound-letter correspondences may be delayed in deep orthographies.

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Introduction

In the recent years there has been a growing interest in cross-linguistic comparisons of literacy skills. In a Nordic context, the IEA-study of the early 1990's that compared reading comprehension skills in children from more than 30 countries (Elley 1992) received much attention for at least two reasons. First, it showed that reading development is remarkably swift in children learning to read the highly regular Finnish orthography. Second, it showed that children learning to read the much more irregular Danish orthography were significantly behind their peers in all the other Nordic countries. More recent cross-linguistic comparisons have indicated that even in Danish adolescents and adults reading comprehension skills are poorer than in the other Nordic countries (Allerup, Mejding and Zeuner 2001; UNICEF 2002).

The relatively poor performances of the Danish participants in these studies may have several explanations. One possibility is that the irregularities of Danish orthography tend to make decoding less efficient (Juul 2001). Sound-letter correspondences in Danish are often ambiguous, and silent letters abound. The relations between sounds and letters in the other Nordic orthographies are relatively more transparent.

However, one may also point to other differences between Denmark and the other Nordic countries that could have an effect on literacy skills. Although the Nordic countries are very similar on most socio-economic parameters, differences in teacher education, educational system, parental attitudes to literacy achievement, etc., may put Danish readers at a disadvantage (Sommer, Lau and Mejding 1996). One may even ask whether technical problems due to orthographic irregularities have any practical importance worth talking about beyond the earliest phases of literacy acquisition (Lundberg 1997). That is the question we address in this paper.

The effects of orthographic depth

Irregularity or complexity in an orthography, i.e., deviations from simple and predictable one-to-one sound-letter correspondences, is often referred to as orthographic depth. Studies of the effects of orthographic depth have primarily been concerned with the reading process. An important issue has been whether the lower accessibility of phonological information in deep orthographies leads to a relatively greater reliance on visual-orthographic information in naming and lexical decision tasks (the orthographic depth hypothesis, cf. Katz and Frost 1992; Frost 1992).

A second issue has been whether orthographic depth affects the size of units used in phonological recoding (the grain size hypothesis). Recent cross-linguistic studies suggest that reading a deep orthography like English tends to involve larger units than reading a more 'shallow' orthography like German (Ziegler, Perry, Jacobs and Braun 2001; Goswami, Ziegler, Dalton and Schneider 2003).

A third issue has been whether orthographic depth impedes the development of accurate and fluent reading skills. The present study primarily addresses this third

issue. Previous studies that have dealt with this issue have had a natural focus on decoding skills. This is because orthographic depth is presumed to affect decoding directly, while only indirect effects would be expected for reading comprehension. If cross-linguistic differences cannot be found for decoding, there will be little reason to suspect that orthographic depth can help explain the differences in reading comprehension that have been found in the international studies referred to above. However, encoding skills should be just as likely as decoding skills to be affected by orthographic depth. Yet, as will become apparent from the review in the following section, few previous cross-linguistic studies have focussed on spelling skills. It is also noteworthy that in the majority of previous studies English has been the deep orthography which was compared to other, more shallow, orthographies.

In the present paper we report a cross-linguistic study which focussed on spelling acquisition, and in which the deep orthography was not English, but Danish. Danish was compared to another Nordic orthography, viz. the relatively more shallow Icelandic orthography. The focus of the study was the spelling of some very specific phonological structures in pupils from grades 3 and 4. The purpose of the comparison was to test the assumption that the orthography is a kind of handicap that makes the acquisition of encoding skills relatively slower in Danish children than in Icelandic children even beyond the earliest phases of spelling acquisition.

Cross-linguistic comparisons of decoding and spelling development

If specific effects of orthographic depth are to be observed in cross-linguistic comparison, it is an important requirement that the comparisons are based on items that are as similar as possible across languages. Obviously, differences with respect to word structure or frequency could lead to differences in performance levels that have nothing to do with orthographic depth. The cross-linguistic matching of items has been quite convincing in several previous studies. For instance, Seymour, Aro and Erskine (2003) found that Danish and Scottish first graders read simple words and pseudo-words less accurately than first graders in European countries with more shallow orthographies, even though the items were highly similar across languages. This result supports the assumption that reading acquisition is more difficult in deep orthographies such as Danish and English.

Similar results have been obtained in comparisons of reading as well as spelling in English and German-speaking (Austrian) children aged 7 to 9 (Wimmer and Goswami 1994; Wimmer and Landerl 1997; Frith, Wimmer and Landerl 1998). These authors exploited the linguistic relatedness of English and German and compared performances for words that had similar meanings as well as similar structures and frequencies. For instance the English word *bread* was matched to the cognate German word *Brot*. In these studies the English participants were outperformed by the Austrians both on reading and spelling. Thus, even when items were very strictly matched, literacy development was found to be slower in the deep

English orthography (cf. also Aro and Wimmer 2003).

Another important requirement of studies that aim to isolate effects of orthographic depth is that the samples differ with respect to orthography, but not with respect to other factors that might influence literacy development. This ideal requirement is somewhat more difficult to meet. If linguistic groups are matched, for instance, on a math test (Ellis and Hooper 2001), one can assume that they do not differ dramatically with respect to educational achievement in general. If they are matched on standardised national tests of reading age one can even assume that they are representative for their educational backgrounds (e.g. Frith et al. 1998; Goswami et al. 2003). However, such matching procedures do not rule out the possibility that cross-linguistic differences are due to other factors than orthography. Literacy standards may differ across countries for reasons that have nothing to do with orthography. Different standards could reflect socio-economic or cultural differences, for instance, and, unfortunately, it can be very difficult to control such differences across countries.

The solution adopted in the present study was to match groups across languages on relatively simple spelling tasks, using cross-linguistically matched items to ensure comparability. For instance, we identified groups of Danish and Icelandic children who performed on the same level when they had to represent single consonant phonemes in onset position. Then we went on to compare their performances on more demanding items with consonant cluster onsets or medial doublets. For reasons explained below we suspected that the scores on these more demanding items would be selectively affected by orthographic depth. Socio-economic and cultural differences between the samples could still have effects on spelling performances, of course, but we would expect such effects to be general, rather than selective.

We now turn from methodology to a theoretical issue: Are the effects of orthographic depth found only when items differ with respect to the regularity of sound-letter correspondences? It is perhaps not so surprising to find an effect where sound-letter correspondences are more regular in one of the orthographies compared. In the English-Austrian comparison of spelling referred to above it was found that the vowel of German *Brot* was spelled correctly by 99 % of the Austrians, while the vowel of the English cognate word *bread* was spelled correctly only by 60% of the English participants (Wimmer and Landerl 1997). Clearly, the English vowel spelling was less regular than the German vowel spelling, because it involved a digraph, *ea*, and because a much more common spelling for English /e/ exists, viz. *e* as in *red* (Carney 1994). It seems logical to assume that the difference in accuracy was due to the difference in regularity. This interpretation is supported by the fact that only 53% of the Austrian participants spelled the vowel correctly in the German word *Boot* 'boat' where the less common digraph spelling *oo* is used for the same vowel as in *Brot*. This error pattern suggests that spelling problems occur specifically when sound-letter correspondences are irregular.

It is also possible, however, that an effect of orthographic depth can be found

even where sound-letter correspondences are similar across orthographies. A case in point are the correspondences between spoken and written consonant clusters in the Germanic languages. These correspondences are quite regular, not only in the more shallow orthographies, like German and Icelandic, but also in English and Danish. Interestingly, reductions of consonant clusters is a spelling error type that seems to persist for some time in English-speaking children (Snowling 1994; Treiman 1998). By contrast, observations of Austrian children's spelling suggest that this error type is almost non-existent in German-speaking children by the end of grade 1 (Wimmer and Landerl 1997). To explain this apparent difference, Wimmer and Landerl proposed that reading the shallow German orthography, paired with an instructional emphasis on sound-letter correspondences, help Austrian children to discover the segmental structure of consonant clusters.

This explanation may be correct, but strong evidence in support of it is wanting. The observation that Austrian first graders made few spelling errors on consonant clusters was based on just 13 clusters occurring in 11 words - e.g. *schwimmt* 'swims' and *trägt* 'carries'. Word-specific spelling knowledge may have contributed to the good Austrian results, and it seems possible that problems with clusters would have shown if more items had been included. Furthermore, the assumption that the frequency of spelling errors on consonant clusters varies as a function of orthographic depth should be tested in a direct comparison. The study reported here is an attempt to fill this gap.

The spelling of consonant clusters has been the focus of one previous cross-linguistic study. Caravolas and Bruck (1993) compared the spelling of Czech and English-speaking (Canadian) first graders, and found that the English-speaking participants made a significantly greater number of errors on consonant clusters in pseudo-words than the Czech participants did. Both groups performed at ceiling when spelling singleton consonants. This result is in line with Wimmer and Landerl's reasoning, as Czech orthography, like German, is relatively shallow.

However, Caravolas and Bruck found that Czech and English also differ with respect to syllable structure. For instance, they observed that the frequency and variety of consonant clusters in onset position is greater in Czech. Thus, the superior spelling performance of the Czech participants may be due, at least in part, to a difference in familiarity with consonant clusters rather than to the difference in orthography. Indeed, these authors found that Czech pre-schoolers were better than English-speaking pre-schoolers at identifying initial phonemes of words with initial consonant clusters.

Using similar phoneme-identification tasks Birgisdóttir and Bryant (2000) found that Icelandic pre-schoolers, too, performed better than English-speaking pre-schoolers. As these authors found the variety and frequency of cluster onsets to be greater in Icelandic than in English, this result also points to a possible cross-linguistic effect of syllable structure (cf. also Seymour et al. 2003). Thus, if specific effects of orthographic depth are to be observed, cross-linguistic comparisons should ideally be

based on languages that are structurally similar, but differ in orthographic depth. As we will argue below, Danish and Icelandic are languages well suited for such comparisons.

A Danish-Icelandic comparison of spelling

Our Danish-Icelandic comparison of spelling focussed on the spelling of two specific phonological structures: consonant phonemes in word medial (intervocalic) position and consonant clusters in onset position.

The spelling of medial consonants was compared because sound-letter correspondences in Danish and Icelandic differ considerably. In both orthographies doublets are sometimes used to spell medial consonants, but the doubling rule is more complex in Danish: Danish doublets mark that a preceding stressed vowel is short - much like English medial doublets (e.g. *tapping* vs. *taping*). Icelandic doublets also follow short stressed vowels, but usually the doubling also marks that the medial consonant itself is phonetically long. This is not the case in Danish. Furthermore, the doubling rule is relatively more consistent in Icelandic. For instance, it applies to word final consonant, too, whereas in Danish it does not. Our expectation was that the more complex and inconsistent correspondences between consonant phonemes and doublets would lead to more doubling errors in the Danish group.

The spelling of consonant clusters was compared for the reasons already described above: Previous studies have suggested that errors on clusters are especially frequent in deep orthographies. Furthermore, consonant cluster spellings are equally regular in Danish and Icelandic and thus provide a possibility to test the hypothesis that error frequencies are associated with orthographic depth even when the regularity of sound-letter correspondences is controlled. We suspected that if the reasoning of Wimmer and Landerl (1997) was correct we would find more spelling errors on consonant clusters in the Danish group, because sound-letter correspondences are *generally* more irregular in Danish - although not in the specific case of consonant clusters!

Errors on consonant clusters and (especially) on consonant doublets are well-known spelling error types in both languages. However, to the best of our knowledge, the present study is the first empirical study in both countries that has explored the frequency of these error types in more detail.

Before we go on to report our study, we should like to demonstrate some crucial differences and similarities between Danish and Icelandic. The depth of an orthography can be measured on at least two dimensions (Van den Bosch, Content, Daelemans and De Gelder 1994). One is the consistency of sound-letter correspondences, i.e., how easily spellings can be predicted from pronunciations and vice versa. Another is the frequency of deviations from the principle of 'one sound per letter'. Traditionally, most emphasis is put on the first dimension, but the second dimension of orthographic depth may have an impact on literacy development, too (Berndt, D'Autrechy and Reggia 1994; Elbro submitted). When graphemes do not

always correspond to single letters, the segmentation of words into functional pronunciation units (graphemes) will tend to become more difficult - whether the resulting graphemes are consistent or not.

Danish orthography is deeper than Icelandic orthography both on the first and the second dimension. As for consistency, the difference is especially clear when the sound-letter correspondences for vowels are compared. Most Danish vowel phonemes correspond to more than one spelling, and vice versa, whereas most Icelandic vowel qualities correspond to just one spelling, and vice versa.

As for deviations from the 'one sound per letter' principle we made a comparison based on the 500 most frequent words in each language (Bergenholtz 1992; Pind, Magnússon and Briem 1991). Deviations were defined relative to maximally distinct standard pronunciations. The comparison showed that deviations were far more common in Danish than in Icelandic (Table 1). Thus, the assumption also made in previous studies (Elley 1992; Seymour et al. 2003) that Danish orthography is deeper than Icelandic orthography was confirmed. The frequency of doublets, which may be said to represent just one sound (whether short or long), were not counted as deviations, as they were counted separately (cf. below). Diphthongs represented by a single vowel letter (cf. English words such as *find* and *most*) were not counted as deviations either, although they have a two-phase pronunciation. Such diphthongs were found in 94 Icelandic words, while they did not occur at all in the Danish word list. It should be noted, however, that Icelandic diphthongs 'behave' like single vowel phonemes: Just like monophthongs they can be either short or long. Similarly, the two-phased pronunciation of the Danish /t/-phoneme - which sounds like /ts/ to many foreigners - was counted as a single sound.

The lists of frequent words were also used to confirm the structural similarity between Danish and Icelandic. As our study focussed on consonant doublets in intervocalic position and consonant clusters in onset position, we compared the frequencies of these orthographic structures. The frequencies were roughly on the same level, both for types and tokens (Table 1). These similarities make it rather unlikely that cross-linguistic differences in spelling accuracy for these structures can be explained by differences in the amount of experience that participants have had with the same structures. We note that four-phoneme cluster onsets occur, although very rarely, in Icelandic - e.g. *skrjóður* 'old car' - but not in Danish. A particular striking cross-linguistic similarity was that clusters with an initial *s* followed by a stop (*p*, *t* or *k*) accounted for approximately a third of all cluster tokens in both languages.

Table 1. Frequency counts for words that deviate from the one sound per letter-principle, words with intervocalic doublets, and words with initial consonant clusters. Counts are based on the 500 most frequent words in each language.

	Danish	Icelandic
One sound per letter-deviations	190	34
Doublets (intervocalic)		
Types	9	9
Tokens	52	66
Clusters (word initial)		
Types	22	19
Tokens	67	54

Method

Participants

A total of 115 Danish and 77 Icelandic children participated in the study (Table 2 provides an overview). Participants came from socially mixed areas outside the centres of the capital cities, Copenhagen and Reykjavík. The Danish participants all came from one school, while the Icelandic participants came from two different schools.

There are several social and cultural differences between Copenhagen and Reykjavík. An obvious difference is that Copenhagen is much bigger than Reykjavík. Another difference is that children in Copenhagen are more often bilingual (cf. Table 2). Participants were asked if Danish/Icelandic was the first language that they spoke, and if they spoke this language with their family. They were classified as bilingual if they responded no to either or both of these questions. As we thought it impossible to select participants with similar cultural backgrounds across countries, we decided *not* to exclude the results of bilingual children on a priory grounds.

Testing was done in the middle of the school year, but earlier in Denmark than in Iceland. On average the Icelandic participants had attended school about two months longer than the Danish. However, because Icelandic children begin school at the age of 6, and Danish children at the age of 7, the Icelandic fourth graders were roughly of the same age as the Danish third graders.

Table 2. Overview of participants by grade level and country.

Grade	Number		Age (months)		Male (pct.)		Bilingual (pct.)	
	DEN	ICE	DEN	ICE	DEN	ICE	DEN	ICE
2	19	-	102	-	53	-	21	-
3	33	39	114	106	39	41	24	8
4	34	38	126	115	47	50	26	0
6	29	-	151	-	24	-	34	-

Note: 5 participants who failed to complete the test are not included here (1 Icelandic third grader, 2 Danish second graders, and 2 Danish third graders).

Measures

All measures were based on pseudo-word spelling. The spelling tasks were constructed in Danish and Icelandic versions which were as similar as possible, as demonstrated in the procedure section below. All pseudo-words had two syllables. Only spellings of the target phonemes were scored.

Simple onsets. This measure was based on 33 items with a single consonant phoneme in onset position. These consonant phonemes were divided equally between 11 different qualities which were the same in both versions of the test. The standard spellings for these phonemes were *b, d, g, f, s, m, n, l, r, v* or *j* - but phonemically plausible alternatives (such as *c* instead of *s*) were accepted.

Consonant cluster onsets. This measure was based on 41 items with consonant clusters in onset position: 33 two-phoneme clusters and 8 three-phoneme clusters. The 41 clusters were divided between 16 different types which were the same in the two versions of the test. They are listed here with their standard spellings, but all phonemically plausible spellings were accepted: *sv, fr* and *ff* (4 items each); *sp, st, sk, sm, sn, fl* and *sl* (3 items each); *str* and *stj* (2 items each); and *spr, skr, spj* and *skj* (one item each).

Word initial sp st sk. Seventeen of the items with consonant cluster onsets had an unvoiced stop consonant following a word initial /s/. Both in Danish and Icelandic the standard spellings for such onsets are *sp, st* and *sk*, respectively. However, the spellings *sb, sd* and *sg* are phonemically plausible alternatives in both orthographies. The frequency of the standard spellings was scored as a percentage of all phonemically plausible spellings.

Unfamiliar clusters. This measure was based on 6 items with two-phoneme clusters that would not normally occur in word initial position. These unfamiliar clusters were: *mb, nt, ks, pf, vl* and *nj* (Danish version) or *rg* (Icelandic version). No other spellings were accepted. The onsets *mb, nt, ks* and *pf* do not occur in any word in any of the two languages, while *vl* occurs in both languages, but only in a Russian name (Vladimir) of low frequency. The onset *nj* which was used for Danish occurs in the famous Icelandic name Njál. It was replaced in the Icelandic version by *rg* which does not occur in any Icelandic word.

Doublets. This measure was based on 24 items with a consonant phoneme in intervocalic position. These were divided equally between two types: 12 consonant followed a short stressed vowel (in the Danish version this consonant was phonetically short, while in the Icelandic version it was long), and 12 consonants followed a long stressed vowel (in both versions this consonant was phonetically short). The consonants following short vowels should be doubled both in Danish and Icelandic spelling. The consonants following long vowels should *not* be doubled and were included to control the extent to which the use of doublets was overgeneralised to consonants where doubling was not appropriate.

The consonant phonemes were divided equally between four different qualities, whether they should be doubled or not: /m n s/ and /f/ (Danish version) or /r/ (Icelandic version). In the Danish version the spelling *nd* was accepted as an equivalent of the doublet *nn* because of the homophony of word pairs such as *venner* 'friends' and *vender* 'turns' (with a silent *d*).

Procedure

Participants were given a booklet with 12 preprinted pseudo-words on each page. In each pseudo-word one or more letters had been replaced by a horizontal line. The pseudo-words were structurally very similar in the Danish and Icelandic versions of the test, as illustrated by the following examples (with IPA-transcriptions and correct spellings added):

<i>Danish</i>	<i>Icelandic</i>
___use /'du:sə/ (<i>duse</i>)	___úla /'du:la/ (<i>dúla</i>)
___yle /'sbry:lə/ (<i>spryle</i>)	___ila /'sbri:la/ (<i>sprila</i>)
ja___e /'jamə/ (<i>jamme</i>)	ja___a /'jam:a/ (<i>jamma</i>)
ba___e /'bæ:mə/ (<i>bame</i>)	ba___a /'ba:ma/ (<i>bama</i>)

Participants were asked to fill in the missing letters as the words were dictated to them. A total of 104 items were used for the measures described above. In both versions of the test, however, additional items were included for other purposes than the present study (71 in the Danish version, and 112 in the Icelandic version).

The test was administered to one class at a time in the participants' own

class rooms. Items were presented and repeated twice by a test leader (not the same person in Copenhagen and Reykjavík) who had been instructed about how each item should be pronounced. Time was allowed until all participants were ready to proceed to the next item. Testing was always completed within two lessons. The whole test was administered on the same day in Copenhagen (with breaks). In Reykjavík it was administered over two days. Items were presented in a fixed random order. The six items used to measure performances with unfamiliar clusters were presented separately at the end of the test.

Results

Table 3 shows the main results in the two countries by grade level. Performances on simple onsets were generally close to ceiling, and there was no clear-cut cross-linguistic difference on this measure. On cluster onsets and doublets, by contrast, the Icelandic participants performed much better than Danish participants at the same grade level. The Icelandic third graders even outperformed the Danish fourth graders, who were almost two years older, and they did nearly as well as the Danish sixth graders, who were almost four years older! There was hardly any difference across languages in the frequency of overgeneralised doublets, suggesting that only word structures where doubling is required were affected by language.

A 3 x 2 x 2 analysis of variance with repeated measures was performed with simple onsets, cluster onsets and correctly used doublets as within-subject factors and grade level (third vs. fourth grade only) and language as between-subjects factors. There were significant main effects of spelling condition ($F(2, 280) = 297.452, p < .001$), as well as grade level ($F(1, 140) = 8.222, p < .01$), and country ($F(1, 140) = 38.783, p < .001$). The effect of spelling condition interacted with grade level ($F(2, 280) = 3.267, p < .05$) as well as country ($F(2, 280) = 34.354, p < .001$). This was because the effects were largest in the third graders and in the Danish participants.

Planned comparisons showed that both the contrasts between single and cluster onsets and between cluster onsets and doublets were significant ($F(1, 140) = 85.662, p < .001$ and $F(1, 140) = 228.132, p < .001$, respectively). Both contrasts interacted with country ($F(1, 140) = 43.3, p < .001$ and $F(1, 140) = 12.079, p = .001$), but only the contrast between simple and cluster onsets interacted with grade level ($F(1, 140) = 13.877, p < .001$). For this contrast there was even a three-way (condition by grade by language) interaction $F(1, 140) = 10.670, p = .001$, because the contrast was very large in the Danish third graders, but quite modest in the Icelandic third graders who spelled cluster onsets nearly as well as they spelled simple onsets.

Table 3. Mean percentages correct (with SDs) by grade level and country on simple onsets, cluster onsets and doublets (percentages correct vs. overgeneralised).

Grade	Simple onsets (n = 33)		Cluster onsets (n = 41)		Doublets			
					Correct (n = 12)		Over generalised (n = 12)	
	DEN	ICE	DEN	ICE	DEN	ICE	DEN	ICE
2	79 (23)	-	35 (31)	-	1 (3)	-	0.5 (2)	-
3	94 (5)	86 (21)	58 (33)	81 (23)	11 (26)	46 (42)	5 (15)	4 (12)
4	89 (15)	96 (5)	75 (25)	92 (12)	17 (26)	62 (38)	4 (9)	5 (14)
6	92 (9)	-	84 (16)	-	51 (43)	-	7 (13)	-

The general results point to the conclusion, then, that Danish third and fourth graders have much larger problems with cluster onsets and doublets than their Icelandic peers. It should be not be overlooked, however, that the Icelandic participants had their spelling problems, too. Even the Icelandic fourth graders performed far below ceiling on doublets.

The relative problems of the Danish third and fourth graders could reflect that these participants were unusually poor spellers for their grade levels, but this did not appear to be the case. A 3 x 4 analysis of variance with repeated measures was performed on all Danish participants with simple onsets, cluster onsets and correctly used doublets as within-subject factors and grade level as the between-subjects factor. This analysis showed a significant overall effect of grade level ($F(3, 111) = 18.948, p < .001$). Importantly, post hoc tests showed that the third and fourth graders performed significantly above the second graders and significantly below the sixth graders (Scheffé, $p < .05$), although they did not differ significantly from each other. Thus, the spelling level of the Danish third and fourth graders did not appear abnormal.

The relatively poorer Danish results could not be ascribed to the larger proportion of bilingual participants either. When bilinguals were excluded, the Danish results were found to be similar to or *worse* than those reported in Table 3. For this reason the results of the bilingual participants were not excluded from the analyses.

We note, also, that the reliability of the measures was satisfactory. Reliability coefficients (alpha) were computed for all third and fourth graders in each country (N = 67 in the Danish group, and N = 77 in the Icelandic group). For these analyses items were scored as correct vs. all other response types. Danish coefficients are reported first, Icelandic last. Simple onsets: .84 and .93. Cluster onsets: .97 and .94. Correctly

used doublets: .93 and .96.

Still, the specific cross-linguistic differences on cluster onsets and doublets in Table 3 may only reflect a general difference in spelling skills between the Danish and Icelandic participants. Because of the ceiling effect on simple onsets, it remains possible that this measure was not sensitive enough to capture a genuine cross-linguistic difference in spelling skills at this level. Thus, the differences on cluster onsets and doublets may not be specific to these particular measures. It also remains possible that the Danish sample happened to include a larger proportion of poor spellers than the Icelandic sample.

To counter such doubts we next report some more restricted cross-linguistic comparisons. For these comparisons participants from the third and fourth grades were matched on their performances on simple onsets or cluster onsets. To increase the comparability of the samples, participants were excluded from the comparisons if they performed at ceiling, and also if their scores were low. Table 4 shows the results for participants matched on their spelling of simple onsets. Only Danish spellers who made from 2 to 5 errors and Icelandic spellers who made from 2 to 7 errors on the 33 simple onset items were included in this comparison.

This more restricted comparison showed cross-linguistic differences similar to those in Table 3. There was a strong effect of spelling condition ($F(2, 108) = 156.309, p < .001$) as well as language ($F(1, 54) = 27.875, p < .001$). The effect of spelling condition interacted significantly with language ($F(2, 108) = 18.220, p < .001$), as the effect of spelling condition was much stronger in the Danish sample. Planned comparisons showed, again, that both the contrasts between single and cluster onsets and between cluster onsets and doublets were significant ($F(1, 54) = 25.578, p < .001$ and $F(1, 54) = 134.033, p < .001$, respectively), and, again, both contrasts interacted significantly with language ($F(1, 54) = 14.996, p < .001$ and $F(1, 54) = 7.596, p < .01$). Again, the frequency of overgeneralisations was remarkably similar across languages.

Thus, this more restricted comparison confirms the impression that, relative to Icelandic children, Danish children have specific spelling problems with consonant clusters and consonant doublets.

We also made a comparison of groups matched on their performances with cluster onsets to check if a cross-linguistic difference would still be found for consonant doublets if the match was based on a more difficult spelling task (Table 5). A further purpose was to compare performances on the more demanding measures of consonant cluster spelling: the use of standard spellings for stops after *s* (i.e., *sp st sk*) and the spelling of unfamiliar cluster onsets such as *mb*. Again, the very best and the very poorest spellers were excluded. Only Danish participants who made from 1 to 10 errors and Icelandic participants who made from 3 to 10 errors on the 41 cluster items entered the comparison.

Table 4. Participants matched on their spelling of simple onsets. Mean percentages correct (with SDs) on simple onsets, cluster onsets and doublets (percentages correct vs. overgeneralised).

Country	N	Simple onsets (n = 33)	Cluster onsets (n = 41)	Doublets	
				Correct (n = 12)	Overgeneralised (n = 12)
DEN	28	91 (3)	67 (27)	8 (17)	4 (12)
ICE	28	90 (3)	87 (15)	51 (39)	4 (13)

The performances on onset clusters (the matched variable) were compared to correctly used doublets, the use of *sp st sk*, and unfamiliar clusters in three 2 x 2 analyses of variance with repeated measures. For cluster onsets vs. doublets there were significant effects of spelling condition ($F(1, 58) = 215.565, p < .001$) as well as language ($F(1, 58) = 5.610, p < .05$), and as expected the interaction was significant because the effect of spelling condition was stronger in the Danish participants ($F(1, 58) = 7.389, p < .01$). Similarly, for (familiar) cluster onsets vs. unfamiliar clusters there were significant effects of spelling condition ($F(1, 58) = 166.066, p < .001$) and language ($F(1, 58) = 9.586, p < .01$), and, again, the larger Danish effect of spelling condition led to a significant interaction ($F(1, 58) = 14.784, p < .001$). For cluster onsets vs. *sp st sk*, however, no significant effects were found.

These comparisons provide even stronger support for the conclusion that the use of doublets is a greater spelling problem in Danish than in Icelandic. They also

Table 5. Participants matched on their spelling of cluster onsets. Mean percentages correct (with SDs) on cluster onsets, doublets (percentages correct vs. overgeneralised), word initial *sp st sk*, and unfamiliar clusters.

Country	N	Cluster onsets (n = 41)	Doublets		<i>sp st sk</i> (n = 17)	Unfamiliar clusters (n = 6)
			Correct (n = 12)	Overgeneralised (n = 12)		
DEN	31	89 (7)	20 (29)	7 (15)	89 (17)	34 (24)
ICE	29	89 (4)	41 (35)	6 (14)	82 (26)	59 (30)

gave further support to the impression that the representation of consonant clusters is affected by the orthographic factor. Although the groups performed on the same level with familiar consonant clusters, there was a very clear difference on unfamiliar clusters. This latter measure was based on only six items, but the difference does suggest that the Danish spellers relied relatively more than their Icelandic peers on previous experience with the clusters presented, and relatively less on an immediate segmental analysis. Finally, the fact that the Danish and Icelandic groups did not differ much when it came to overgeneralisations of doublets and to the use of the standard spellings *sp*, *st* and *sk* suggests that the spelling problems of the Danish group were indeed confined to specific linguistic structures.

Discussion

The present study was an attempt to isolate the effects of orthographic depth on the acquisition of spelling skills in Danish and Icelandic. The results support the conclusion that orthographic depth can be described as a kind of handicap for children learning to spell.

Children learning to spell in the deep Danish orthography were outperformed by children learning to spell in the more shallow Icelandic orthography when we compared the use of doublets for medial consonants - in spite of the fact that both groups performed on the same level on simple spelling tasks. Because the doubling rule is simpler and more consistent in Icelandic, this result was expected. In fact, the cross-linguistic difference can be seen as a parallel to the finding that the unpredictable vowel spellings of English orthography are a greater spelling problem than the more predictable vowel spellings of German orthography (Wimmer and Landerl 1997).

The Danish participants were also outperformed when we looked at the accuracy with which familiar and unfamiliar consonant clusters were spelled. Apparently, Danish children are less efficient than their Icelandic peers when they have to use writing as a sound script. This was perhaps more surprising, as the sound-letter correspondences of consonant clusters are perfectly regular in both orthographies. Such a difference would be expected, however, if Wimmer and Landerl (1997) were correct in claiming that learning to read a shallow orthography provides a better training of phoneme segmentation skills than learning to read a deep orthography. The idea that reading a deep orthography such as Danish makes it relatively harder to discover the phonemic structure of words seems to go well with the fact that we found deviations from the principle of 'one sound per letter' to be very common in Danish words.

We must point out that differences found between matched groups can sometimes be misleading. If the match had been based on the poorest Icelandic and

the best Danish spellers, measurement error would be expected to yield an overestimate of the performance level for Danish spellers, but an underestimate of the performance level for Icelandic spellers, and differences found on other measures could simply be a regression toward the 'true' spelling ability of the groups compared (Cook and Campbell 1979). It is not likely, however, that the differences found between matched groups in the present study can be explained as a regression effect, as all participants with extreme scores were excluded from the matched comparisons. Furthermore, the reliability of the measures was found to be high.

The study also supported Wimmer and Landerl's claim that the spelling of consonant clusters is only a marginal problem in the acquisition of spelling in a shallow orthography. As our measures were based on more items, they were presumably more sensitive than measures in previous studies. Even so, the Icelandic children were found to represent consonant clusters rather accurately, much like the Czech children studied by Caravolas and Bruck (1993) and the Austrian children studied by Wimmer and Landerl (1997).

The Icelandic participants did show problems on the use of consonant doublets, however. This suggests that the representation of phonemic quantity may be a general problem in learning to spell, even when the marking of quantity is quite straight-forward. Problems with doublets are known also from Greenlandic and Finnish, where consonant doublets, as in Icelandic, correspond to phonetically long consonants (Jacobsen 1994; Lyytinen et al. 1995).

As pointed out earlier, the fact that the Danish and Icelandic participants performed on the same level on simple spelling tasks makes it less likely that there was a *general* difference in spelling skills between the groups. However, this still does not rule out the possibility that other factors than orthographic depth could lead to the *specific* differences found on onset clusters and doublets. We will discuss two such factors.

First, just as a shallow orthography may favour the development of basic decoding and encoding skills, so may a phonics based instructional approach (Wimmer and Landerl 1997; Bruck, Treiman, Caravolas, Genesee and Cassar 1998; Landerl 2000). We do not know whether the Icelandic teachers were more phonics-oriented than the Danish teachers, but it is certainly possible. However, the very fact that the sound-letter correspondences of Danish orthography appear so irregular may be one of the most important reasons if Danish teachers tend not to adopt a purely phonics-oriented approach to literacy instruction. It should also be pointed out that cross-linguistic differences have been found between English and German children's decoding skills even when the instructional approach was controlled (Landerl 2000).

Second, specific differences in the degree of attention paid by teachers to errors on consonant clusters and doublets may, of course, lead to specific differences in spelling performances. To find out whether Danish teachers have a more tolerant attitude to certain spelling errors than their Icelandic colleagues, we distributed a questionnaire to all teachers at the participating Danish school and at a neighbouring

school. The teachers were asked to indicate the grade level at which normal pupils should be able to detect and correct various examples of spelling errors, including errors on consonant clusters and doublets. According to the respondents (N = 12) normal Danish children should be able to correct cluster errors by the end of the third grade and doubling errors by the end of the fourth grade. Unfortunately, however, only 20 % of the Danish teachers responded to the questionnaire. Because of this low response rate a planned Icelandic parallel was not implemented. Thus, we can only note the possibility that differences in attitudes towards specific spelling error types affected the results. Nevertheless, we believe that assessments of teacher attitudes may contribute interesting new data to future cross-linguistic comparisons. It should be added, though, that since the doubling rule is more complex in Danish than in Icelandic, it seems reasonable to suspect that Danish teachers have a more tolerant attitude to doubling errors.

What are the instructional implications of the cross-linguistic differences observed in the present study? If the acquisition of phonemic encoding skills is more difficult in a deep orthography, then instructional practices should definitely take account of this fact. However, to do this, it is important to understand the nature of the problem.

Some may conclude that what Danish spellers need to learn must be something very different from what Icelandic spellers need to learn, given that the relations between spoken and written language in Danish differ so much from those in Icelandic. This is not the conclusion we would draw. As shown, there are some clear differences between Danish and Icelandic orthography - e.g. in the spelling of vowels and intervocalic consonant phonemes and in the frequency of silent letters. However, there are also great similarities, e.g. in the spelling of consonant clusters. At least for consonant clusters, then, what spellers need to learn appears to be almost the same in the two languages.

It should be noted, also, that although deviations from the principle of 'one sound per letter' are frequent in Danish, we did find that more than 60 % of the 500 most frequent Danish words had a perfect match between the number of sounds and letters. Furthermore, it is well-known that Danish pre-schoolers' phonemic awareness is a strong predictor of later development of literacy skills (Lundberg, Frost and Petersen 1988; Petersen and Elbro 1999). This would hardly be the case if knowledge of sound-letter correspondences did not play an important role for this development, even in Danish.

Thus, rather than to teach something completely different from basic sound-letter correspondences, the challenge to teachers of Danish and other deep orthographies may be to pay special attention to children's knowledge of these correspondences. One way of helping could be to reduce the number of irregular words in early reading and spelling instruction (Borstrøm, Petersen and Elbro 1999).

Danish children do have to learn about the irregularities of their orthography,

of course. However, there is reason to believe that the irregularities are easier to cope with when a sound knowledge of regular sound-letter correspondences has been achieved (Caravolas, Hulme and Snowling 2001). Assisting children in developing such knowledge may be an instructional challenge of special importance in deep orthographies.

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STUDY 2

Knowledge of context sensitive spellings as a component of spelling competence: Evidence from Danish

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Abstract

Spelling performances in 104 Danish children from grades 4 to 6 were compared across three levels of orthographic transparency. At the first level all spellings that were plausible at the level of the single phoneme were accepted. At the second level spellings were accepted only if they were plausible even when the phonological context was considered (context sensitive spellings). At the third level word-specific spellings had to be used. There were 16 word items per level, matched for structure and frequency. Scores for context sensitive spellings were intermediate between scores at the phonemic level and the word-specific level, both for vowel and consonant spellings. Scores for context sensitive vowels and consonants were significantly interrelated even when performances at the phonemic and word-specific levels were controlled. The results demonstrate that Danish spellers beyond the initial phases of literacy development rely on phonological entities larger than the single phoneme. They extend similar findings from English in suggesting that knowledge of context sensitive spellings is a separate component of spelling competence.

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Introduction

It is a well-known fact that some spellings are easier to learn than others. Some spellings are quite predictable from the sounds they represent, while others are ambiguous (e.g. the vowel spellings of *sail* and *sale*) or even quite exceptional (e.g. the *o* of *women*). It has been shown that even adults misspell words with inconsistently spelled phonemes more often than words with predictable spellings (Fischer, Shankweiler, & Liberman, 1985; Kreiner & Gough, 1990).

Some inconsistent spellings are more consistent than others, however. Thus, although the consonant doublet of a word like *cancelled* is not predictable from the /l/ phoneme as such, it is nevertheless predictable from the information that the /l/ is preceded by a single vowel and followed by a vowel initial suffix. By contrast, the fact that a doublet is used in a word like *hemorrhhage* is not predictable from the context and has to be memorised as a fact about that specific word (Fischer et al., 1985).

Fischer et al. found that words like *cancelled* were spelled correctly more often than words like *hemorrhage*, but less often than 'predictable' words like *vibrated*, even though word types were equated for frequency and number of syllables. To characterise the spellings of words such as *vibrated* vs. *cancelled* vs. *hemorrhage* Fischer et al. made a distinction between three levels of 'orthographic transparency'. Their results suggest that orthographic transparency is an important parameter in assessments of spelling competence.

It is a common procedure, of course, to use words with predictable spellings to assess phonological spelling knowledge, and words with ambiguous or exceptional spellings to assess lexical (word-specific) spelling knowledge. Although it is a matter of debate whether phonological spelling knowledge and lexical spelling knowledge are integrated as in connectionist models of spelling production (Brown & Loosemore, 1994) or distinct as in dual route models (Barry, 1994), it is widely accepted that measures of both types of knowledge contribute important information to assessments of spelling competence. The importance of spelling knowledge at the intermediate level of transparency, where contextual constraints are taken into account, is not as generally recognised, however, and proficiency at this level is not often assessed. This paper reports a study that attempted to clarify the status of this intermediate level of orthographic transparency in spelling acquisition. The study was based on Danish orthography which like English orthography is often characterised as 'deep' or 'inconsistent'. Danish spellings are very often inconsistent at the level of the single phoneme, but, as in English, they are often – although not always - much more consistent when contextual constraints are taken into account.

'Contextual constraint' is a very broad term, of course, as it covers any type of context that increases the consistency of a spelling. Reference may be made, for instance, to 'suffixes with an initial vowel' (cf. above) and other categories of some

linguistic sophistication. The present study deals with a less sophisticated kind of context, viz. the phonological context of phonemes to be spelled.

The relevance of the phonological context to spelling was demonstrated by Kessler and Treiman (2001) who showed that the overall consistency of sound-to-spelling correspondences in an American vocabulary was improved considerably when context sensitive consistency measures were employed. This held true both for an adult vocabulary and for a child vocabulary. Context effects were strongest for phonemes within the rime unit. For instance, the *igh* spelling of /aɪ/ applies more often than otherwise when the following coda consonant is /t/, as in *right* and *night*. Conversely, the use of doublets for certain coda consonants is more predictable when the preceding vowel is taken into account (e.g., doublets are common after /ɪ/, as in *Jill*, but not after /e/, as in *jail*). Similar context effects are found also in the direction from spelling to sound (Kessler & Treiman, 2001; Treiman, Kessler, & Bick, 2003).

It has been pointed out before that English (and American) orthography is better than its reputation (e.g. Venezky, 1970; Sampson, 1985; Carney, 1994; Aronoff & Koch, 1996), but Kessler and Treiman make the point very convincingly as they support their claim with computations of conditional sound-to-spelling consistencies. Of particular interest in the present context is their suggestion that paying attention to context sensitive spellings is helpful to children learning to spell.

If this is correct, it is clearly important to take account of the phenomenon of context sensitivity in assessments of spelling development. One question that needs to be addressed in this connection is how the concept of phonological plausibility should be defined. If phonemes are considered in isolation, then the misspelling *educat* for *educate*, for instance, is phonologically plausible, because it is possible to represent the vowel /e/ by a simple *a*-spelling (as in *alien* and *Cambridge*). If the phonological context is considered, however, the spelling *educat* may be classified as phonologically implausible, because the simple *a*-spelling for /e/ is not appropriate before a word final consonant. In this context, *e*-marking or a vowel digraph (as in *late* and *wait*) is required. Some researchers have adopted a narrow definition of phonological plausibility that requires spellings to be plausible even when the context is taken into account (Bruck & Waters, 1988; Lennox & Siegel, 1996; Caravolas, Bruck, & Genesee, 2003). This has the undesirable consequence, however, that misspellings which are plausible at the level of the single phoneme, e.g. *educat*, and misspellings that are *not* plausible at this level, e.g. *ebucate*, are categorised together as phonologically implausible.

An alternative approach to context sensitivity is to devise distinct measures of performances on context sensitive spellings. Such an approach was used by Varnhagen, Boehler and Steffler (1999) who assessed (presumably) Canadian children's use of *o*-spellings and *a*-spellings for the vowel phoneme /a/. According to these authors, the *o*-spelling is the default spelling, as in *cost*, but in certain contexts the *a*-spelling is the more frequent spelling, e.g. before /l/ as in *salt*. Using pseudo-words such as /nɑst/ and /nɑlt/, Varnhagen et al. found that first graders used

the *o*-spelling regardless of the context, while third graders used both *o*- and *a*-spellings in words like /nɔlt/; in words like /nɔst/ they used the *o*-spelling. Thus, knowledge of the default /a/-spelling clearly preceded knowledge of the context sensitive spelling. This points to the importance of distinguishing between basic phoneme level spelling knowledge and knowledge of context sensitive spellings.

The fact that the third graders in the study by Varnhagen et al. used the *a*-spelling in pseudo-words when /a/ preceded /l/, but not otherwise, suggests that they did take account of the phonological context. Otherwise, they would have used the *a*- and *o*-spellings with the same frequency in all contexts. Apparently, they were able to generalise their spelling knowledge of real words where /a/ precedes /l/ (e.g. *salt*) to pseudo-words. Possibly, these children knew that the spelling of particular phonemes can be subject to contextual constraints. An alternative possibility is that they spelled the pseudo-words in analogy to specific real words (Campbell, 1983; Goswami, 1988; Goswami & East, 2000; Marsh, Friedman, Welch, & Desberg, 1980; Nation, 1997). The focus in the present study is on Danish children's spelling of particular phonemes, and for this reason it is convenient to talk about phoneme level spelling knowledge and knowledge of contextual constraints. However, this is not to deny the possible role of word analogies in children's spelling production.

Adults also appear to be sensitive to the phonological context when they spell pseudo-words. For instance, Treiman, Kessler and Bick (2002) found that college students only used the *igh* spelling for the vowel phoneme /aɪ/ if it was followed by /t/. Before other coda consonants (where *igh* never spells /aɪ/ in real words) they never used the *igh* spelling. Yet, although in real words *ight* is the most frequent spelling for the rime unit /aɪt/, the most frequent pseudo-word spelling was not *ight*, but *ite*.

An almost identical observation was made by Perry, Ziegler and Coltheart (2002) who found that college students preferred to spell the pseudo-word /jaɪt/ *jite* rather than *jight*. Based on such findings Perry et al. suggested that spellers predominantly prefer to base their pseudo-word spellings on phoneme sized units rather than larger units such as rimes. This argument appears to be flawed, however, as there is no strong reason why spellers should avoid the *jite* spelling for pseudo-words like /jaɪt/. A word final /t/ does not *exclude* the split *i_e* spelling for /aɪ/ (cf. *bite*, *site*, *kite*). In fact, the *i_e* spelling is attractive because silent *e* is a common marker of vowel length. Thus, the predominance of the *ite* spelling cannot be used as evidence that college students are not sensitive to the phonological context of phonemes (or units larger than single phonemes). On the contrary, the fact that 19% percent of the participants in the Perry et al. study did use the *jight* spelling strongly suggests that they did not always consider the spelling of /aɪ/ in isolation from the following /t/.

Although spellers are able to generalise knowledge of contextual constraints to pseudo-word spelling, it does not follow that this knowledge plays any important

role when spellers spell real words. If knowledge of context sensitive spellings is derived entirely from word-specific spelling knowledge, it may not be necessary to make a distinction between context sensitive and word-specific spelling knowledge. To test the relevance of such a distinction one can compare the accuracy with which context sensitive and word-specific spellings are used. If knowledge of contextual constraints is indeed applied, one might expect spelling accuracy to be higher for context sensitive spellings.

Similarly, one can test the relevance of the distinction between phoneme level spelling knowledge and context sensitive spelling knowledge by comparing the frequency with which phonemically plausible spellings are used to the frequency with which context sensitive spellings are used. Thus, a design like the one used by Fischer et al. (1985), where spelling performances were compared across three levels of orthographic transparency, can be used to clarify whether it is important to distinguish knowledge of context sensitive spellings from other aspects of spelling knowledge.

A similar design was employed by Zinna, Liberman and Shankweiler (1986) to study the importance of contextual constraints in word decoding. These authors compared three types of vowel digraphs in monosyllabic words: digraphs with predictable pronunciations, e.g. *ee* as in *green*; ambiguous digraphs which occurred in a context where their pronunciation was in fact consistent, e.g. *ea* before the coda consonant *n*, as in *clean*; and digraphs with ambiguous pronunciations even when the context was considered, e.g. *ea* before *k* (cf. *speak* vs. *steak*). They found that in third and fifth graders, but not in first graders, naming accuracy rates were higher for words with context sensitive digraph pronunciations than for words with word-specific digraph pronunciations. Thus, as in the spelling study by Varnhagen et al. (1999), it was found that children beyond the initial phase of literacy acquisition begin to pick up knowledge of contextual constraints on the correspondences between sounds and spellings.

A particular strength of the study by Zinna et al. (1986) was that the differences between items were confined to a particular kind of segment, viz. vowel digraphs, which occurred in otherwise similar words. In the study by Fischer et al. (1985) orthographic transparency was defined at the word level, rather than at the level of the phoneme. Items at the lowest level of orthographic transparency often had several ambiguously spelled phonemes (e.g. *hemorrhage* and *hieroglyphic*), while items at the intermediate level usually had just one 'problem segment'. This means that the difference found in spelling accuracy across the two levels may have been due to differences in the number of problem segments, rather than to intrinsic differences in the transparency of sound-to-spelling correspondences.

The present study employed a design much like that used for decoding by Zinna et al. (1986). It was hypothesised that spelling performances in Danish children beyond

the earliest phases of spelling development (children from grades 4 to 6) would reflect the level of orthographic transparency of spellings. Performances were expected to be best when only plausibility at the level of the single phoneme was required, and poorest when spellings were word-specific, i.e. when they were inconsistent even when the phonological context was considered. Performances for context sensitive spellings - i.e. spellings which are inconsistent at the level of the single phoneme, but consistent if the phonological context is considered – were expected to fall somewhere in-between performances at the phonemic level and the word-specific level. Comparisons between the three levels were based on phonemes occurring in the same position in words matched for structure and frequency.

Table 1. Examples of sound-to-spelling correspondences in Danish for intervocalic consonants (the upper section) and stressed vowels (the three bottom sections).

Phonemes	Spellings	Approximate overall frequencies of spellings
/VsV/	VsV or VssV	76% vs. 24%
/VmV/	VmV or VmmV	68% vs. 32%
/i/	<i>i</i>	100 %
/y/	<i>y</i>	100 %
/e/	<i>i</i> or <i>e</i>	76% vs. 24%
/ɔ/	<i>u</i> or <i>o</i> or <i>å</i>	72% vs. 14% vs. 14%
/ɛ/	<i>æ</i> or <i>e</i>	48% vs. 52%
/ø/	<i>ø</i> or <i>y</i>	60% vs. 40%

V = Vowel phoneme.

Table 1 provides examples of Danish sound-to-spelling correspondences addressed in the study (word examples illustrating the correspondences can be found in the Appendix and in the Method section below). One focus was the spelling of intervocalic consonant phonemes. As shown in the first section of Table 1, intervocalic consonants can be represented in writing either by a singleton consonant or by a consonant doublet. As indicated by the frequency counts (based on the official Danish spelling dictionary) the default spelling is a singleton consonant. Overall, the odds that an intervocalic consonant is spelled with a doublet are around 1:3 for /s/ and around 1:2 for /m/. However, for some consonant phonemes – including /s/ and /m/ - one can be next to certain that the correct spelling is a doublet if the preceding vowel is stressed and short ('a context sensitive doublet'). By contrast, if the preceding vowel is stressed and *long*, the default singleton spelling applies with few exceptions (cf. the doubling rule in English; e.g. Cassar & Treiman, 1997). After unstressed vowels, both doublet and singleton consonant spellings occur. Doublets in this position ('word-specific doublets') occur mainly in words of foreign origin with an unstressed first syllable. However, many

such words are very common, so it is doubtful whether speakers of Danish perceive them as foreign. To illustrate, the following Danish words, well-known to any child, are all stressed on the final syllable: *appelsin* ‘orange’, *ballon* ‘balloon’, *dessert* ‘dessert’, *banan* ‘banana’, *tomat* ‘tomato’.

The expectation for intervocalic consonants, then, was that errors on context sensitive doublets would be less frequent than errors on word-specific doublets, but more frequent than phonemically implausible errors.

A second focus of the study was the accuracy with which stressed short vowels were spelled. While the spellings of long vowels are fairly consistent in Danish, the consistency of short vowels differs. This is illustrated by the three bottom sections of Table 1. Some short vowels, such as /i/ and /y/ are almost invariably spelled in the same way. By contrast, vowels such as /e/, /ɔ/, /ɛ/ and /ø/ (the last two sections of Table 1) can be represented by two or even three different vowel letters. Among these vowel phonemes /e/ and /ɔ/ stand out in two important ways.

First, one of the possible spellings of these phonemes is more frequent than the alternatives – *i* being the more common spelling of /e/, and *u* being the more common spelling of /ɔ/ - whereas the relative frequencies of the /ɛ/ and /ø/ spellings are closer to fifty-fifty. The frequency counts provided for vowel spellings in Table 1 are very approximate, however. They are derived from information on spelling-to-sound correspondences reported in Becker-Christensen (1988). A concise qualitative description of sound-to-spelling correspondences in Danish can be found in Basbøll & Wagner (1985).

Second, the *i* and *u* spellings of /e/ and /ɔ/ are used consistently in certain contexts – the constraining factor being the quality of the following consonant phoneme - whereas the spellings of /ɛ/ and /ø/ are inconsistent regardless of the context. The study compared children’s use of the context sensitive /e/ and /ɔ/ spellings to their use of the phonemically straight-forward /i/ and /y/ spellings on the one hand and their use of the word-specific /ɛ/ and /ø/ spellings on the other hand. Performances for /e/ and /ɔ/ were expected to be intermediate between performances on the other two pairs of vowel phonemes, both because the phoneme level consistency of /e/ and /ɔ/ spellings was intermediate and because the correct spellings were context sensitive.

A difference between the consonant and vowel items used was that there were no phonemically plausible spelling alternatives for the /i/ and /y/ vowel phonemes, whereas there were always two phonemically plausible spellings for the intervocalic consonants - either a doublet or a singleton consonant (cf. Table 3 below). To assess performances with relatively transparent consonant spellings, items were chosen where the default singleton spelling applied.

Another difference was that the context sensitive vowels and consonant items differed with respect to the constraining context. The critical vowel spellings were constrained by the following consonant phonemes, while the critical consonant spellings were constrained by the quantity of the preceding vowel phoneme. Yet, if

sensitivity to contextual constraints is a general component of spelling competence, one might expect measures of context sensitive spelling knowledge to be strongly interrelated across types of constraints and across types of phonetic segments (consonants vs. vowels). Indeed, Treiman et al. (2002) found that adult spellers who were sensitive to constraints on vowel spellings from the syllable coda tended to be sensitive to constraints from the syllable onset as well. Thus, in the present study it was hypothesised that a strong relation would be found between performances on the context sensitive consonant and vowel items.

Studies of spelling in English-speaking adults have suggested that proficiency at the intermediate level of transparency is a distinguishing feature of good spellers (Fischer et al., 1985; Treiman et al., 2002). Therefore, it was also hypothesised that good spellers would show greater sensitivity to contextual constraints on spellings than poor spellers.

Spelling knowledge that goes beyond knowledge of predictable sound-to-spelling correspondences is often referred to as ‘orthographic’ (e.g. Varnhagen et al., 1999; Steffler, 2001; Notenboom & Reitsma, in press). Apart from the specific purposes stated above, it was a more general purpose of the present study to open up this ‘orthographic’ dimension of spelling competence and to focus on a more specific type of orthographic knowledge, viz. knowledge of context sensitive spellings.

Method

Participants

A total of 104 children from grades 4, 5 and 6 participated in the study (cf. Table 2). Two classrooms per grade level were tested. All participants came from the same school in a socially mixed suburban neighbourhood in Copenhagen. Testing was done in the first part of the second half of the school year. It should be noted that, contrary to expectation, the fourth graders obtained higher scores on a test of word reading than the fifth graders. The difference was not significant, however.

Table 2. Participants.

	Grade 4	Grade 5	Grade 6	Total
N	38	32	34	104
Mean age (years;months)	11;0	12;0	12;7	11;10
Boys/girls (pct.)	58/42	41/59	53/47	51/41
Danish as 1st/2nd language (pct.)	90/10	94/6	94/6	92/8
Word reading* (SD)	139 (32)	128 (34)	163 (23)	143 (33)

* Correct responses after 5 minutes on the test OS 400 (Sjøgård & Petersen, 1968).

Measures

The study was based on 48 words spelled to dictation. Half of the items assessed spelling performances for stressed vowels, and the other half assessed spelling performances for consonants in intervocalic position. Within each phonetic category there were three levels of orthographic transparency: Phonemically plausible spellings, context sensitive spellings, and word-specific spellings (cf. Table 3). There were 8 items per level. The Appendix provides a list of all items used. The phonemic structures of words as well as word frequencies were similar across phonetic types and transparency levels. Frequency counts were based on a text corpus of approximately 36.6 million Danish words (*Den Danske Ordbogs Korpus*, DSL-testversion 1.0; available from www.dsl.dk). This corpus comprises a variety of text types, including some not often read by school children. Frequency counts restricted to texts from children's books and the like would have been preferable, but were not available.

Spelling performances were assessed only for the critical phonemes in order to observe the effects of orthographic transparency specifically. Errors on other parts of the items are not reported. At the phonemic level there was only one phonemically plausible vowel spelling. For instance, the letter *i* is the only possible representation of the phoneme /i/ in Danish orthography, as in the item *gnisten* 'the spark' (Table 3). Plausible consonant spellings at the phonemic level, however, comprised singleton spellings as well as doublet spellings, as explained in the introduction. In the item *flise* 'flagstone', for instance, a singleton *s* is correct, but if the medial /s/ phoneme is considered in isolation a doublet *ss* is also a plausible spelling.

For the context sensitive items there were two or more phonemically plausible spellings of the critical phonemes, but these phonemes occurred in contexts where one of these possible spellings is used almost exclusively. As explained in the introduction, the constraining contexts for vowels were the following consonant phonemes. For instance, the phoneme /e/ can in principle be represented either by *i* or *e*, but when the vowel is followed by /s/ within the same morpheme, as in the item *kvisten* 'the twig', the correct spelling is very consistently the letter *i*. This contextual constraint is also found in the uninflected monosyllabic word *kvist* 'twig'; the bisyllabic inflected form was used to keep the phonemic structure of items similar for vowel and consonant items, as items with intervocalic consonants could not be monosyllabic, of course. For the consonant items the constraining context was the quantity of a preceding stressed vowel, doublets being correct after stressed short vowels. In the item *tisse* 'pee', for instance, a doublet *ss* is required because the preceding phoneme is a stressed short /i/.

For the word-specific items there were also two phonemically plausible spellings. Neither of these could be excluded from considerations of the phonological context, as is the case for the vowel spellings of English *sale* vs. *sail*. For instance, the Danish vowel phoneme /ɛ/ is represented by *æ* in the item *blæsten* 'the wind', but the spelling *e* is also frequent and occurs in similar phonological contexts, e.g. in the

Table 3. Examples of items used in the study.

Transparency level	Item example	Critical phoneme*	Correct spelling	Alternative spelling
Vowel items				
Phonemic	<i>gnisten</i> 'the spark'	/i/	<i>i</i>	-
Context sensitive	<i>kvisten</i> 'the twig'	/e/	<i>i</i>	<i>e</i>
Word-specific	<i>blæsten</i> 'the wind'	/ɛ/	<i>æ</i>	<i>e</i>
Consonant items				
Phonemic	<i>flise</i> 'flagstone'	/s/	<i>s</i>	<i>ss</i>
Context sensitive	<i>tisse</i> 'pee'	/s/	<i>ss</i>	<i>s</i>
Word-specific	<i>missil</i> 'missile'	/s/	<i>ss</i>	<i>s</i>

* The notation is IPA as conventionally modified for Danish.

word *hesten* 'the horse', a perfect rhyme to *blæsten*. The consonants at the word-specific level followed *unstressed* short vowels, in which position both single and doubled consonants occur. For instance, a doublet is correct for the intervocalic /s/ in the item *missil* 'missile' (pronounced with stress on the final syllable), whereas a singleton *s* is correct in the word *musik* 'music' (pronounced also with stress on the final syllable).

Participants were also asked to spell 10 structurally complex pseudo-words, such as /sgvald/ and /sgrɔmfə/. All phonemically plausible spellings were accepted - e.g. *skvalt* or *sgvald* for /sgvald/. A maximum of 3 errors per word were scored. The purpose of this measure was to assess basic phoneme-grapheme encoding skills.

Procedure

Participants were asked to supply the spellings of words to dictation. Words were presented in sentence contexts which were printed on the test sheets. The sentence contexts were designed to facilitate word identification. More items than the 48

relevant to this study were included. The sixth graders spelled a total of 116 words, while the fourth and fifth graders were given a more limited version of the test comprising a total of 69 words. The words were presented in a random order which was fixed for each version of the test. The pseudo-word items were always presented last. Tests were administered class by class in the participants' own classrooms.

Results

Table 4 presents the mean scores for vowel and consonant spellings at the three levels of orthographic transparency. As expected, it was found that context sensitive spellings were used correctly more often than word-specific spellings, both for vowels and consonants. The spelling accuracy for the vowels was even better at the phonemic level, where there were no plausible alternatives to the correct spellings. For the consonants, however, the spelling accuracy observed was no better at the phonemic level, where the default singleton spellings were correct, than at the context sensitive level, where doublets were correct. This was because the participants tended to overgeneralise the use of doublets to the items where singleton consonants were correct (on average 18% of their responses to these items were overgeneralisations). If the total number of phonemically plausible spellings produced is considered, however, it is evident that the children in the study mastered the use of phonemically plausible spellings earlier than the use of context sensitive and word-specific spellings, both when they spelled vowel and consonant items.

When the total number of plausible spellings at the phonemic level was compared to the number of correct spellings produced for items at the context sensitive and word-specific levels, a significant overall effects of the level of transparency (phonemic vs. context sensitive vs. word-specific) was found (General Linear Model, $F(1, 103) = 764,107$; $p < .001$). The differences between the individual levels were significant, too ($p < .001$). There was also a significant effect of phonetic type (i.e., vowels vs. consonants; $F(1, 103) = 268,392$; $p < .001$). Furthermore, the interaction between transparency level and phonetic type was also significant ($F(1, 103) = 474,682$; $p < .001$). This interaction was due to the fact that word-specific spellings were particularly difficult for consonant spellings, an observation which is in line with the fact that word-specific consonant doublets are considered particularly difficult even by proficient Danish adult spellers.

When only correct responses were considered (i.e. when phonemically plausible errors were not accepted at the phonemic level), the same effects were found, and the differences between the individual levels were still significant. The only change was that an interaction between transparency level and phonetic type was found even when the analysis was confined to the phonemic vs. the context sensitive level. Because of the overgeneralisations of doublet spellings mentioned

Table 4. Mean percentages of correct spellings and phonemically plausible errors (with SDs) by transparency level and phonetic item type. The maximal number of correct spellings per transparency level was 8. All participants ($N = 104$).

Transparency level	Vowel spellings			Consonant spellings		
	Correctly spelled	Phonemically plausible error	Total	Correctly spelled	Phonemically plausible error	Total
<i>Phonemic</i>	97 (8)	-	97 (8)	78 (19)	18 (16)	95 (11)
<i>Context sensitive</i>	81 (27)	11 (19)	92 (14)	80 (18)	15 (15)	95 (9)
<i>Word-specific</i>	76 (21)	19 (18)	96 (10)	30 (20)	60 (20)	90 (17)

above correct responses were relatively less frequent for consonant items than for vowel items at the phonemic level.

When the results were analysed by items, there was, again, a significant overall effect of transparency level ($F(2, 42) = 36,569$; $p < .001$), and the differences between the individual levels were also significant ($p < .05$). There was, again, a significant effect of phonetic type ($F(1, 42) = 16,279$; $p < .001$), and a significant interaction between transparency level and phonetic type ($F(2, 42) = 13,2$; $p < .001$). As before, the results were much the same when only correct responses at the phonemic level were considered. On this analysis, however, the difference between scores at the phonemic and context sensitive levels was no longer significant.

Item reliability coefficients (alpha) were .79 for all items, .76 for vowel items, and .58 for consonant items.

These results suggest that Danish children beyond the earliest phase of literacy acquisition do rely on the phonological context when spelling. Otherwise, scores on context sensitive items would not have differed from scores on word-specific items. However, the use of context sensitive spellings continued to be more difficult for these children than the use of phonemically plausible spellings.

Next, it was hypothesised that there would be a strong relation between the use of context sensitive vowel and consonant spellings. If performances on the two types of context sensitive spellings reflect a *separate* 'context sensitive' component of spelling competence, then performances at the other levels (phonemically plausible and word-specific spellings) should not account for the correlation between the two. To test this possibility the correlation between scores on context sensitive vowels and consonants was computed, controlling for scores on phonemically plausible as well as word-specific spellings. The control measures used were the means of the normalised scores on consonant and vowel items at the phonemic and word-specific levels, respectively. This partial correlation was clearly significant ($r = .32$, $df = 100$, $p = .001$).

Finally it was a question whether the phonological context was exploited mainly by the most proficient spellers. To answer this question, the total set of participants was divided into three percentile groups based on the scores on the pseudo-word spelling task. Presumably, scores on this task reflected basic phoneme-grapheme encoding skills. On average, the first percentile group ('good encoders') made 1 error on the 10 pseudo-words, the second group ('medium encoders') made 6 errors, and the third percentile group ('poor encoders') made 18 errors. (Please recall that up to 3 errors could be scored per pseudo-word.)

Table 5 is an elaboration of Table 4, reporting the mean scores by encoding group. A significant overall effect of encoding group was found ($F(2, 101) = 49.437$; $p < .001$). However, post hoc tests (Scheffe) revealed that only the differences between the poor encoders and the other two groups were significant ($p < .001$). Thus, as one would expect, performances were generally poorest in the poor encoders. These analyses are based on phonemically plausible responses at the phonemic level (the 'total' columns) and on correct responses at the other two levels of transparency. The pattern of results was the same when correct spellings were compared at all three levels of transparency.

Generally, there were significant differences between performances at the level of context sensitive spellings and performances at the phonemic and word-specific levels within all three encoding groups (paired samples t-tests; $p < .05$). However, there were no significant differences between the phonemic level and the context sensitive level when only correct spellings were considered, as all three groups showed the tendency to overgeneralise the use of doublets to the items at the phonemic level. Furthermore, the poor encoders did not spell context sensitive vowels better than word-specific vowels. This result suggests that the poor encoders exploited the context when spelling consonants, but not when spelling vowels.

Discussion

Danish children take account of the phonological context when spelling ambiguous phonemes. This conclusion is suggested by the fact that the children in the present study spelled phonemes with context sensitive spellings more accurately than phonemes with word-specific spellings. However, the use of context sensitive spellings was clearly more difficult than the use of phonemically plausible spellings, suggesting that context sensitive spelling knowledge is acquired later than spelling knowledge at the phonemic level. Thus, spelling accuracy appears to be a function of orthographic transparency. Phonemes with context sensitive spellings are misspelled more often than phonemes with entirely consistent spellings, but not as often as phonemes with word-specific spellings. It must be noted, however, that in the present study errors on intervocalic consonant phonemes were as common when the correct

Table 5. Mean percentages of correct spellings and phonemically plausible errors (with SDs) by encoding groups. The maximal number of correct spellings per transparency level was 8.

Transparency level	Encoding group*	Vowel spellings			Consonant spellings		
		Correctly spelled	Phonemically plausible error	Total	Correctly spelled	Phonemically plausible error	Total
<i>Phonemic</i>	G	100 (2)	-	100 (2)	83 (16)	15 (15)	98 (5)
	M	99 (4)	-	99 (4)	85 (13)	13 (12)	98 (5)
	P	93 (12)	-	93 (12)	66 (20)	23 (19)	90 (15)
<i>Context sensitive</i>	G	96 (8)	2 (7)	99 (4)	86 (15)	12 (13)	98 (5)
	M	94 (10)	3 (7)	97 (6)	84 (15)	14 (15)	99 (4)
	P	57 (30)	25 (25)	82 (19)	70 (20)	19 (16)	89 (12)
<i>Word-specific</i>	G	88 (13)	11 (13)	99 (4)	40 (15)	58 (14)	98 (5)
	M	82 (17)	18 (17)	100 (2)	34 (22)	61 (20)	95 (9)
	P	62 (22)	27 (19)	89 (14)	15 (13)	63 (23)	78 (17)

* G = Good encoders (N = 34), M = Medium encoders (N = 32), P = Poor encoders (N = 38).

spelling was a singleton consonant (the default spelling) as when the correct spelling was a context sensitive doublet.

The results are in line with findings from English which have also indicated that spellers are sensitive to the phonological context (Varnhagen et al., 1999; Treiman et al., 2002). Furthermore, the results of the present study suggest that knowledge of context sensitive spellings is a separate component of spelling competence because a significant relation was found between the use of vowel spellings constrained by the following consonant and the use of consonant spellings constrained by the preceding vowel, even when the use of phonemically plausible and word-specific spellings was controlled.

In the case of context sensitive spellings, spellers will benefit if units larger than single phonemes are available as input to the spelling process because of the increased consistency of sound-to-spelling correspondences. Thus, the results suggest that Danish spellers are able to process more than one phoneme at a time – either in parallel or as larger complex units. Clearly, models of spelling production must be able to account for this aspect of spelling competence.

For the context sensitive vowel items in the present study an alternative interpretation of the results is possible, however. These items differed from the word-specific items because they had vowels that could only be spelled in one way in the given phonological context. However, they also differed in terms of their phoneme level consistency, so that the chances of guessing the correct spelling would be better for the context sensitive vowels, even if the phonological context was ignored (cf.

Table 1 above). From the present results it is difficult to say whether context sensitivity or phoneme level consistency was the more important factor. The relation found between context sensitive vowel and consonant spellings does point to the relevance of context sensitivity, but clearly phoneme level consistency is a factor that needs to be controlled. Unfortunately, comprehensive quantitative analyses of sound-to-spelling correspondences in Danish are not available.

Assuming that context sensitivity is relevant, this raises the question whether children are sensitive to all sorts of phonological contexts, or whether context sensitivity is confined to certain types of large units? The rime unit has often been a focus of attention in discussions of the role of larger units in reading and spelling (Carlisle, 1991; Goswami, 1988; Goswami & East, 2000; Nation, 1997; Treiman, Mullennix, Bijeljac-Babic, & Richmond-Welty, 1995; Treiman & Zukowski, 1988). This makes sense, at least in English where the consistency of sound-to-spelling correspondences is improved most markedly when neighbouring segments within the rime unit are taken into account (Kessler & Treiman, 2001). More recently it has been suggested that contextual effects are confined to the syllable (Treiman et al., 2002).

The results on context sensitive spellings from the present study are of some relevance to this issue. While the context sensitive vowel spellings were constrained by the syllable coda, the consonant spellings were constrained by a vowel belonging to the *preceding* syllable. Recall from Table 3 that a consonant doublet is used for the /s/ in the two-syllable word *tisse* /'tɪsə/ 'pee' because it follows a short stressed vowel. Thus, it appears that Danish children learn a contextual constraint which applies across a syllable boundary. However, although Danish children would typically divide words such as *tisse* into two 'CV' syllables: /'ti/ + /sə/, some phonologists argue that the syllable structure of such Danish words should be described with the boundary placed *after* the /s/: /'tɪs/ + /ə/. On such an analysis the contextual constraints studied here are internal to the syllable and rime units, even for the consonant spellings. Thus, the conclusion with respect to the role of rimes and syllables is not quite clear.

While the Danish results presented here are in accordance with research on spelling in English, it is an open question whether they hold for other orthographies, too. Recent research has indicated that the size of the units employed in reading depends on the specific demands posed by orthographies (Martensen, Maris, & Dijkstra, 2000; Goswami, Ziegler, Dalton, & Schneider, 2003). It seems likely that the same will hold for spelling. What the present results do suggest is that flexibility with respect to unit size is not an idiosyncratic characteristic of English orthography users. Thus, the findings support the view that the strategies used in reading and spelling vary both within and across orthographies as a function of orthographic transparency. Data from more orthographies are needed, however.

Another question about spelling production concerns the relation between lexical and phonological spelling knowledge. The phonological (non-lexical) route in

dual route models of spelling may allow for context sensitivity or larger units and thus explain the data (Treiman et al., 2002). Yet, it may not be desirable to pose a sharp distinction between lexical and non-lexical spelling processes (Campbell, 1983). Such a distinction does not accord well with the lack of a sharp distinction between consistent and inconsistent spellings. Orthographic transparency appears to be a continuum rather than a dichotomy: Many spellings that are usually regarded as phonemically straight-forward in English and Danish do have exceptions, and for this reason word-specific spelling knowledge is rarely completely irrelevant. Furthermore, all knowledge of sound-to-spelling correspondences derives ultimately from real words, and the relevance of this knowledge rests on the fact that it can be applied to real words. Thus, it may be equally misleading to characterise knowledge of phonemically plausible spellings as non-lexical and to characterise knowledge of words-specific spellings as non-phonological. Rather, what matters is the extent to which the use of particular spellings can be generalised from one word to another, and the extent to which spellers actually make such generalisations. The interplay in spelling production between knowledge of spellings at various levels of orthographic transparency certainly calls for further study. Interesting new evidence may come from brain activity studies of subjects making decisions about spelling (Varnhagen, 2003).

It has been suggested that good spellers are more sensitive to contextual constraints than poor spellers (Fischer et al., 1985; Treiman et al., 2002). The present study seemed to confirm this, as good spellers (defined by scores on a pseudo-word spelling task) performed better on context sensitive vowels than on word-specific vowels, whereas poor spellers did not. However, for the consonant spellings even the poor spellers showed a clear difference between context sensitive and word-specific spellings. Possibly, this difference reflects the fact that the use of consonant doublets in the context after stressed short vowels is usually pointed out explicitly in Danish spelling instruction, whereas context-sensitive vowel spellings are traditionally not paid much attention. Thus, explicit attention to context sensitive spellings in spelling instruction may be a great help for poor spellers. On the other hand, it seems likely that spellers with a good mastery of default phoneme level spellings will have more resources to learn spellings with a more restricted scope of application (Gough, Juel, & Griffith, 1992; Caravolas, Hulme, & Snowling, 2001). Good spellers may be sensitive to contextual constraints because they were good spellers in the first place! In that case spelling instruction should focus first of all on poor spellers' performances at the phonemic level.

Longitudinal studies are called for to reveal how children's use of context sensitive spellings develops and to shed light on the factors which determine this development. Both good and medium encoders in the present study performed near ceiling on context sensitive spellings. Thus, it appears that the ability to exploit contextual constraints in spelling develops well before grade 4 (the youngest grade level in the present study). For models of spelling development it is of great interest

to discover how early this ability emerges (Goswami, 1988; Varnhagen, McCallum, & Burstow, 1997; Varnhagen et al., 1999).

Measures of context sensitive spelling knowledge seem important, then, for practical as well as theoretical reasons. Broad spelling error categories such as vowel errors, consonant errors or doubling errors tend not to be very informative about context sensitive spelling knowledge. A vowel error, for instance, may reflect a problem with the use of phonemically plausible, context sensitive or word-specific spellings alike. In order to identify specific spelling problems, a finer subcategorisation of errors is necessary. At the same time, some distinctions between spelling errors seem somewhat arbitrary. Traditionally, a distinction is made between vowel and consonant errors, whereas other phonetic distinctions - e.g. the distinction between front and back vowels - are ignored, although they could, in principle, be just as relevant – or irrelevant - as the vowel-consonant distinction. Perhaps assessments of spelling competence should focus less on children's ability to spell particular types of phonetic segments and more on their mastery of spellings at particular levels of orthographic transparency.

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Appendix

Items used in the study are listed in the tables below. The tables list correct spellings (with the critical spellings in bold), critical phonemes (in IPA as conventionally modified for Danish), and English translations. Mean item frequencies (with SDs) are added in the final line of each section of the table. The frequency measure is the logarithm to the summed frequency of the three most frequently occurring inflectional forms of each item (counts based on *Den Danske Ordbogs Korpus*, available from www.dsl.dk).

For the critical vowel phonemes of the context sensitive and word-specific items there were phonemically plausible alternative spellings: /e/: *e*; /ɔ/: *å* and *o*; /ɛ/: *e*; /ø/ and /œ/: *y*. For the critical consonants phonemes both singleton and doublet spellings were phonemically plausible (cf. Table 3).

Vowel items		
Phonemic	Context sensitive	Word-specific
gnisten /i/ 'the spark'	kvisten /e/ 'the twig'	blæsten /ɛ/ 'the wind'
biller /i/ 'beetles'	piller /e/ 'pills'	kælder /ɛ/ 'cellar'
piftede /i/ 'deflated'	viftede /e/ 'waved'	kvæstede /ɛ/ 'injured'
stivnet /i/ 'hardened'	skiltet /e/ 'advertised'	bæltet /ɛ/ 'the belt'
smutte /u/ 'nip'	skuffe /ɔ/ 'drawer'	kølle /ø/ 'club'
bytte /y/ 'swop'	guffe /ɔ/ 'guzzle'	bøtte /ø/ 'bin'
dystet /y/ 'fought'	duftet /ɔ/ 'smelled'	trøstet /œ/ 'comforted'
hykler /y/ 'hypocrite'	pukle /ɔ/ 'swot'	spøgte /ø/ 'haunted'
2.55 (0.33)	2.61 (0.47)	2.61 (0.34)

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Consonant items		
Phonemic	Context sensitive	Word-specific
flise /s/ 'flagstone'	tisse /s/ 'pee'	missil /s/ 'missile'
knase /s/ 'crunch'	basse /s/ 'big lump'	passager /s/ 'passenger'
fuser /s/ 'non-starter'	nusser /s/ 'fondle'	bassist /s/ 'bass player'
tøserne /s/ 'the girls'	bøsserne /s/ 'the guns'	kolossal /s/ 'enormous'
fræset /s/ 'torn off'	belæsset /s/ 'loaded'	fallit // 'bankrupt'
slimet /m/ 'slimy'	svømmet /m/ 'swum'	billet // 'ticket'
lime /m/ 'glue'	hæmme /m/ 'impede'	ballon // 'balloon'
reklamer /m/ 'commercials'	klammer /m/ 'brackets'	satellit // 'satellite'
2.32 (0.43)	2.35 (0.49)	2.74 (0.27)

STUDY 3

Phonemic quantity awareness and the consonant doublet problem

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Abstract

Awareness of vowel quantity and its relation to knowledge of consonant doublets in spelling was the focus of two experiments with Danish children. As in English and German, there is a link between vowel quantity and consonant doublets in Danish because doublets nearly always follow a short vowel. Experiment 1 showed that ability to match vowels of identical quantity and quality was related to the use of doublets in pupils from Grades 4 to 6 (N = 96). Experiment 2 found a relation between ability in third graders (N = 22) to categorise vowels as long or short and the speed with which spelling knowledge of doublets was acquired. A dynamic test in which participants learned pseudo-word spellings with feedback from a computer was used to assess the rate of acquisition. The relation between quantity awareness and success in this test suggests that some aspects of phonological awareness continue to have an impact on spelling development beyond the earliest grades.

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Introduction

The alphabetic principle provides us with a fascinatingly simple and economical way of representing spoken words. Indeed, it is difficult to think of a more successful technology than the alphabet. However, even when each and every phoneme of a word is duly represented by a letter, important information is often still missing. This is so because there is more to spoken words than the quality of phonemes. Other aspects of phonology, such as tone and stress, also serve to distinguish spoken words in many languages. Furthermore, it is often the case that phonemic *quantity* contrasts are important as well as phonemic *quality* contrasts.

A common way of representing quantity contrasts in writing is, quite simply, to double any letter that represents a long phoneme. Doublets are used in this way in the orthographies of languages as diverse as Finnish, Greenlandic and Icelandic. Simple as the doubling principle may seem, it appears to be a problem in reading as well as spelling in all orthographies where it applies. A tendency to make quantity errors is characteristic of adult Finnish dyslexics (Lyytinen, Leinonen, Nikula, Aro, & Leiwo, 1995), quantity errors persist in Greenlandic children's spelling far beyond the elementary grades (Jacobsen, 1994), and an error rate of 38 % was found for Icelandic fourth graders' spelling of long consonants (Juil & Sigurðsson, in press).

What is the cause of this doublet problem? One possibility is that we are looking at a phonological awareness problem, analogous to the problem involved in learning the alphabetic principle. Just as phonemic awareness is crucial if one is to master the alphabetical principle, so it may be that awareness of phonemic quantity is crucial if one is to master the doubling principle (Nauc ler, 1980; Wiggen, 1992). Awareness of phonemic quantity has rarely been assessed in previous studies, so, unfortunately, it is not very clear how quantity awareness relates to literacy development. However, Landerl (2003) reported that German-speaking good and poor spellers differ in their ability to categorise vowels as short or long. Furthermore, a recent longitudinal study of spelling development in Finnish showed that performances on a quantity awareness measure (an oddity task) administered in December of Grade 1 predicted the use of doublets in a spelling task 12 months later in December of Grade 2 (Lehtonen, submitted). In the present paper I report two experiments that explored the possibility that quantity awareness is a facilitating factor when Danish children acquire spelling knowledge of doublets.

As in the orthographies mentioned above, doublets in Danish are used to mark phonemic quantity. However, the doubling rule in Danish is indirect. Doublets are used for consonants to mark that a preceding stressed vowel is short. After long vowels singleton consonants are used. Irrespective of vowel length the consonant phonemes themselves are always short. Thus, doublets in Danish are context sensitive

because they depend on the quantity of preceding stressed vowels. The doubling rule does not apply if the consonant is in word final position, or if it is followed by another consonant.

Indirect relations between vowel quantity and doubling are found in other languages, too. In English there is a vowel quantity contrast, e.g. between *tapping* and *taping* (Veltman, 1992; Venezky, 1999), and in German e.g. between *Hütte* and *Hüte*. English and German differ from Danish, however, because vowel spellings can also be used to mark vowel quantity, e.g. in English *feel* (long vowel represented by a vowel doublet) or in German *fühlen* (long vowel marked by adding *h* to the vowel letter). Direct vowel quantity marking is not used in Danish.

In Icelandic, Norwegian and Swedish consonant doublets can be said to mark the quantity of preceding vowels, too. However doubling in these orthographies is also a direct marker of phonemic quantity, because the consonants represented by doublets tend to be phonetically long. The indirect doubling in Danish results from the loss of a quantity contrast in consonants (Skautrup, 1944). Apparently this sound change was well underway in Danish before 1300 (Brøndum-Nielsen, 1957; Skautrup, 1944), so the use of consonant doublets to this day is a striking example of the conservativeness of writing systems.

As one would expect, the indirect doubling rule seems to cause even greater problems than the direct doubling rule. Thus, in a comparison of spelling in Danish and Icelandic third and fourth graders, we found that the Danes failed to use doublets even more often than the Icelanders (Juul & Sigurðsson, in press). Danish third and fourth graders also had considerable problems with vowel quantity in a naming task based on pseudo-word with and without medial consonant doublets (Juul & Elbro, 2001). The doublet problem is also well-known in English (Cassar & Treiman, 1997; Siegel & Faux, 1989) and German (Landerl, 2003; Röber-Siekmeyer, 2002). Furthermore, Naucler (1980) found doubling errors to be very frequent in children from the south of Sweden where the doubling rule is indirect because, as in Danish, the quantity contrast has been lost for consonant phonemes in this region.

These cross-linguistic findings suggest that there are two different problems involved in learning to use consonant doublets in orthographies like Danish. One problem is to take account of neighbouring vowel phonemes while spelling (Juul, submitted). Another problem is to become aware of vowel quantity. There may also be other sources of doubling errors.

First, one has to know that consonant doublets occur at all, and that they belong in certain orthographic contexts (in Danish mainly between two vowels). Thus, doubling errors may simply reflect a limited knowledge of possible orthographic structures. It seems unlikely, however that the persistence of doubling errors beyond the earliest grades is due to a lack of orthographic knowledge. Studies

of American and Finnish children have indicated that children notice where doublets can and cannot be used very early on in literacy development (Cassar & Treiman, 1997; Lehtonen, in press).

Second, doublets depart from the 'one letter per sound' relation between sounds and letters. Inexperienced spellers may feel that it is time to move on to the next phoneme as soon as one letter has been written for a given consonant (Nauclér, 1980; Wiggen, 1992). Thus, awareness of the ways sounds and letters can be related ('grapho-phonemic' awareness with a term borrowed from Scarborough, Ehri, Olson and Fowler, 1998) may be needed in order to use doublets correctly.

Third, many doublet errors may simply be performance errors. Indeed, errors in the actual production of doublets appear to be relatively frequent. To illustrate, a search in a database containing English article abstracts from the field of psychology produced 16 hits for *aggressive* and 41 hits for *agressive* - as against 26.765 hits for the correct spelling *aggressive* (the database *Psycinfo* searched in October 2003)! Very likely these errors are mere slips of the pen (or the keyboard). As Brown and Ellis (1994) point out, cognitive models of spelling tend not to be very specific about the sequential processing involved in spelling production, but intuitively it is understandable that performance errors on doublets should occur. Normally, the output mechanism should be designed so as to *avoid* that the same linguistic entity is produced twice in succession, of course.

To the extent that problems with doublets can be explained as performance errors, or as problems with orthographic or grapho-phonemic knowledge, no strong relation with awareness of phonemic quantity is to be expected. Another reason why a relation between quantity awareness and knowledge of doublets cannot be taken for granted is the fact that the use of doublets can be learned lexically, i.e., as facts about particular words. This means that it is possible to use doublets correctly without awareness of phonemic quantity differences. Lexical learning of doublets is sometimes necessary in Danish, because doublets mark the shortness of stressed vowels only. Short *unstressed* vowels can be followed either by a doublet or a singleton consonant (much as in English *assign* vs. *aside*, *annoy* vs. *anoint*, etc.), and one simply has to remember which spelling is correct.

In a previous paper I compared doublet error frequencies for words where doublets could only be learned lexically and words where doublets were predictable from the phonological context (Juul, submitted). The participants (from grades 4 to 6) made far more errors on lexical doublets than on context sensitive doublets. This suggests that Danish children do exploit the phonological context when they use doublets. However, they did have problems with context sensitive doublets, too.

The present study is concerned with the nature of the problem with context sensitive doublets - and especially with the relation between awareness of vowel

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quantity and doublet knowledge. The phonological awareness measures most commonly used in literacy research are based on segmentation tasks where participants have to count or delete phonological units of a particular size, usually phonemes or syllables. Importantly, quantity awareness cannot be studied with similar tasks for the simple reason that quantity is not a countable unit, but a dimension of contrast. Another difference is that quantity contrasts are a matter of degree, whereas quality contrasts tend to be more categorical.

Awareness of quantity and quality contrasts may be strongly interrelated in spite of these intrinsic differences, of course. However, in their Finnish study Lehtonen and Bryant (submitted) found that phonemic quantity awareness had a much stronger relation with spelling skills than phonemic quality awareness, suggesting that it is important to distinguish these two aspects of phonological awareness.

When devising measures of phonological awareness, it is important to pay attention to the level of awareness that is required by different tasks. In sound comparison tasks participants have to somehow sense that the items compared are 'different' or 'the same', but they do not have to be aware what the exact difference or similarity is. By contrast, in sound blending and segmentation tasks explicit awareness is needed (Catts, Wilcox, Wood-Jackson, Larrivee, & Scott, 1997). Thus, one should distinguish between implicit and explicit awareness (Berry, 1994; Steffler, 2001), or - terminology varies - between 'epilinguistic' and 'metalinguistic' awareness (Gombert, 1992) or between 'analysed' and 'unanalysed' forms (e.g. Bialystok, 1986; Catts et al., 1997). If awareness of vowel quantity facilitates the acquisition of doublet knowledge in Danish children, then what is the specific level of awareness required?

Phonological awareness tasks are also sometimes classified according to their complexity (Yopp, 1988), and, more specifically, the according to the degree of control over the relevant unit that is required (Bialystok, 1986; Tunmer & Hoover, 1992). Such a classification may be relevant to quantity awareness, too, of course. Interestingly, Yopp (1988) found that a phonemic segmentation task (requiring explicit knowledge) and a deletion task (requiring a high level of control) predicted independent variance on a measure of the ease with which preschoolers learned to read pseudo-words, whereas tasks that only required implicit knowledge and little control did not.

Experiment 1 below studied the relation between the use of doublets in Danish children from grades 4 to 6 and their scores on a sound comparison task that required explicit awareness of vowel sounds but only implicit awareness of vowel quantity and quality. The main purpose of this experiment was to clarify whether

Danish children's knowledge of doublets is at all associated with their awareness of vowel phonemes.

EXPERIMENT 1

The doubling rule in Danish applies so generally that competent spellers use doublets for intervocalic consonants after short stressed vowels even in pseudo-words. Yet, the fact that spellers are able to take account of the quantity of vowels in pseudo-word spelling does not imply that this ability is also important for their use of doublets in words. As pointed out above, doublets can also be learned lexically. Experiment 1 was designed to test the hypothesis that vowel awareness is related to knowledge of context sensitive doublets in Danish children even when the assessment of doublet knowledge is based on words.

Vowel awareness was assessed with a task in which vowels of identical quantity and quality had to be matched. Vowel *quantity* is the crucial piece of information in relation to context sensitive doublets, of course, but in order to become aware of vowel quantity contrasts, awareness of vowels as such is needed. For this reason a task that tapped vowel awareness more generally was used in this first experiment.

It is well known that there is a link between phonological awareness and the development of spelling knowledge (e.g. Caravolas, Hulme, & Snowling, 2001). Thus, a correlation between vowel awareness and knowledge of context sensitive doublets might not reflect the relevance of vowel awareness to knowledge of context sensitive doublets in specific, but the relevance of phonological awareness to spelling knowledge in general. For this reason the study included two control measures of other aspects of spelling competence than knowledge of context sensitive doublets. One additional aspect was basic phonemic encoding skills (pseudo-word spelling). The other was lexical (word-specific) spelling knowledge.

The assessment of lexical spelling knowledge was based on doublets which, unlike context sensitive doublets, cannot be related to the quantity of a preceding vowel (cf. the introduction). Items with these 'lexical' doublets were otherwise quite similar to the items with context sensitive doublets, both with respect to orthographic structure and frequency of occurrence. Thus, similar results on the two types of items would be expected, unless participants exploited the link between context sensitive doublets and vowel quantity.

As explained earlier, it is possible that doublets are difficult because they depart from the 'one letter per sound' relation. A test of 'grapho-phonemic' awareness

was included in the experiment to assess whether participants were aware of deviant sound-letter relations.

The doublet problem does not necessarily reflect a lack of spelling knowledge. A failure to *retrieve* doublets from memory could also be a source of spelling errors. Furthermore, as noted above, doublets may cause problems in the actual production of spellings because the same letter has to be written twice. If doublet errors are due to such more superficial problems, one would expect scores to be better in a test where participants merely have to select correct spellings than in a test where they have to produce them. Evidently, memory and production problems are ruled out if spellings with doublets are already provided as candidate spellings in a selection task. To address this possibility, Experiment 1 assessed doublet knowledge with a spelling selection task as well as with a spelling production task.

Method

Participants

A total of 96 children from grades 4, 5 and 6 were tested, 49 girls and 47 boys. (The results reported in Juul, submitted, are based on the same experiment.) Two classrooms per grade level were tested. The mean age was 11;10 years (SD: 9 months; range: 10;4 to 13;2 years). All participants spoke Danish as their first language, and all attended the same school in a non-deprived, socially mixed suburban neighbourhood of Copenhagen.

The two grade 4 classrooms did not complete the whole test battery (one left out spelling selection, and the other left out grapho-phonemic awareness). Furthermore, data are missing in a few cases when pupils were absent on the second day of testing (cf. the procedure section below).

Measures

Production of context sensitive doublets. A dictation test was given. The test featured 16 word items with an intervocalic target consonant following a stressed vowel (cf. Appendix A). Half of these vowels were short (consonant doublet spelling appropriate) and half were long (singleton consonant appropriate).

To provide a score that took account of overgeneralisations - i.e., doublets used after long vowels where they are not appropriate - the correlation between the type of spelling produced (doublets vs. singleton consonants) and the type of word (doublet vs. singleton consonant appropriate) was calculated for each participant (phi coefficients, as both variables were dichotomous). The coefficients were based on scores for the target consonants only, and phonemically implausible spellings were

disregarded in order to obtain a measure that reflected specific problems with the use of doublets vs. singleton consonants.

Production of lexical doublets. The dictation test described in the preceding paragraph also featured 16 words with intervocalic consonants occurring after *unstressed* vowels, in which context the use of doublets is *not* related to vowel quantity (cf. the introduction). As with context sensitive doublets, doublets were appropriate for half of the items, and phi coefficients were computed to provide a score that took account of overgeneralisations. The frequency and structure was similar for context sensitive and lexical doublet items.

Spelling selection. Knowledge of doublets was also assessed in a task where participants had to *select* whether a spelling with or without a doublet was correct. The items were the same 32 words which were used to assess production of context sensitive and lexical doublets. This task was inspired by a task used by Cassar and Treiman (1997). In the present study, however, alternative spellings were provided for the rhyme parts of the words only. For instance, the word *flise* 'flagstone' was presented like this:

fl ____ - ise
 - isse

Participants were asked to tick the box next to the correct spelling as the words were dictated to them. This mode of presentation was used to draw attention to the possible spellings *without* allowing judgements to be based on visual recognition of the correct spelling. This style of presentation also avoided exposing participants directly to incorrectly spelled words (Dixon & Kaminska, 1997). Scores (phi coefficients) were computed as in the tests of spelling production.

Vowel matching. In this task participants were instructed to listen carefully to the vowel in the first (stressed) syllable of a two-syllable word. This word was presented twice by the experimenter. The task was to find a word with exactly the same vowel among three candidate words. There were 24 trials with 3 practice trials (cf. Appendix A). The target vowels were divided equally between long and short vowels. In order to make the test sensitive (Catts et al., 1997), the two distractor words had vowels that differed only minimally from the target vowel. One distractor word always differed with respect to vowel quantity, but had the same quality as the target vowel. The second distractor word differed either with respect to vowel quality (either more open or more closed) or with respect to the presence of 'stød'. Stød is a

very common prosodic feature of Danish vowels, a kind of ‘creaky voice’ (Grønnum, 1998). No explicit reference was made to vowel quantity, vowel quality or to the prosodic feature *stød*.

Participants used a coupon to indicate the position of the correct word, which was randomised. To minimise the burden on short term memory, the base word was repeated before each of the three candidate words. The three candidates were presented twice in this way. After that the participants were requested to make their decision immediately. Participants were told that they were allowed to guess.

Grapho-phonemic awareness (after Scarborough et al., 1998). In this task participants were asked to count the number of sounds in 18 words presented in written form (cf. Appendix A). Participants did this by underlining each letter or group of letters that corresponded to a single sound. The test items were listed in a column printed in lowercase letters to show them in their standard printed form. Next to each lowercase word the same word appeared in capital letters, with space between letters to allow separate marking, followed by a box for recording the number of sounds. The experimenter pronounced each of the 18 words, using a distinct but normal pronunciation, and allowing the participants all the time they needed to perform the task before going on to the next word.

Seven practice items demonstrated that the relationship between sounds and letters is not always one-to-one. For instance, the final *-ng* of the practice item *lang* ('long') corresponds to just one sound, a velar nasal. Participants were instructed that only one joint line was required for the two letters *-ng*. Another practice item, the name *Max*, illustrated that the letter *x* should be marked by two lines because it corresponds to two sounds. The silent *h* of the practice item *hvem* 'who' illustrated that silent letters should be left unmarked.

Responses were recorded as erroneous if separate sounds were not marked separately, or if groups of letters were marked separately although they corresponded to one sound only. Unlike Scarborough et al. (1998), no error was recorded if a joint line was used for a silent letter and a neighbouring sounding letter (e.g. *sw* of the English word *sword*). Whether a silent letter (e.g. *w* of *sword*) was categorised as silent or categorised as a part of a complex grapheme (e.g. *sw* jointly representing /s/ in *sword*) seemed unimportant for the present purposes.

Pseudo-word spelling. Participants were asked to spell ten pseudo-words with a complex syllable structure, e.g. /sgvald/ and /flemsg/ (cf. Appendix A). The score was the number of phonemically implausible spellings. A maximum of three errors was scored per word.

Word reading. This measure was based on a published test where words have to be matched to one of four pictures (Søegård & Petersen, 1968). The test has 400 items. The score was the number of correctly solved items within a time limit of five minutes.

Procedure

All tests were administered on a group basis in the participants' own classrooms. The test of spelling production was always given first. The order of the remaining tests was not fixed. Tests were administered during two lessons on the same day. Any remaining tests were administered on a different day.

The test of spelling production comprised other items than those used to assess the use of consonant doublets. The version given to sixth graders had 116 items, and the version given to fourth and fifth graders had 69 items. The items were presented by the test leader in sentence contexts which were also printed on the test sheets. The sentences were designed to facilitate identification of the items. The sentences were presented in a random order which was fixed for each version of the test. To avoid fatigue, the longer version of the test was divided into three parts, and the shorter version into two parts.

In the test of spelling selection items were not presented in a sentence context. Context sensitive and lexical doublet items were mixed at random in a fixed order.

Results

Table 1 presents the results on context sensitive and lexical doublets, respectively. As described in the method section above, phi coefficients were computed to assess the strength of the links made between doublet spellings and words where doublets were correct.

As previously reported (Juil, submitted), spelling accuracy was much better for context sensitive doublets than for lexical doublets, suggesting that Danish fourth to sixth graders do exploit the phonological context to some extent when spelling.

Somewhat surprisingly, the selection task - where participants were reminded that doublet spellings were possible - did not yield better results than the production task, neither for context sensitive nor lexical doublets. This was true also when the comparison was confined to participants who took the test under both conditions (please recall that one group of fourth graders did not take the selection part of the test). However, results from the two conditions did not provide exactly the same information. The correlation between production and selection scores was only

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moderate for context sensitive doublets ($r = .53$, $p < .001$), and relatively weak for lexical doublets ($r = .30$, $p = .01$).

The mean number of correct responses on vowel matching for all participants was 10.9 (SD: 2.9, $N = 93$). This is significantly above the chance score of 8 ($t(92) = 9.72$, $p < .001$), but far below the maximal score of 24. When participants made errors, they selected the quantity distractor more often than the quality/stød distractor (7.2 vs. 5.9 errors). This difference was significant ($t(92) = 3.32$, $p = .001$).

Error rates were relatively high on the test of grapho-phonemic awareness, too. The mean number of errors made on the 18 items was 11.6 (SD: 8, $N = 75$), i.e., errors were made on roughly two out of three items. More than one error could be made on the same item, however.

For pseudo-word spelling the mean number of errors made on the 10 items was 8.8 (SD: 8.5, $N = 96$), i.e., nearly one error per item, but, again, more than one error could be made on the same item. On word reading the mean number of correctly read words was 145 (SD: 33, $N = 96$).

The main question in Experiment 1 was whether the production of context sensitive doublets was related to scores on the vowel matching task. A significant, although moderate correlation was found ($r = .36$, $p < .001$). Importantly, the partial correlation remained significant when scores on lexical doublets, pseudo-word spelling and word reading was controlled ($r = .29$, $df: 87$, $p < .01$). As one group of fourth graders did not take the test of grapho-phonemic awareness, adding this measure as a fourth control meant that the data set was reduced. The partial correlation was still marginally significant, however ($r = .23$, $df = 66$, $p = .06$). Thus, a specific relation between the use of doublets and vowel awareness was confirmed.

Selection of context sensitive doublets had a correlation with vowel awareness of approximately the same size as production ($r = .35$, $p < .01$, $N = 75$). This correlation was still marginally significant when scores on lexical doublets, pseudo-word spelling and word reading was controlled ($r = .22$, $df = 69$, $p = .07$).

Interestingly, vowel awareness was not the only important correlate of production of context sensitive doublets. The correlation with the use of lexical doublets was significant even when vowel awareness, pseudo-word spelling and word reading was controlled ($r = .28$, $df = 87$, $p < .01$). This suggests that lexical learning plays a role in the acquisition of knowledge of context sensitive doublets. The correlation was not significant, however, when grapho-phonemic awareness was added as a fourth control measure.

Table 1. Mean scores (with SDs) for the production/selection of context sensitive and lexical doublets. $N = 96$ (production) and 75 (selection). The maximal score for correct and overgeneralised spellings was 8.

Context sensitive doublets					
Production			Selection		
<i>Phi</i>	Correct	Overgen.	<i>Phi</i>	Correct	Overgen.
.66	6.4	1.4	.62	6.7	1.9
(.23)	(1.4)	(1.3)	(.27)	(1.3)	(1.7)
Lexical doublets					
Production			Selection		
<i>Phi</i>	Correct	Overgen.	<i>Phi</i>	Correct	Overgen.
.27	2.4	0.7	.28	3.2	1.3
(.27)	(1.6)	(0.8)	(.25)	(1.7)	(1.4)

Overgen.= Overgeneralised.

Likewise, the correlation with errors on pseudo-word spelling survived controls for vowel awareness, the use lexical doublets, and word reading ($r = -.23$, $df = 87$, $p < .05$), suggesting that basic phonemic encoding skills play an important role in the acquisition of knowledge of context sensitive doublets. Again, however, the correlation dropped below significance when grapho-phonemic awareness was added as a fourth control measure.

Discussion

The main finding of Experiment 1 was that vowel awareness was uniquely correlated with knowledge of context sensitive doublets. The vowel awareness measure did not tap quantity awareness exclusively, but also other aspects of vowel awareness. For this reason it is an open question whether production of doublets was associated specifically with quantity awareness or with vowel awareness more generally. Both may be important. However, problems with quantity awareness was evident from the fact that the distractor words that differed with respect to vowel quantity attracted more errors than the other distractor words in the vowel matching task.

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As noted, the fact that the use of context sensitive doublets had fairly robust relations with the use of lexical doublets and with pseudo-word spelling suggests that vowel awareness is not the only important factor involved in the acquisition of context sensitive doublets. Lexical learning and basic phonemic encoding skills may play important roles, too. Grapho-phonemic awareness did not emerge as an important correlate, but as the data set was smaller for this measure no strong conclusion should be drawn from this fact.

The similarity of results from spelling production and spelling selection was interesting for practical as well as theoretical reasons. It was interesting for practical reasons because administering the selection task was much less time consuming than administering the production task. However, the measures were far from equivalent as the correlations between production and selection scores were moderate to weak. Although a selection task is a quick way of obtaining information on children's spelling knowledge, it probably should not replace measures based on spelling production altogether. Presumably, a selection task invites random responses to a larger extent than a production task.

The similarity of production and selection scores was theoretically interesting because it suggests that doublet errors are not merely due to a problem with retrieving spelling knowledge from memory or to a problem with the actual production of doublets. Had that been the case, one would expect scores on selection to be superior to scores on production. Apparently, it is a genuine problem to link the use of doublets to just those words where they are correct.

An obvious limitation of Experiment 1 is that causal connections between variables cannot be inferred from the correlations. Given these data, vowel awareness could be a consequence as well as a cause of spelling development, or vowel awareness and spelling development could both depend on some other factor. To tackle the issue of causality, and to examine the role of quantity awareness more specifically, a new experiment was needed.

EXPERIMENT 2

Whereas Experiment 1 aimed to assess the participants' knowledge of doublets, Experiment 2 aimed to assess the ease with which knowledge of doublets was acquired. Third graders with limited knowledge of context sensitive doublets were selected for the experiment. The main idea was to test whether measures of phonological awareness would predict the ease with which these children learned the spellings of a series of pseudo-words (spelled with or without a doublet). Thus, the experiment was similar to a traditional longitudinal study where the development of a

given skill is followed, and where the predictive validity of pretest measures is tested. However, the present experiment used a test of learning potential (a dynamic test) instead of following spelling development over a time. A computer-based learning task with standardised feed-back was used, and the measure of spelling development was the amount of feed-back needed before the pseudo-word spellings were learned.

Dynamic tests have some times been used as a supplement to traditional static tests, e.g. to predict later schooling achievement (Grigorenko & Sternberg, 1998). The present study went the other way and looked for predictors of performances on a dynamic test. An obvious advantage of this approach is that the outcome measure (the potential for learning) can be assessed at the same time as the possible predictors. Previous studies using this 'condensed' longitudinal design include Dixon, Stuart and Masterson (2002) who found that the ease with which reception class children learned to recognise ten six-letter words depended on their phoneme segmentation skills, and Yopp (1988) who taught kindergartners to sound out six CVC pseudo-words and examined how well learning was predicted by various measures of phonemic awareness. Generally, however, this design has not been used very often.

The experiment included four different phonological awareness tasks in order to examine whether success on the dynamic test could be predicted from specific aspects of phonological awareness. One task was a rhyme matching task. This task was expected to be easier than the vowel matching task used in Experiment 1 because it did not require explicit awareness of vowels. Implicit awareness of vowels and vowel quantity was still required however. If the doublet problem reflects a problem with implicit awareness of vowels, then a significant correlation between scores on this task and success on the dynamic task would be expected. A second task required a high level of control over vowel quantity as participants were asked to transform words into new words by making the vowel longer or shorter (cf. English *filling* > *feeling*). A third task required explicit awareness of vowel quantity as participants were asked to identify vowels as short a long (a similar task was used by Landerl, 2003). The fourth task was a phoneme deletion task, included to test whether quantity awareness would predict success on the dynamic test better than a more traditional measure of phonological awareness.

In Experiment 1 above it was found that the accuracy with which context sensitive doublets were used was related to other aspects of spelling (lexical spelling knowledge and basic encoding skills). In the present experiment the importance of lexical spelling knowledge was addressed by assessing knowledge of context sensitive doublets with word items as well as pseudo-word items (static measures). If lexical learning is important, a lexicality effect would be expected.

The importance of basic encoding skills was not addressed in Experiment 2 because encoding skills were used as a criterium in the selection of participants. If an initial screening test (cf. the method section below) indicated that participants had problems with representing VCV sequences, they were not included in the study. It seemed pointless to administer the dynamic test - where *alternative* spellings for VCV sequences had to be considered - to participants with basic encoding problems. Good spellers who made few or no doubling errors in the screening test were not included in the experiment either. Thus, the range of encoding skills in the sample was restricted.

The test of grapho-phonemic awareness used in Experiment 1 was included again in Experiment 2. Furthermore, Experiment 2 included measures of two possible sources of doublet errors which were not addressed in Experiment 1. These were the lexical representation of vowel quantity and visual memory.

It is a generally recognised fact about Danish phonology that vowel quantity is distinctive, i.e. a vowel quantity difference is sufficient to distinguish two words from each other. However, quantity contrasts are affected by several ongoing sound changes in modern Danish pronunciation (Grønnum, 1998). Furthermore, it is not necessarily the case that all language users employ information about vowel quantity to distinguish between words. Using doublets to mark vowel quantity contrasts could certainly be difficult if lexical representations of pronunciations do not include information about vowel quantity. To check this possibility a lexical decision task with spoken words was administered. The nonword items in this task differed from genuine Danish words in one respect only: A long vowel had been substituted for a short vowel, or vice versa. Presumably, these items would only be categorised as nonwords if participants did rely on quantity contrasts to judge lexicality.

Visual memory skills are often assumed to play an important role in spelling acquisition. For instance, Bruck and Waters (1988) argued that “visual memory must play a role in spelling, since there are some words, or parts of words, whose spellings cannot be derived on the basis of grapheme-phoneme correspondences (e.g., *sapphire*).” Lennox and Siegel (1998) found empirical support for this position from studies of spelling-grade-matched samples. These studies indicated that “poor spellers attain the same spelling level as do good spellers by using their good visual memory skills.” Visual skills in these studies were measured by scoring misspelled words for visual similarity with correctly spelled words (shared letters and bigrams). Pattison and Collier (1992) went as far as to compare the number of up-strokes and down-strokes to assess visual similarity with correctly spelled words.

By contrast, the importance of visual skills to spelling acquisition has not been evident when independent measures of visual memory skills have been used (Caravolas et al., 2001; Giles & Terrell, 1997). This may seem surprising, as it is a

common experience that a correct spelling just *looks* right when compared to phonemically equivalent alternatives. On the other hand, the fact that spellers know what a word look like does not imply that spelling production is based on this visual knowledge under normal circumstances. A test of visual memory was included in the experiment to check whether it would predict success on the dynamic test. This seemed especially relevant because a spelling selection task was used in the dynamic test. Participants were shown alternative spellings for pseudo-words and had to select and remember the correct one. It did seem possible that success in such a task would to some extent depend on visual memory.

Method

Participants

32 third graders participated in the experiment. They came from four different classrooms and from two different schools in Valby, a socially mixed neighbourhood near central Copenhagen. The participants were selected from a larger sample of 60 pupils on the criteria that they spoke Danish as their first language, and that an initial screening test indicated that they had problems with the use context sensitive doublets, although their phonemic encoding skills were reasonably good. The screening test was a pseudo-word dictation test with 10 items administered to one classroom at a time. All the pseudo-words had a VCV-ending. For half of the items the consonant of the ending should be represented by a doublet because the preceding stressed vowel was short. Pupils were included in the study only if they made a minimum of three doublet errors on the five short vowel items and if they represented the VCV endings of at least 8 items in a plausible way (undoubled consonants accepted after short vowels).

Eleven of the original 60 pupils were excluded because they did not speak Danish as their first language. Another nine pupils were excluded because they made few or no doubling errors, and four were excluded because of poor phonemic encoding skills. Four pupils met the criteria, but were not available for the following individual test sessions. The remaining 32 pupils - 14 boys and 18 girls - had a mean age of 9;4 years (SD = 4 months).

Measures

Except for the stimuli used for grapho-phonemic awareness all stimuli, spoken as well as written, were prerecorded and presented from a computer using the software platform Cognitive Workshop (courtesy of P.H.K. Seymour, University of Dundee).

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Written stimuli appeared on the screen in a dark blue typeface (Arial 24 pt.) on a white background. Responses were recorded by the computer, too.

Stimuli used in the tests are listed in Appendix B.

Static test of doublet knowledge. Knowledge about the relationship between medial consonant doublets and preceding short vowels was assessed using a selection test similar to the one used by Cassar and Treiman (1997). Sixteen two-syllable items were presented orally in a random order, eight with a short and eight with a long stressed vowel preceding a single medial consonant phoneme. Participants were asked to choose from two alternative spellings how each item should be spelled. The alternatives appeared on the screen simultaneously with the spoken stimulus, a spelling with a single medial consonant on the left and a spelling with a medial doublet on the right. Participants used the left and right arrow keys to indicate their choice of spelling. No feedback was given, and the fact that the alternative spellings differed only with respect to the presence of a medial doublet was not made explicit. As in Experiment 1 the strength of the links made between doublet spellings and short vowel items was used as a measure (ϕ coefficients).

The test was given first in a version with word items, and subsequently in a version with pseudo-word items. The words (if not their spellings) were presumed to be well-known to third graders. Because the participants in Experiment 2 were younger, items were used which were structurally simpler than those used in Experiment 1. None of the Experiment 2 items had more than two syllables, and the medial consonant was always followed a schwa vowel and nothing more. The pseudo-word items were derived from the word items by changing the onset consonant. Thus, the rhyme parts of word and pseudo-word items were identical.

Dynamic test of doublet knowledge. This test was a modification of the static test. Exactly as in the static test, spoken items were presented, and participants chose whether a spelling with or without a doublet was appropriate. In this version however, immediate yes/no feedback (in green/red letters) appeared on the screen. The test had three parts. In each part eight items were presented. After the first round of presentation, the participant was told that they had nine more chances to get as many green feedbacks as possible, and that the computer would be defeated if they got green feedbacks for all items! Then the items were repeated another nine times, or until the computer was 'defeated'. Thus, the criterion for successful learning was that correct spellings were selected for all 8 items within the same round of presentation. The score was the number of presentation rounds needed.

The items used for each part of the test were divided equally between items with short and long stressed vowels. For the first two parts of the test the items were

the same 16 pseudo-words that were used in the static test of doublet knowledge. The items in the third and final part were new. These items were created by changing the onsets of the pseudo-word items used for the first part of the test. Thus, the items of the first and the final part of the test had identical rhyme parts.

Rhyme matching. In this task participants had to select the perfect rhyme for a given word from two alternatives. All words were presented orally only. The word to be rhymed with was presented twice, then the two alternatives. Participants pressed the left and right arrow keys, respectively, to select the first or the second alternative. The order of perfect/imperfect rhyme alternatives was randomised. There were two conditions of eight trials each. In one condition the imperfect rhyme alternatives differed from the perfect rhymes with respect to vowel quantity. In the other condition it differed with respect to the presence of the phonetic feature *stød* (cf. Experiment 1 above). Under both conditions the words to be rhymed with were divided equally between words with a short or a long vowel. The trials of the two conditions were mixed at random. To avoid fatigue there was a break after the first eight trials. Trials within each half of the test were presented in a random order. The score was the number of correct responses.

Quantity transformation. In this task participants had to transform words into different words by changing the quantity of a vowel, either from short to long, or from long to short. The test had two parts consisting of eight trials each.

In the instruction to the first part of the test participants were asked to listen to the vowel phoneme /ø/ of the word *kølle* 'club', and to observe how a new word resulted if the vowel was prolonged: /'kø|ø/ (*kølle* 'club') turns into /'kø:|ø/ (*køle* 'cool'). Two similar examples were given. Then participants were asked to transform eight words presented by the computer into new words in the same way.

In the second part of the test participants had to make transformations in the opposite direction, from long to short vowels. Again three examples were given in the instruction before the eight test items were presented, e.g., shortening the vowel turns /'vi:|ø/ (*hvile* 'rest') into /'vi|ø/ (*ville* 'would'). The score was the total number of correct responses.

Quantity identification. In this task participants had to indicate whether or not a two-syllable word presented had a long vowel. Participants were instructed that they should pay attention to the first (stressed) vowel of the words presented. Two of the minimal pairs used in the instruction for Quantity transformation (cf. above) were used to illustrate the fact that vowels can be either long or short. Participants were asked to press the left arrow key if words presented (orally) by the computer featured

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a long vowel, and the right arrow key if it did not. There were 16 word items. The items were the same words as were used for the static test of doublet knowledge. Unfortunately, some participants reversed the arrow keys, so that the number of correct responses could not be used as a score. Instead, the correlations between the key pressed (left or right) and vowel quantity (long or short) were computed for each participant (phi coefficients because both variables were dichotomous). Negative coefficients were converted to positive coefficients so that scores reflected the degree to which participants distinguished between long and short vowels, even if the buttons had been reversed.

Phoneme deletion. In this task participants had to transform words into different words by deleting the first consonant phoneme. There were 12 items. Participants were instructed that a new word can result if one omits the first sound of a word. Three examples were given where the deletion of a simple one-consonant onset produced a new word, e.g. /fed/ (*fedt* 'fat') turns into /ed/ (*et* 'one'). Participants were told that not all the items would be as easy as the examples.

The test items had two or three consonant phonemes in onset position. Items were selected so that a new word would result no matter how much of the onset was deleted (one, two or three consonants). Responses were scored as correct if one consonant phoneme only was deleted.

Quantity representation. This was a lexical decision task. Sixteen items were presented orally. Half of the items were genuine Danish words, presumed to be well-known to third graders. The remaining items differed minimally from a well-known genuine word as the quantity of the stressed vowel of the word had been changed (short to long or vice versa). To ensure that decisions of lexicality were based on vowel quantity, long and short vowels of the exact same quality occurred both in words and nonwords. The rhyme parts of items were kept constant, too. For instance, a long /u:/ occurred both in the word item *smule* 'bit' and in a nonword item which was derived from the word *dulle* 'baby doll' (which is pronounced with a short /u/). Likewise, a short /u/ occurred both in the word item *rulle* 'roll' and in a nonword item derived from the word *skjule* 'hide' (which is pronounced with a long /u:/). The score was the number of correct responses.

Visual memory. In this task participants had to remember and recognise a string of Greek letters. There were sixteen trials. A sequence of two, three or four Greek letters was displayed on the computer screen for four seconds. Following a two-second pause, the same stimulus was displayed again, this time together with a slightly altered stimulus, and participants had to identify the original stimulus. As in the tests

of doublet knowledge the position of the correct choice was divided equally between the left and the right side of the screen, and participants used the left and right arrow keys to respond.

The incorrect alternatives were created by altering the original stimulus in one of two ways: Either two neighbouring letters had been transposed, or a letter had been replaced by a letter not present in the original stimulus. The use of Greek letters (inspired by Goulandris & Snowling, 1991) had the advantage that the stimuli consisted of letter-like shapes, but did not allow access to phonology. Each trial was introduced by an alert (***) displayed for 1 second in the same position as the following stimulus. To avoid fatigue there was a break after the first eight trials. The order of trials was randomised within each half of the test. The score was the number of correct responses.

Grapho-phonemic awareness. This was the same test as in Experiment 1.

Procedure

Testing was done early in the second half of the school year. Grapho-phonemic awareness was administered on a group basis at the screening session. All other tests were administered individually from a computer (cf. above) in a quiet room at the participants' school.

The tests were always given in the same order: Static doublet knowledge, followed by Quantity representation, Rhyme matching, Quantity transformation, Phoneme deletion, Quantity identification and Dynamic doublet knowledge. Visual memory was administered in between the second and the third part of Dynamic doublet knowledge. Administering the test battery usually took about 60 minutes.

Results

Static tests of doublet knowledge

The static tests of doublet knowledge served two purposes. First, scores on word and pseudo-word items were compared to test the assumption that a lexicality effect would be found. This assumption was confirmed. The mean phi coefficient for word items was .42, (SD .27) against .23 (SD .25) for pseudo-word items, and this difference was significant ($t(31) = -2.83; p < .01$).

Second, the static test based on pseudo-words was used to confirm that participants in the study did not already master the link between doublets and preceding short vowels. This was important because the hypothesis to be tested was whether phonological awareness would predict the acquisition of doublet knowledge

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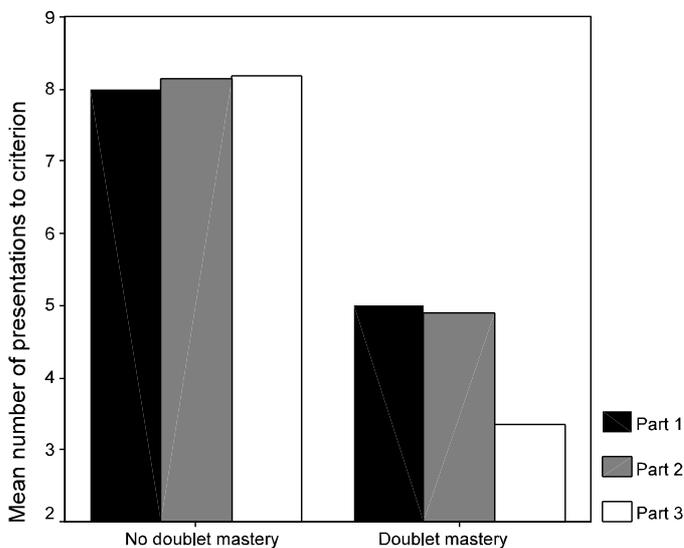
in children who did not yet master this link. Presumably, such children would chose pseudo-word spellings with and without doublets at random and obtain a phi coefficient close to zero on the static test. However, as just reported, the mean was in fact as high as .23, and, indeed, the scores of some participants were unlikely to result from random responses. The phi coefficients for pseudo-words were converted to chi square values, and for nine of the 32 participants it was found that the probability of the value was smaller than 5%. These nine participants are referred to below as participants with (some) doublet mastery, and their scores on other measures are reported separately.

Dynamic test of doublet knowledge

Unfortunately, testing of one of the participants who did not obtain a significant score on the static test was interrupted during the third and final part of the dynamic test of doublet knowledge. For the remaining 22 participants the mean number of trials needed to learn the new spellings in the dynamic test was 8.2 (SD: 2.5). As one would expect, spellings were learned faster by the nine participants who did obtain a significant score on the static measure. For these participants the mean number of trials needed was 4.4 (SD: 4.3).

The number of trials needed was fairly constant across the three parts of the dynamic test. This is shown in Figure 1. Apparently, participants did not improve their general knowledge of context sensitive doublets in the course of the test. For the nine participants with doublet mastery, however, there was a tendency towards faster learning in the final part of the test.

Figure 1. The number of presentations of pseudo-words required in the 3 parts of the dynamic test before correct spellings were selected for all 8 items.



The scores of individual participants varied somewhat from one part of the test to the next. Thus, test-retest reliability was moderate. Part 1 and 2 correlated at .52, part 1 and 3 at .44, and part 2 and 3 at .66 ($p < .01$, $N = 31$).

Scores on phonological awareness measures

Table 2 shows the scores on the four measures of phonological awareness. As explained in the Method section some participants reversed the response keys in the test of Quantity identification, and for this reason the score for this measure is not the percentage of correct responses, but the correlation between response type (left/right arrow key) and stimulus type (short/long vowel). Scores are reported both for participants with and without doublet mastery. For participants in the latter group it seems justified to expect that performances on the quantity awareness tasks were not influenced by spelling knowledge of doublets. In the former group, however, this possibility cannot be excluded.

The rhyme matching task turned out to be the easiest task in both groups. A significant difference between the groups was found only on Quantity identification (Mann-Whitney $U(9, 22) = 49$, $p < .05$), where the participants with mastery of doublets were clearly better at identifying vowel quantity.

Scores on other background variables

Table 3 shows the scores on the remaining three background variables. Scores were similar in participants with and without doublet mastery on the lexical decision task used to assess representations of vowel quantity. Overall, the scores on this measure

Table 2. Scores (with SDs) on the phonological awareness measures. Scores are percentages correct except for Quantity identification (phi coefficients, cf. the method section). Scores are shown separately for participants with and without doublet mastery.

	Rhyme matching	Quantity transformation	Quantity identification	Phoneme deletion
No doublet mastery	78 (10)	70 (28)	.51 (.29)	56 (35)
Doublet mastery	83 (10)	80 (21)	.76 (.31)	54 (27)

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were significantly above the chance level of 50 % correct responses (one-sample t-test: $t(30) = 11.90$, $p < .001$). Thus, it appears that in general Danish children - at least those who participated in the present study - do use information about vowel quantity to identify words as words. Some uncertainty was evident, however. Two participants performed at chance level, and not a single participant scored 100% correct.

Participants with doublet mastery were not characterised by better visual memory than participants without doublet mastery. In fact the reverse was true, as participants without doublet knowledge obtained the higher scores on Visual memory. This difference between groups was significant (Mann-Whitney U (22, 9) = 54.5, $p < .05$). The participants without doublet mastery also tended to make fewer errors on Grapho-phonemic awareness. Roughly, scores on Grapho-phonemic awareness were similar to those observed for fourth to sixth graders in Experiment 1.

Correlates of dynamic doublet knowledge

Correlates of the scores on dynamic doublet knowledge are reported only for the 22 participants without doublet mastery. Only one measure had a significant correlation with the number of presentations needed to learn the spellings in the dynamic test (the means of the three parts of the test). This measure was Quantity identification ($r = -.47$, $p = .03$). The correlation was negative because participants who were good at identifying vowel quantity required fewer presentations before they remembered the correct spellings.

Scores on the dynamic test also showed a marginally significant correlation with Grapho-phonemic awareness ($r = .41$, $p = .08$). The correlation with Visual memory was .20 (n.s.). Note that this correlation was positive, indicating that participants with good visual memory tended to need *more* trials to learn the spellings. All other correlations were quite low (.13 or smaller).

Discussion

A relation between awareness of vowel quantity and knowledge of context sensitive doublets was attested in two ways. Most importantly, explicit awareness of vowel quantity (Quantity identification) predicted the speed with which the spellings were learned in the dynamic test of doublet knowledge. Secondly, the participants who showed some mastery of doublets in the static test of doublet knowledge also obtained better scores than the remaining participants on Quantity identification. Thus, a link between *explicit* awareness of vowel quantity and doublet knowledge was demonstrated.

Table 3. Scores (with SDs) on Quantity representation and Visual memory (percentages correct) and on Grapho-phonemic awareness (errors). Scores are shown separately for participants with and without doublet mastery.

	Quantity representation	Visual memory	Grapho-phonemic awareness
No doublet mastery	72 (12)	88 (9)	11.6 (4.7)
Doublet mastery	75 (9)	79 (13)	13.3 (8.8)

The fact that scores on Quantity identification were related to the acquisition of doublet knowledge in children who did not show mastery of the doubling rule beforehand suggests that explicit awareness of vowel quantity facilitates the acquisition of doublet knowledge. It must be pointed out, however, that a causal relationship between quantity awareness and acquisition of doublet knowledge cannot be inferred with certainty because the present study was not a training study, but only a (condensed) longitudinal study. However, the results of the present study are in accordance with the view that training explicit quantity awareness should have a positive effect on spelling acquisition in Danish children. It would also be of interest to see whether the results of a condensed longitudinal study such as the present one can be replicated in a real time longitudinal study.

The fact that Quantity identification was the only measure that was related to scores on the dynamic test does not necessarily mean that the remaining measures are not important for the acquisition of doublet knowledge. One should bear in mind that the sample was small. Furthermore, it is always possible that measures could have been more sensitive. It was puzzling that the scores on the Quantity transformation task were quite high, and that they were barely correlated with scores on the dynamic test. The intention of creating a task that required a high level of control over vowel quantity contrasts may not have been fulfilled. Possibly, two features of this task should be changed. First, transformations in the same direction (short to long, or long to short) were blocked so that a transformation pattern could be repeated. Second, word to word transformations were used so that a search for a similar sounding known word could lead to success.

Even if the sample had been larger, and the tests more sensitive, it seems unlikely, however, that a failure to represent vowel quantity contrasts would explain much variance in doublet knowledge. The lexical decision task demonstrated that Danish children do use vowel quantity contrasts to distinguish between words and

nonwords. Furthermore, this result together with the good results on the rhyme matching task suggest that Danish children are generally quite able to *perceive* vowel quantity differences. Thus, problems with explicit awareness emerged as a more likely explanation of doublet errors than problems with perception (or implicit awareness) of phonemic quantity.

The results of the study also make it questionable whether the doublet problem can be ascribed to visual memory problems, as the poorer spellers seemed to have better visual memory. Possibly, poor spellers rely on visual memory to a greater extent than good spellers, as suggested by Lennox and Siegel (1998).

The acquisition of doublet knowledge in the dynamic test occurred in an experimental setting. The dynamic test required that correct spellings were learned for several new words within a very short time, and - luckily perhaps - this is not often necessary in more natural settings. Nevertheless, the problem that had to be solved was the same problem that spellers meet in 'real life', viz. to learn the correct orthographic representation of a given sound structure.

Spelling development may to a large extent be a matter of implicit learning rather than a matter of applying explicit rules (Steffler, 2001). The dynamic test was realistic in the sense that the learning that took place could be implicit. No reference was made during the experiment to the rule that doublets should be used after short vowels. Experiment 2 can be seen as a parallel to the experiment carried out to Dixon and colleagues (2002) where children with good phoneme segmentation skills learned to recognize words faster, although phonemic analysis as a strategy to solve the task was not encouraged. In the present experiment correct spellings were learned faster by children who were able to identify vowels as long or short although the relevance of vowel quantity was not made explicit.

Although most participants did learn the correct spellings in the dynamic test, they did not appear to learn the doubling rule. If participants had been picking up the rule, one would expect that results improved from one part of the test to the next, but they did not. Given the persistence of the doublet problem in Danish children, such fast improvement would clearly be to expect too much. After all, the dynamic test was quite brief. However, it was encouraging that the spellers who did show some mastery of context sensitive doublets on the static test, did tend to improve their scores on the third part of the test. It is quite possible that genuine transfer effects can be obtained if more parts are added to the test, or if the test is repeated over several test sessions.

GENERAL DISCUSSION

Learning to use consonant doublets after stressed short vowels is a well-known spelling problem in Danish. Experiment 1 and 2 converged in showing that Danish children's knowledge of such context sensitive consonant doublets is related to their awareness of vowels phonemes. The results of Experiment 2 suggested that this relationship is causal, so that vowel awareness facilitates the acquisition of doublet knowledge. More specifically, Experiment 2 suggested that awareness of vowel quantity contrasts is important, and that explicit rather than implicit awareness is needed to acquire knowledge of consonant doublets. Taken together, the two experiments suggest that phonological awareness continues to have an impact on the development of spelling skills, even beyond the earliest grade levels.

While insufficient quantity awareness was identified as a likely cause of the doublet problem, other possible causes were not supported. The surprisingly poor performances on the spelling selection task in Experiment 1 suggest that the doublet problem cannot be explained as a problem with retrieving spelling knowledge from memory or as a problem with the actual production of consonant doublets. Experiment 2 indicated that visual memory problems are not a likely explanation either.

Phonological awareness was not the only factor that was found to be associated with knowledge of context sensitive doublets, however. Lexical knowledge clearly made a contribution to performances on context sensitive doublets, too. This was evident from the correlation between scores on context sensitive and lexical doublets in Experiment 1, and from the lexicality effect observed on knowledge of context sensitive doublets in Experiment 2.

Furthermore, it seems likely that the acquisition of doublet knowledge is helped by a basic understanding of the way phonemes can be represented in writing. The doublet problem tended to be smaller in participants who were good pseudo-word spellers (Experiment 1) and in participants with a high level of grapho-phonemic awareness (both experiments). Pseudo-word spelling requires familiarity with basic one-to-one sound-letter relations, while grapho-phonemic awareness requires familiarity with deviant (one-to-many) sound-letter relations. Presumably, children who are good at matching sounds to letters are more likely to reflect on the doublet problem, and, indeed, to realize that there *is* a problem.

As already mentioned, a training study would be needed to produce harder evidence of a causal relationship between quantity awareness and spelling development in Danish. The purpose of such a study would be to test whether a quantity awareness training programme would have a positive effect on spelling development. It may be the case that teachers tend to regard awareness of vowel

quantity as sufficient when implicit awareness is evident, e.g. when children distinguish without problems between words with long and short vowels (cf. English *feeling* vs. *filling*). However, as the present study shows, explicit awareness of vowel quantity cannot be taken for granted, and explicit awareness may be what matters. Although Experiment 2 indicated that many Danish third graders have problems with consonant doublets, a training study should begin at an earlier age in order that the full range of developmental curves can be included.

The dynamic test that was used in Experiment 2 can be modified in several ways. For instance, one could compare the ease with which alternative orthographic markers of vowel quantity are learned. Indirect marking by doubling consonants after short vowels (as in Danish) could be compared to direct marking by doubling long vowels (as in Finnish) or to a system using accents to mark quantity. Such modifications may yield further insight into the nature of the doublet problem and reveal to what extent the difficulty lies in the indirect marking, and to what extent doublets as such are difficult. There may be an ethical problem, however, in teaching Finnish orthographic conventions to Danish children!

If transfer effects can be obtained, so that new spellings are learned faster as the test is repeated, it would be possible to ask at what linguistic level the doubling rule is acquired. If the rule is learned at the level of the rhyme, for instance, one would expect transfer to occur when new items have rhyme parts previously trained, but not if only the vowel is repeated from trained items.

Finally, future studies may tell us more about how specific cognitive abilities relate to the acquisition of specific types of spelling knowledge. For sure, there is much more to learn about what it takes to become a competent speller. The present study is in line with previous studies of Finnish and German (Landerl, 2003; Lehtonen, submitted) in suggesting a link between awareness of phonemic quantity and the frequency of doubling errors in spelling. Thus, the relevance of quantity awareness to spelling acquisition does not appear to be confined to Danish. Possibly, quantity awareness is important in all orthographies where the doublet problem is found.

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Appendix A. Items used in Experiment 1

Knowledge of doublets. Target consonant spellings are in bold. Context sensitive doublets represent consonants preceded by a short stressed vowel, while the singleton consonants represent consonants preceded by a long stressed vowel. All lexical targets (both doublet and singleton spellings) represent consonants preceded by a short unstressed vowel.

Context sensitive doublets		Lexical doublets	
Doublet correct	Singleton correct	Doublet correct	Singleton correct
hæmme ‘impede’	lime ‘glue’	ballon ‘balloon’	galop ‘gallop’
svøm mm et ‘swum’	slim met ‘slimy’	fall it ‘bankrupt’	salat ‘salad’
kl amm er ‘brackets’	rekl am er ‘commercials’	satell it ‘satellite’	katolik ‘catholic’
belæs set ‘loaded’	fræs et ‘milled’	bil let ‘ticket’	ske let ‘skeleton’
bøs ser ne ‘the guns’	tøs er ne ‘the girls’	koloss al ‘enormous’	filosof ‘philosopher’
bass e ‘big lump’	knas e ‘crunch’	bass ist ‘bass player’	rosin ‘raisin’
tiss e ‘pee’	flis e ‘flagstone’	miss il ‘missile’	dus in ‘dozen’
nuss e r ‘fondle’	fus e r ‘bummer’	passag e r ‘passenger’	posit ion ‘position’

Pseudo-word spelling. Expected spellings (with examples of phonemically acceptable alternatives):

skvalt (sgvald), flimsk (flemsg), skrumfe (sgråmfe), splosket (sblåsged),
flandage (flandasje), sjanifade (schannifade), kalustraten (kalustraten),
halifarnisk (halifarnisg).

Vowel matching. The vowel to be matched is specified in IPA (in oblique brackets) as conventionally modified for Danish. Vowel length is represented by a colon. The vowel pronunciations of the candidate match words are indicated by the column headings.

Base of comparison	Candidate match words			
	Same vowel	Wrong quantity	Wrong quality	Stød added
bille 'beetle' /i/	tipper 'tip'	rimer 'rhyme'	nisser 'pixies'	
pæne 'nice' /ɛ:/	æbler 'apples'	ælder 'knead'		æsler 'donkeys'
nisse 'pixie' /e/	etter 'number one'	scener 'scenes'	stepper 'does tap dancing'	
tube 'tube' /u:/	buler 'bumps'	futter 'puff'		Nuser 'Snoopy'
samme 'same' /ɑ/	lapper 'mend'	parker 'parks'	basser 'big lumps'	
mene 'think' /e:/	seler 'straps'	fedter 'grease'		snedker 'carpenter'
lytte 'listen' /y/	hygger 'make comfortable'	fryser 'freezer'	skyller 'rinse'	
dine 'yours' /i:/	timer 'hours'	liter 'litre'		smiler 'smile'
nytte 'utility' /ø/	bøsser 'guns'	køler 'cooler'	skønner 'estimate'	
løse 'loose' /ø:/	køber 'buyer'	tønder 'barrels'		føler 'feel'
dutte 'beep' /u/	pudser 'polish'	ugler 'owls'	skummer 'foam'	
hyle 'howl' /y:/	dyner 'quilts'	bytter 'exchange'		ymer 'junket'
puffe 'push' /ɔ/	trommer 'drums'	otter 'number eight'	klodser 'blocks'	
føle 'feel' /ø:/	tøser 'girls'	bøtter 'bins'		døber 'christen'
kulde 'cold' /u/	putter 'put'	fuser 'bummer'	skummer 'foam'	

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dele 'share' /e:/	stener 'stone'	peber 'pepper'		meter 'metre'
bisse 'hooligan' /i/	gitter 'grating'	timer 'hours'	sikker 'sure'	
fæle 'nasty' /ɛ:/	læber 'lips'	tæpper 'rugs'		hvæser 'hiss'
skaffe 'get' /ɑ/	takker 'thank'	varmer 'heat up'	kalder 'call'	
syle 'awls' /y:/	lyner 'zip'	tygger 'chew'		nyser 'sneeze'
ikke 'not' /e/	fedter 'grease'	skeler 'squint'	esser 'aces'	
gribe 'catch' /i:/	ligner 'resemble'	bisser 'hooligans'		hviler 'rest'
fylde 'fill' /y/	hytter 'cottages'	gyser 'thriller'	stykker 'pieces'	
lune 'warm' /u:/	bruser 'spray'	duller 'baby dolls'		super 'super'

Grapho-phonemic awareness. The proper grapho-phonemic segmentation of the words is shown with hyphens, and the total number of phonemes is given. Silent letters are in brackets. The *x* of *taxi* and the *J* of *John* are counted twice because they represent two phonemes.

<i>råbe</i> 'yell'	r-å-b-e (4)	<i>unger</i> 'kids'	u-ng-er (3)
<i>pudser</i> 'polish'	p-u-(d)s-er (4)	<i>hjælp</i> 'help'	(h)j-æ-l-p (4)
<i>taxi</i> 'taxi'	t-a-x-x-i (5)	<i>spand</i> 'bucket'	s-p-a-n(d) (4)
<i>Uffe</i> boy's name	U-ff-e (3)	<i>pjatte</i> 'fool about'	p-j-a-tt-e (5)
<i>kjole</i> 'dress'	k-j-o-l-e (5)	<i>økse</i> 'axe'	ø-k-s-e (4)
<i>var</i> 'was'	v-ar (2)	<i>John</i> boy's name	J-J-o(h)-n (4)
<i>det</i> 'it'	d-e(t) (2)	<i>spurgt</i> 'asked'	s-p-u-r(g)-t (5)
<i>elleve</i> 'eleven'	e-ll(e)-v-e (4)	<i>svensk</i> 'Swedish'	s-v-e-n-s-k (6)
<i>hammer</i> 'hammer'	h-a-mm-er (4)	<i>hvidt</i> 'white'	hv-i-(d)t (3)

Appendix B. Items used in Experiment 2

Static test of doublet knowledge. Consonant doublets represent consonants preceded by a short stressed vowel, while singleton consonants represent consonants preceded by a long stressed vowel. Pseudo-word items were derived from word items by changing the onset. Each item was presented together with an alternative spelling where doublets had been changed to singleton consonants or vice versa.

Words		Pseudo-words	
Doublet correct	Singleton correct	Doublet correct	Singleton correct
kasse ‘box’	flise ‘flagstone’	jasse	klise
tisse ‘pee’	blæse ‘blow’	gisse	spæse
trylle ‘conjure’	smile ‘steals’	nylle	snæle
bølle ‘rowdy’	smile ‘smile’	hølle	svile
nænne ‘have the heart to do smth.’	lune ‘warm’	bænne	fune
bønne ‘bean’	svane ‘swan’	pønne	fjane
hætte ‘hood’	myte ‘myth’	kætte	syte
kamme ‘combs’	lime ‘glue’	pamme	dime

Dynamic test of doublet knowledge. Pseudo-word items from the static test were used for Part 1 and 2. Items for Part 3 were derived by changing the onset of the Part 1 items. Each item was presented together with an alternative spelling where doublets had been changed to singleton consonants or vice versa.

Part 1: jasse, hølle, bænne, kætte, klise, svile, fune, syte

Part 2: gisse, nylle, pønne, pamme, spæse, snæle, fjane, dime

Part 3: tasse, jølle, fænne, pætte, stise, prile, gunne, fyte

Rhyme matching. The rhyme to be matched is specified in IPA (in oblique brackets) as conventionally modified for Danish. Vowel length is represented by a colon, and stød is represented by an apostrophe. The rhyme pronunciations of the candidate match words are indicated by the column headings.

Base of comparison	Candidate match words		
	Perfect rhyme	Wrong vowel quantity	Stød missing (-) or added (+)
dele 'share' /e:/	hele 'whole'	spille 'play'	
klippen 'the rock' /e/	vippen 'the seesaw'	kneben 'meagre'	
slibe 'grind' /i:/	knibe 'difficulties'	sjippe 'skip'	
kilde 'tickle' /i/	bille 'beetle'	smile 'smile'	
næse 'nose' /ɛ:/	hvæse 'hiss'	messe 'chant'	
prinsesser 'princesses' /ɛ/	læsser 'load'	næser 'noses'	
svedte 'sweated' /e:/	ledte 'searched'	fedte 'grease'	
stille 'quiet' /e/	pille 'pill'	hele 'whole'	
mener 'think' /e'/	gener 'genes'		scener 'scenes' (-)
alene 'alone' /e:/	scene 'scene'		forene 'unite' (+)
læser 'read' /ɛ'/	hvæser 'hiss'		flæser 'flounces' (-)
skeler 'squint' /e:/	heler 'heal'		deler 'share' (+)
forvente 'expect' /ɛn'/	kendte 'known'		sendte 'sent' (-)
vente 'wait' /ɛn/	hente 'fetch'		kendte 'known' (+)
forsvinder 'disappear' /ɛn'/	skinner 'shine'		vinder 'winner' (-)
fælde 'trap' /ɛ/	hælde 'pour'		fortælle 'tell' (+)

Quantity transformation. Correct transformations of vowel quantity resulted in new words (given in brackets). For the items *masse* and *klase* the change of vowel quantity also involves a slight change of quality.

Short to long vowel	Long to short vowel
fulde 'full' > (fugle 'birds')	hyle 'howl' > (hylde 'shelf')
pippe 'cheep' > (pibe 'pipe')	Ribe [Danish town] > (ribbe 'rib')
blusse 'blaze' > (bluse 'blouse')	kugle 'ball' > (kulde 'cold')
minde 'remind' > (mene 'think')	spæne 'run' > (spænde 'buckle')
pakken 'the parcel' > (parken 'the park')	storken 'the stork' > (stokken 'the walking stick')
hælde 'pour' > (hæle 'heels')	pæle 'poles' > (Pelle [boy's name])
tamme 'tame' > (tarme 'guts')	larmet 'been noisy' > (lammet 'the lamb')
masse 'a lot of' > (mase 'mash')	klase 'cluster' > (klasse 'class')

Quantity identification. The word items from the static test of doublet knowledge were used.

Phoneme deletion. Appropriate deletion of the initial phoneme resulted in a new word (in soft brackets). Deleting an additional phoneme resulted in a third word [in sharp brackets].

snyde 'cheat' > (nyde 'enjoy') > [yde 'yield']
 klatter 'small lumps' > (latter 'laughter') > [atter 'again']
 fjord 'inlet' > (jord 'earth') > [ord 'word']
 svane 'swan' > (vane 'habit') > [ane 'suspect']
 trille 'roll' > (rille 'groove') > [ilde 'badly']
 fjerne 'remove' > (hjerne 'brain') > [ærinde 'errand']
 knægte 'lads' > (nægte 'deny') > [ægte 'genuine']
 sprød 'crisp' > (brød 'bread') > [rød 'red']
 flet 'plait' > (let 'easy') > [ædt 'eaten']
 skråt 'sloping' > (gråt 'grey') > [råt 'raw']
 pris 'price' > (ris 'rice') > [is 'ice']
 tvære 'smear' > (være 'be') > [ære 'honour']

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Quantity representation (lexical decision). The nonwords were created by changing the quantity of the stressed vowel of a genuine word (either long to short or short to long). The genuine words are listed.

Word items		Words permuted to nonwords	
Long vowel	Short vowel	Long vowel	Short vowel
Lise [girl's name]	trisse 'reel'	brise 'breeze'	bisse 'hooligan'
smule 'bit'	rulle 'roll'	skjule 'hide'	dulle 'baby doll'
fryser 'freezer'	krydse 'cross'	fnyse 'snort'	tysser 'shush'
håne 'mock'	kunde 'customer'	skåne 'spare'	bonde 'farmer'

Visual memory. One of the Greek 'words' within each pair (the one printed in bold here) was first presented in isolation. Subsequently this 'word' had to be recognized when presented together with the other 'word'.

2 or 3 letter 'words'		4 letter 'words'	
θς - ςθ	ξφ - ξμ	θεφβ - θβφε	ζςδθ - μςδθ
ζψ - ψζ	μφ - μψ	θψφβ - θφψβ	ζεβψ - ζωβψ
μξζ - μζξ	εςω - εθω	δμψξ - δψμξ	ξβθε - ξωθε
βδφ - βφδ	ςωδ - ςωβ	ςεξζ - ςξεζ	φμθζ - φμθς

STUDY 4

The Links Between Grammar and Spelling: A Cognitive Hurdle in Deep Orthographies?

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Abstract

A cross-sectional study tested Danish students' mastery of links between grammar and spelling (cf. the English link between past tense verbs and the *-ed* spelling for a word final /t/, e.g. *missed* vs. *mist*). 142 students aged 10 to 17 spelled pseudo-word items with ambiguous phonemes, where the choice between a 'conditional' spelling (cf. English *ed* for /t/) and a simple spelling (cf. *t* for /t/) was predictable from the grammatical context of items. Overgeneralisations (conditional spellings used where simple spellings were appropriate) were controlled to obtain pure measures of grammatical spelling competence. The oldest group of participants performed near ceiling on four of five spelling problems studied while three younger groups in the experiment never did. The nature of the apparent grammatical hurdle in Danish spelling acquisition is discussed.

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Introduction

Inconsistent relations between phonemes and graphemes are a key characteristic of deep orthographies. The concept of orthographic depth is most commonly associated with feedforward inconsistency (graphemes with ambiguous pronunciations), but the consequences of feedback inconsistency (phonemes with ambiguous spellings) are also an important object of study (Ziegler, Jacobs & Stone 1996; Ziegler, Stone & Jacobs 1997). English orthography is notorious for its feedback inconsistencies. To give a simple example, the phoneme /s/ can be represented by several different graphemes including *s*, *c*, *ps*, *sc*, and *ce* (Carney 1994). Similar examples can be supplied by many other orthographies, including the French, the Portuguese, the Greek, and the Danish.

Feedback inconsistencies are clearly a challenge to the speller. When simple spellings, such as *s* to represent /s/, do not apply, spellers will often need to make links between spellings and specific words as well as between spellings and phonemes: /s/ is spelled *c* in *cigar*, *ps* in *psychology* and so on. The need for a word-based (lexical) spelling strategy as well as a phoneme-based strategy obviously makes spelling acquisition a much bigger task, as spellings have to be learned word by word and not just phoneme by phoneme (Leong 1998). The problems caused by inconsistencies may be reflected in the relatively poor spelling of English children as compared to children learning to spell in German, a relatively consistent orthography (Wimmer & Landerl 1997).

However, the phoneme-level ambiguities of deep orthographies often reflect regularities at higher linguistic levels. Thus, an ambiguity can some times be resolved when the phonological context of a phoneme is considered. For instance, alternative spellings such as *c*, *k*, and *ck* for /k/ in English are largely sensitive to the position of the phoneme (e.g., *ck* does not occur word initially) and to the quality of the following segment (e.g., *c* is the dominant spelling before consonants and certain vowels) (Kessler & Treiman, in press; Marsh, Friedman, Welch & Desberg 1980). It is also often the case that ambiguities can be resolved when the morphological structure of words is considered. A standard English example of this is the *ea* spelling common to the morphologically related words *heal* and *health*. Discovering such higher level regularities can promote accurate spelling, even when words are new to the speller, and thus reduce the problem of having to memorise spellings word by word (Perry, Ziegler & Coltheart 2002).

This paper focuses on higher level regularities of a special kind, viz. regularities in the ways words of different grammatical categories are represented in writing. As an example, consider the alternative spellings *-ed* and *-t* for word

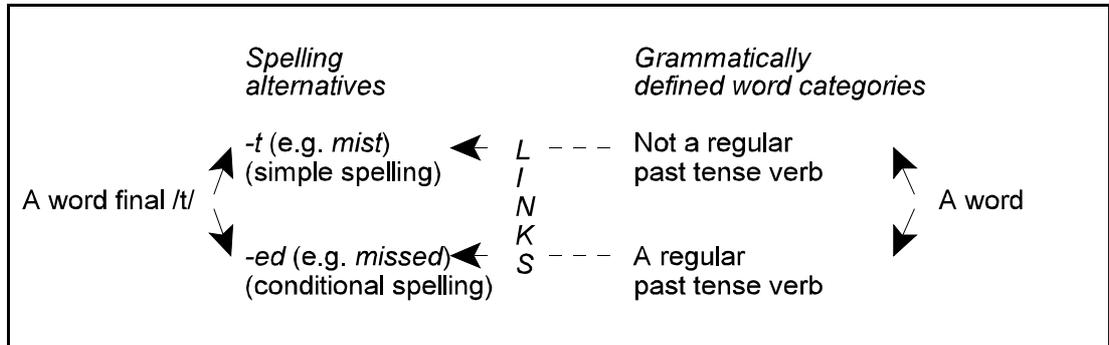
final /t/ in English (Figure 1). It is a grammatical regularity of English orthography that a word final /t/ is spelled *-ed* if the word is a regular verb in the past tense, e.g. *missed*; otherwise the simple *t* spelling usually applies, e.g. in the noun *mist* (Nunes, Bryant & Bindman 1997a). Such links between grammar and spellings are also found in a number of other orthographies - including Danish, the linguistic focus of the present paper. We will refer to spellings like the *-ed* spelling in English as 'conditional' or 'grammatically defined' spellings (because of the grammatically defined condition). Spellings like the *-t* spelling will be referred to as 'simple' spellings.

The *-ed* spelling for /t/ in English is used, of course, because an inflectional morpheme, the past tense marker, is spelled in the same manner in spite of differences in its pronunciation. In fact, most grammatical regularities can be classified as morphological regularities pertaining to inflectional morphemes. Knowing about regularities involving inflectional morphemes may be especially useful to spellers because this knowledge can be used more generally than knowledge of regularities involving derivational morphemes and stem morphemes. To illustrate, knowledge of the link between the past tense and the *-ed* spelling in English can be used to spell a great many past tense verbs in /t/ (*passed, puffed, bumped, lacked*, etc.). Knowledge of stems and derivatives with a constant spelling (cf. *heal* and *health*) obviously has a more limited scope of application. However, while the relevance of derivational morphology to spelling seems to be widely recognized (and quite rightly so; e.g., Carlisle 1988), this is perhaps not quite the case for inflectional morphology.

It should be noted that regularities in the relation between grammar and orthography is not always confined to inflectional morphemes. For instance, the use of an initial upper case letter in proper names is not particular to any specific morpheme, but to a *category* of morphemes. This link between grammar and spelling is also made in 'shallow' orthographies, of course.

In the following section we review some of the existing evidence concerning the degree to which spellers are able take account of grammatical categories. Special attention will be paid to the problem of devising measures that specifically reflect grammatical spelling competence. We refer broadly to cases where grammar is relevant to spelling, regardless of the specific way in which grammatical distinctions are reflected in writing (cf. Bryant, Nunes and Aidinis, 1999, for a typology) and regardless of the nature of the grammatical knowledge that is needed (identification of a particular word class, inflectional morpheme, syntactic function, etc.).

Figure 1. An English example of a link between a grammatical category and a spelling. The 'conditional' spelling -ed for a word final /t/ is correct for regular verbs in the past tense, while the 'simple' spelling -t is correct for most other words.



Grammar and spelling

Grammatical knowledge has been found to influence children's spelling very early on. Thus, Treiman and Cassar (1996) observed that the *r* of uninflected words such as *Mars* was omitted more often in the spellings of American first graders than the *r* of inflected words such as *bars*. Presumably, the /r/ of the consonant cluster /rz/ is easier to identify when the final /z/ corresponds to an inflectional ending which has been attached to a stem ending in /r/. This may be true even if spellers are not consciously identifying the inflection. Similarly, Rubin (1988) found that kindergartners and first graders omitted an /n/ more often in one-morpheme words such as *band* than in two-morpheme words such as *canned*. These findings suggest an indirect relation between grammatical knowledge and spelling performance because spellers are able to use grammatical knowledge to support their identification of phonemes.

This indirect relation between grammar and spelling must be distinguished from the direct links between grammar and grammatically defined spellings that we are concerned with in this paper. In the case of grammatically defined spellings grammatical information does not merely support the identification of phonemes, but even helps the speller in deciding how to spell ambiguous phonemes.

The use of grammatically defined spellings has primarily been studied in beginners. In the earliest phases of spelling acquisition it appears that grammatically defined spellings are largely ignored. Thus, in a summary of findings from studies on English, Portuguese, Greek, and French, it was reported that beginning spellers tend to a simple spelling for ambiguous phonemes, even

when a 'conditional' spelling would be correct (Bryant, Nunes & Aidinis 1999). Furthermore, some beginning spellers tend to omit inflectional endings, such as the past tense marker in English (Rubin 1988; Zutell 1980).

Still, some conditional spellings seem to be learned early on in spelling development. Greek children, for instance, have been reported to spell grammatically defined word endings rather accurately already in the second grade (Harris & Giannouli 1999). French third graders have been found to apply spellings specific to plural nouns (e.g. the silent *-s* in *pommes* 'apples') almost consistently (Totereau, Thevenin & Fayol 1997). A study of past tense spellings in English showed that *some* 8-year-old children were able to use the *-ed* ending correctly in the past tense (Nunes, Bryant & Bindman 1997b). Using a task with pseudo-verbs appearing in meaningful sentence contexts, the same authors found that 10-year-olds on average used the *-ed* spelling correctly in 4.3 of 5 items (Nunes, Bryant & Bindman 1997a). Results on this pseudo-verb task correlated strongly with results on a real-verb spelling task. The problem of using the *-ed* spelling correctly has also been found to be quite small in a study of stories written by second and third graders (Carlisle 1996).

There is also evidence, however, that the use of grammatically defined spellings presents problems to spellers beyond the earliest grade levels. Totereau et al. (1997) found that correct plural marking of French verbs (e.g., the silent *-nt* in *Ils marchent* 'They walk') lagged somewhat behind plural marking of nouns. And the use of apostrophes to mark words with a genitive inflection has been shown to be a problem to many English 12-year-olds (Bryant, Nunes & Bindman 1997). Even when we turn to teenagers and adults, spelling errors are not unusual in words that exhibit complexities of a morphological or morpho-phonemic nature (Fischer, Shankweiler & Liberman 1985; Shankweiler, Lundquist, Dreyer & Dickinson 1996). Specific problems with grammatical morphemes are attested in English, where adults in a task based on pseudo-words surprisingly often used incorrect spellings such as *-z* or *-se* for a plural inflectional /z/, where only *-s* would be correct (Kemp & Bryant 2003). Likewise, Dutch teenagers often make errors when the inflectional *-t* of verbs in the third person singular is not predictable from phonology (Frisson & Sandra 2002). From Danish there is anecdotal evidence of similar grammatical spelling errors in high school students and adults, e.g., omissions of the inflectional final *-r* of present tense verbs when it is not predictable from phonology.

In conclusion, it is not clear at what age the use of grammatically defined spellings is generally mastered. It may be that size of the learning problem differs considerably from one spelling to the other, or from one orthography to the other. To clarify this, it may be useful to assess performances with a range of

grammatically defined spellings, and to examine performances in different orthographies.

In order to compare different grammatically defined spellings, or to make comparisons across orthographies, it is obviously important to use comparable and precise measures. To this end, the use of pseudo-words was an important feature of the study by Nunes et al. (1997a), because this excluded the possibility that positive results were due to word-specific spelling knowledge. Indeed both Harris and Giannouli (1999) and Frisson and Sandra (2002) found effects of word frequency, suggesting that familiarity with word-specific spellings contributed to the scores. If the participants in these studies had based their responses exclusively on the grammatical categories of items, frequency effects would not be expected, as the categories were the same for frequent and less frequent items.

Even when pseudo-word items are used, however, the frequency with which conditional spellings are used is not necessarily a good reflection of grammatical spelling competence. For instance, when the 'conditional' *-ed* spelling is used for English past tense verbs, the reason could be that spellers use this spelling quite generally to represent word final /t/ or /d/. Indeed, 'overgeneralisations' of conditional spellings to contexts where a simple spelling should be used seem to be a common phenomenon (Bryant, Nunes & Aidinis 1999; Bryant, Nunes & Bindman 1999; Fayol, Thevenin, Jarousse & Totereau 1999; Nunes et al. 1997b). For example, English 6- to 8-year-olds sometimes use the *-ed* ending for 'non-verbs' that end in /t/ or /d/ such as *soft* and *ground* (Nunes et al. 1997b). If measures are to reflect grammatical spelling competence specifically, it seems important that the frequency of such overgeneralisations is controlled. In their experiment with past tense pseudo-verbs, however, Nunes et al. (1997a) did not include non-verbs, and hence it is not known to what degree participants in that study would have overgeneralised the *-ed* spelling to such items.

Another problem in using the raw frequencies of conditional spellings as a measure of grammatical spelling competence is the fact that basic problems with phoneme level encoding will reduce the score. Consequently, raw frequency scores may reflect an undesirable mixture of basic spelling skill and knowledge of the relevant links between grammar and spellings.

One final problem in measuring the degree to which spellers take account of grammatical categories needs to be pointed out. In some contexts the use of a simple spelling may lead to an unusual letter combination, and to avoid this some spellers may adopt a conditional spelling without understanding the grammatical basis of the conditional spelling. This may have been the case for some of the pseudo-verbs used by Nunes et al. (1997a) to assess English

children's knowledge of the *-ed* ending. The 'correct' spellings of the five pseudo-words used were *deaved*, *crelled*, *linged*, *dreeped*, and *feached*. Some participants may have preferred the *-ed* ending for these items to avoid unusual letter combinations, such as word final *-vd*, *-ngd*, or *-cht*, which could result from using simple *-d* and *-t* spellings. Thus, to avoid confounding grammatical and orthographic aspects of spelling competence, it seems important to devise items where neither simple nor conditional spellings lead to unusual letter combinations.

So far, we have looked at evidence concerning the age at which mastery of grammatically defined spellings is acquired. We now turn to evidence about what it *takes* to acquire such mastery.

In English, strong correlations have been found between the use of the *-ed* spelling for verbs in the past tense and the use of the *wh-* spelling for interrogatives (Bryant, Nunes & Aidinis 1999). This may indicate that knowledge of the two spellings has a common basis in grammatical awareness, so that children who discover the *-ed* spelling are likely to discover the *wh-* spelling, too. However, since the *wh-* spelling of interrogatives is found mainly in a handful of highly frequent words, the importance of linking this spelling to a grammatically defined category of words (interrogatives) is not very evident. Possibly, performances with *wh-* and *-ed* spellings were related because both measures reflected the word-specific spelling knowledge. We are not aware of other studies where performances on different grammatically defined spellings have been compared.

A good many studies, longitudinal as well as intervention studies, have assessed the importance of morphological skills to later literacy development. However, such studies have typically focussed on reading development or on other aspects of spelling than grammatically defined spellings (e.g., Casalis & Louis-Alexandre 2000; Carlisle 1995; Elbro & Arnbak 1996; Levin, Ravid & Rapaport 2001; Lyster 1997; Rubin 1988). Luckily, a few longitudinal studies specifically concerned with grammatically defined spellings do exist (Bryant, Nunes & Bindman 2000; Kirby, Bell & Deacon 2003; Nunes et al. 1997a, 1997b). These studies suggest that specific types of linguistic awareness can predict developments in the use of such spellings. Notably, Nunes et al. (1997a) found grammatical awareness (a word analogy task) to predict unique variation in the use of the English *-ed* ending (the pseudo-verb measure discussed above) over a 21 month period. Interestingly, however, it was found that phonological awareness (a phoneme oddity task) also predicted unique variance in this measure. Possibly, this was because children with good phonemic awareness are

more aware of the problem of ambiguously spelled phonemes, and thus more likely to discover the links between spellings and grammar. Part of the problem of learning to use conditional spellings may be to realize that there is a spelling problem in the first place. However, another possible explanation could be that the outcome measure (the frequency of *-ed* spellings) to some degree reflected basic skills in phoneme level encoding (cf. above). It would hardly be surprising if phonemic awareness predicted the development of basic phonemic encoding skills (Brown & Ellis 1994).

Apart from awareness of grammar and phonology, teaching may be of importance, of course. Although both Nunes et al. (1997a) and Harris and Giannouli (1999) point out that children seem to discover grammatical constraints on spellings, at least to some extent, without being explicitly taught, it is clear that students may benefit from explicit instruction. Indeed, in two intervention studies concerned with grammatically defined spellings participants were successfully taught to use these spellings (Bryant, Devine, Ledward & Nunes 1997; Fayol et al. 1999). Nunes, Bryant and Olsson (2003) studied the effects of teaching children about stems and suffixes either with or without explicit spelling instruction. The effects of these morphological training programmes were not entirely convincing, however.

The study

The present study used a cross-sectional design to examine the mastery of links between grammar and spellings in Danish students beyond the early school years (students from grades 4 to 10, aged 10 to 17). Grammar - and morphology more generally - plays an important role in Danish orthography because morphemes often preserve their spellings in spite of variations in pronunciation (Elbro 1990). For instance, the *d* spelling for a morpheme final /ð/ is usually preserved before inflectional and derivational suffixes, even in contexts where the phoneme /ð/ is omitted, as in *bid* - *bidt* /bið - bit/ 'bite - bitten'. The spelling of the past participle *bidt* /bit/ 'bitten' has a silent *d* which can be inferred if the verbal stem is pronounced without the inflectional suffix. It is a very common situation in Danish that spellings are conditioned by morphology. On the other hand, one cannot take it for granted that morphology is reflected in writing. Thus, although the adjective *jysk* /jysk/ 'Jutish' is derived from the noun *jyde* /'jy:ðø/ 'person from Jutland', the *d* of the noun *jyde* is *not* preserved in the spelling of the derived adjective. In fact, the adjective *jysk* is often misspelled **jyds*k with an incorrect silent *d*.

Some of the classic spelling problems in Danish concern the spelling of inflectional morphemes (cf. the Method section for examples). Thus, grammar

and morphology play a role in Danish orthography which is in many ways similar to the role they play in English (probably the most studied orthography in the world), and studies of Danish can help to clarify the general nature of problems with this aspect of orthography. To the best of our knowledge, the present study is the first to focus specifically on grammatical spelling problems in Danish. Three main questions were addressed.

First, we asked at what grade level such links are fully mastered. In order to provide a general answer to this question we looked at five different grammatical spelling problems presumed to vary in difficulty (descriptions of these problems are given in the Method section below). Four of these involved spellings of inflectional endings, while the fifth involved the marking of proper names by upper case initials. Steps were taken to avoid the problems described above in obtaining pure measures of grammatical spelling competence. For instance, measures were devised to take account of overgeneralisations, so that they reflected to what extent the use of conditional spellings was confined to the grammatical contexts where they were appropriate (cf. below).

Second, we asked whether performance levels for the five grammatical spelling problems had a common basis. One possibility is that awareness of grammatical categories provides such a common basis, in which case strong intercorrelations between performances would be expected. However, shared variance could also be due to more general factors such as sensitivity to higher level orthographic regularities, or general literacy skills. As controls of these factors we included a spelling measure focussing on spellings sensitive to the phonological context (cf. above) and a measure of word reading.

Third, we asked, within the limits of a cross-sectional design, how the use of conditional spellings develops. At what point in time do Danish students adopt the use of conditional spellings? And to what extent do spellers overgeneralise conditional spellings to contexts where simple spellings should be used?

Method

Participants

There were four groups of participants, all with Danish as their first language (Table 1). All participants came from the Copenhagen area. At each grade level the study comprised two classrooms. The fourth, sixth, and eighth graders all attended the same school. The oldest participants (grade 10) were in their first year of high school. As only about 45 % of Danish school children continue to

Table 1. Participants in the study.

	Grade level			
	4	6	8	10*
Number of participants	31	40	33	38
Mean age (years:months)	10:9	12:9	14:9	17:0
Male/female (pct.)	42/58	42/58	70/30	37/63

* The participants from grade 10 were attending high school.

high school, it is likely that this group differed from the other groups on other parameters than age.

Five grammatical spelling problems in Danish

Performances with the following five grammatical spelling problems in Danish were assessed.

Problem 1. Present tense verbs in *-rer*. Danish verbs in the present tense usually end in the inflection /ɾ/, spelled *-er*, while infinitives end in /ə/, spelled *-e*. However, when the stem of a verb has a final /r/, both present tense verbs and infinitives end in /rɾ/, spelled *-rer* or *-re* according to the inflectional ending. Thus, to know when to use the *-rer* spelling (in this paper labeled the 'conditional' spelling) rather than the *-re* spelling (labeled the 'simple' spelling), spellers must link the conditional spelling to the appropriate grammatical category (viz. present tense verbs, but not infinitives).

Problem 2. Present participles in *-ende*. Danish verbs in the present participle end in the inflection /ənə/, spelled *-ende* (with a silent *d*). However, definite plural nouns may also end in /ənə/, spelled *-ene* (without a silent *d*). Thus, to know when to use the 'conditional' *-ende* spelling rather than the 'simple' *-ene* spelling, spellers must link the conditional spelling to the appropriate grammatical category (viz. present participles, but not definite plural nouns)

Problem 3. Past participles in *-et*. Danish verb in the past participle usually end in the inflection /əð/, spelled *-et*. However, some uninflected nouns also end in

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/əð/, spelled *-ed* or, in a few words, *-ede*. Thus, to know when to use the 'conditional' *-et* spelling rather than the 'simple' *-ed* (or *-ede*) spelling, spellers must link the conditional spelling to the appropriate grammatical category (viz. past participles, but not uninflected nouns).

Problem 4. Definite nouns in *-en*. Danish nouns of common gender take the definite inflection /ən/, spelled *-en*. However, in casual pronunciations the /ən/ is reduced to just /n/ when the inflection follows a vowel. Uninflected nouns may also end in a vowel followed by /n/, and this /n/ is simply spelled *-n*. Thus, to know when to use the 'conditional' *-en* spelling rather than the 'simple' *-n* spelling, spellers must either access a distinct pronunciation (with an unreduced /ən/), or they must link the conditional spelling to the appropriate grammatical category (viz. definite nouns, but not uninflected nouns).

Problem 5. Upper case marking of proper names. As in most alphabetic writing systems, names are marked in Danish orthography by an upper case initial letter. This marking does not apply to other grammatical word categories. Thus to know when to use an upper case initial ('conditional' spelling), rather than a lower case initial (the 'simple' spelling), spellers must link this marker to the appropriate grammatical category (viz. names, but not, e.g., verbs).

There are other grammatical spelling problems in Danish than the five in focus here. These particular problems were examined because the grammatical conditions involved apply so consistently that we would expect competent spellers to take account of them. Also, the difficulty of the problems were presumed to differ somewhat. Problems 1, 2 and 5 are classic spelling problems in Danish which are addressed in spelling instruction approximately from grade 4 onwards (Problem 5 even earlier). The introduction of grammatical terminology is often integrated with spelling instruction. Problem 3 is less often addressed explicitly during spelling instruction, probably because uninflected words ending in /əð/ are relatively few. Problem 4 is not commonly taught either, but the conditional *-en* spelling can be inferred from distinct pronunciations with unreduced /ən/. For this same reason it was expected that Problem 4 would be relatively easy. Problem 5 was expected to be easy, too, because both the distinction between upper and lower case letters and the category of names were presumed to be very familiar to all participants.

Measures

Grammatically defined spellings. Measures to assess performances on the five spelling problems described above were based on ten pseudo-words per problem. Each pseudo-word was spelled twice, once in a context where the 'conditional' spelling was correct and once in a context where the 'simple' spelling was correct (cf. Appendix A). The score was the correlation in each participant between spellings used (conditional or simple) and grammatical contexts (conditional spelling correct or simple spelling correct). The idea was to measure how strongly conditional spellings were linked to the appropriate grammatical contexts, rather than just the frequency with which they were correctly used (Richards & Siegler 1982).

The correlations reported are so-called phi coefficients because both variables (spellings used and grammatical contexts) were dichotomous. More information on phi correlations can be found, for instance, in Hatch and Lazaraton (1991). The correlations were based on phonemically adequate responses only, so that low scores could not simply be due to basic problems with phoneme level encoding. Items were constructed so that neither conditional nor simple spellings would lead to unusual letter combinations.

For convenience items are referred to as 'conditional' or 'simple' according to their correct spelling. Items used for Problem 4 (definite nouns in *-en*) were presented using casual, although perfectly normal pronunciations, in order that the *e* of the conditional *-en* spelling could *not* be inferred directly from the pronunciations (cf. above). To facilitate scoring items used for Problem 5 (upper case marking of proper names) all began with consonants which differ in letter shape as well as size from the upper to the lower case.

Spellings sensitive to the phonological context. This measure assessed the spelling of phonemes which are ambiguous at the phoneme level, but predictable from the *phonological* context in which they occur. The measure was based on seven pseudo-word items (listed in Appendix B; three other pseudo-words, disregarded here, were included for other purposes). These seven items featured a total of fifteen target phonemes. The score was the percentage of spellings used that were conventional for the target phonemes when the phonological contexts were considered. The score was based on phonemically adequate responses only.

Word reading. Word reading was assessed using an existing test, OS 400, where participants are asked to match printed words to one of four pictures (Søegård & Petersen 1968). The measure was the number of correct responses with a time limit of 5 minutes. The maximal score was 400.

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Procedure

The test battery was administered as group tests to participants in their usual classrooms. Usually testing was completed within one session (with appropriate breaks). The test of grammatically defined spellings was always given first. For this test, participants were given a booklet with a total of 100 pre-printed sentences. Each sentence contained a pseudo-word, and each pseudo-word featured an ambiguously spelled phoneme, the spelling of which had been replaced by a line. The task was to complete the spellings of the pseudo-words as the sentences were dictated. Each pseudo-word was presented twice but in different sentence contexts. A pair of sentences (translated to English) featuring the pseudo-word /bep/ could look like this:

My dog is called ___ep.

My uncle likes to ___ep

As the examples show, the grammatical category of each pseudo-word, and from that the spelling of the ambiguous phoneme, could be inferred from the sentence context - in this case an upper case initial *B* when the pseudo-word represented a name (Problem 5).

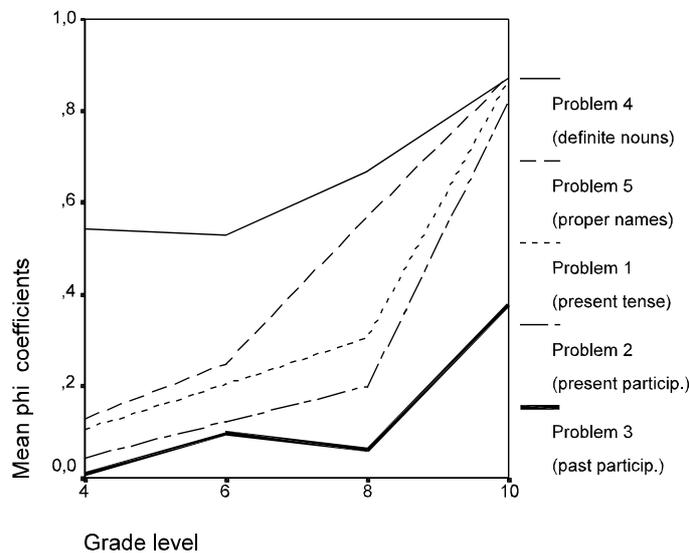
After seven practice sentences the 100 test sentences were presented (two sentences for each of the ten pseudo-words for each of the five spelling problems). Participants were instructed that one word in every sentence was not a real word, and that they should complete the spelling of this word when they had listened to the sentence. After the presentation of a sentence the pseudo-word was repeated twice in isolation. Pseudo-words were first presented embedded in sentence contexts to make their grammatical functions more salient, but participants were not told that the correct spellings were conditioned by the sentence contexts. The sentences were presented from a high quality tape recording using a large portable cassette player. The tape was stopped and sentences were repeated on request. Sentences were presented in a fixed randomized order. However, care was taken that sentences featuring the same pseudo-word were separated by at least 12 intervening sentences, and context types (conditional spelling correct vs. simple spelling correct) were counter-balanced.

At the end of the booklet space was provided for the pseudo-words used to assess spellings sensitive to the phonological context. These items were also presented from a tape recording, but they were not presented in a sentence context, and they had to be written in full.

Results

To answer our first question, concerning the grade level at which links between grammar and spelling are mastered, we computed how strongly each participant's use of the conditional spellings was associated with the appropriate grammatical contexts. Figure 2 presents the results for each of the five spelling problems studied. (phi coefficients) by grade level. The reliability of items used was assessed by scoring the ten pseudo-word used for each spelling problem as 'correct' when they had been spelled correctly in both sentence contexts (i.e., both when a simple and when a conditional spelling was correct), and otherwise as 'incorrect'. Reliability coefficients (alpha) were satisfactory (Problem 1: .95, Problem 2: .79, Problem 3: .94, Problem 4: .92, and Problem 5: .90). Responses to the items were generally phonemically adequate (89 % in grade 4, 95% in grade 6, and 96 % in grades 8 and 10). This was important because the phi coefficients were based exclusively on phonemically adequate responses. Scores

Figure 2. Average scores (phi coefficients) on five grammatical spelling problems.



Notes: Two participants (one 4th and one 8th grader) produced upper case letters throughout the test. Their results on Problem 5 (upper case marking of names) were thus not interpretable and are not included. Some participants failed to produce a reasonable number of phonemically adequate responses for coefficients to be computed. Problem 1: one 6th grader. Problem 2: two 4th, two 6th, and one 8th grader. Problem 3: three 4th, one 6th, one 8th, and one 10th grader. Problem 4: one 8th and one 10th grader. The results of these participants are also excluded.

on each problem were computed only when participants had produced a minimum of four phonemically adequate responses (of ten possible) in each grammatical context. This criterion was not always met (cf. the notes to Figure 2). To the extent that phonemically inadequate spellings occurred, they seemed to be due to simple mishearings or to problems with identifying exactly those phonemes that should be represented. Some times a phoneme (typically a schwa) was left out, and some times letters already provided were repeated. Missing responses were quite rare.

The results shown in Figure 2 suggest that mastery of links between grammar and spelling is achieved only at an advanced stage in spelling development. Roughly, the results were the same for all five spelling problems: Only the oldest group performed near ceiling, and scores in the youngest group were close to zero. Problems 3 and 4 were exceptions to the general pattern, as even the tenth graders scored below ceiling on Problem 3, and even the fourth graders obtained relatively high scores on Problem 4. We suggest reasons for these exceptions in the discussion.

It is noteworthy that in spite of the participants' different schooling experiences, etc., the size order of the scores on the five problems was the same at all four grade levels. Because of the extreme scores in grades 4 and 10, a non-parametric test (Wilcoxon Signed Ranks Test) was used to compare the results on the five problems. Overall the scores on all problems differed significantly from scores on the other problems ($p < .05$ in all cases). We also found significant overall effects of grade level for all five problems (Kruskal-Wallis; $df = 3$, $p < .001$ in all cases). Pair-wise tests (Mann-Whitney) showed that the tenth graders performed significantly better than the eighth graders on all five problems. The eighth graders outperformed the sixth graders on Problems 4 and 5, and the sixth graders outperformed the fourth graders on Problem 3 only.

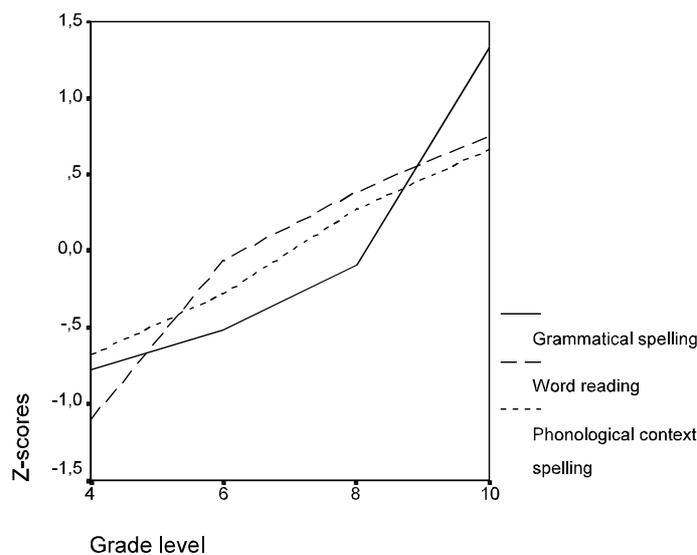
The particularly marked differences between grades 8 and 10 could be due to the fact that the tenth graders were high school students. High school students are usually recruited among the more bookish students, and thus the large difference could merely reflect a general difference in literacy skills. To check whether this was the case, we compared the difference between scores on grammatical spelling, word reading and spellings sensitive to the phonological context in the eighth and tenth graders. As shown in Figure 3, the difference between the two grade levels was considerably larger for grammatical spelling than for word reading or spellings sensitive to the phonological context, suggesting that specific progress in grammatical spelling is made at a late stage in literacy acquisition. Indeed, grade level interacted significantly with the type of

literacy skill (GLM Repeated Measures, analyses confined to grades 8 and 10; grammatical spelling vs. word reading: $F(1,65) = 19.6$; $p < .001$; grammatical spelling vs. phonological context spelling: $F(1,65) = 34.8$, $p < .001$). In other words, when compared to the eighth graders, the high schoolers performed better on grammatical spelling than one would have expected from their scores on the other two measures of literacy skills.

The raw scores (with standard deviations) for spellings sensitive to the phonological context were: grade 4, 64 % (22); grade 6, 74% (15); grade 8, 83 % (13); grade 10, 90% (8). For word reading the raw scores were: grade 4, 133 (33); grade 6, 174 (25); grade 8, 190 (134); grade 10, 108 (32).

Our second question was whether the intercorrelations between scores on the five grammatical spelling problems would be strong. This would be expected to the extent that mastery of the problems had a common basis, e.g., in grammatical awareness. Because of the many extreme scores in the youngest and the oldest groups, correlations were computed only for the two middle groups (collapsed). However, as scores close to zero dominated even in this middle group, non-parametric correlations (Spearman's rho) are reported. Surprisingly,

Figure 3. Results on grammatical spelling (mean sum of scores on the five grammatical spelling problems), word reading, and spellings sensitive to the phonological context. Scores have been converted to z-scores to allow comparison. Only participants who obtained a score on all five grammatical problems (cf. the notes to Figure 2) are included.



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intercorrelations were very weak. Only Problem 1 (present tense verbs) and Problem 4 (definite nouns) were significantly related ($n = 71$, $\rho = .25$, $p < .05$). Thus it appeared that these spelling problems were mastered independently of each other.

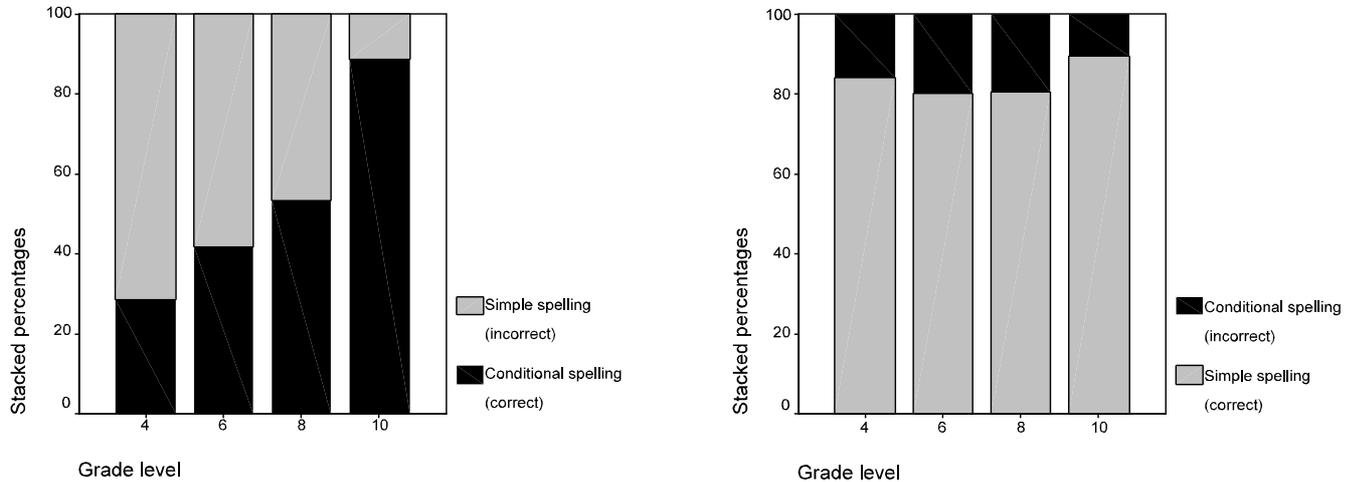
Although the spellings problems were weakly interrelated, Problems 1, 2, 3, and 4 were all significantly related to the measure of spellings sensitive to the phonological context, suggesting, perhaps, that familiarity with other higher level orthographic regularities plays a role in mastering the links between grammar and spelling. Correlations with this measure were $.33^{**}$ (Problem 1), $.32^{**}$ (Problem 2), $.28^*$ (Problem 3), and $.32^{**}$ ($** = p < .01$; $* = p < .05$). Conversely, word reading was related significantly to Problem 5 (proper name marking; $\rho = .33$; $p < .01$), but not to any of the other four spelling problems.

Our third and final questions concerned the development of the use of conditional spellings. Figure 4a and 4b show the frequencies of conditional spellings (for all five spelling problems collapsed) for conditional and simple items respectively. For conditional items there was a significant effect of grade level on the scores ($df = 3$; $F = 78.284$; $p < .001$), and post-hoc analyses (with Scheffé, $p < .05$) showed that all grade level differences were significant or near-significant. Generally, the younger groups of participants did not use the conditional spellings for conditional items very often, and it is remarkable that simple spellings were used as often as conditional spellings even in grade 8 (Figure 4a).

Conditional spellings were overgeneralised to simple items (where they were not correct) at all grade levels, but only to some degree (Figure 4b). Overgeneralisations were least frequent at the youngest and the oldest grade levels, to the effect that the grade level progression in scores on simple items was slightly U-shaped. A rising-falling development in the frequency of overgeneralisation errors has also been observed among students in other orthographies (Bryant, Nunes & Aidinis 1999), and for other aspects of linguistic development (Bowerman 1982). However, the incidence of overgeneralisations in the present study was fairly stable across grade levels. There was an overall effect of grade level on the scores on simple items ($df = 3$; $F = 4.773$; $p < .01$), but post-hoc analyses showed that only the differences between tenth graders vs. sixth and eighth graders were significant.

What distinguished between grade levels, then, was primarily the frequency with which conditional spellings were correctly used, and less so the frequency of overgeneralisations. The fact that the grade level progression in the use of conditional spellings was largely specific to the items where these spellings

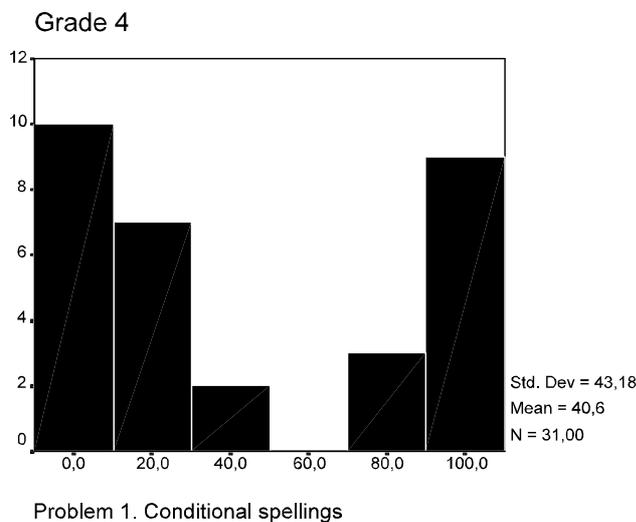
Figure 4a (left) and 4b (right). Overall frequencies (percentages of phonemically plausible spellings) with which conditional and simple spellings were used for conditional items (4a) and for simple items (4b).



were correct, suggests that spellers generally stick to simple spellings until they have a positive reason to do otherwise.

This impression was reinforced when we looked at the scores for each conditional spelling separately. We found a tendency that participants at the same grade level, even within the same class, either never used the conditional spelling

Figure 5. Conditional spellings on Problem 1 (present tense verbs in -rer, conditional items only) as percentages of phonemically adequate responses. Frequencies of scores in grade 4.



or always used it. Thus, in some cases bimodal distributions were found, a pattern which was especially clear for Problem 1. Figure 5 illustrates this with the results from grade 4. The fact that there were relatively few observations in the middle range may reflect that spellers go from being non-users to being users of conditional spellings within a short time, so that few participants would be caught 'in transit'. A similar suggestion was made by Zutell (1980). In any case, the results indicate that Danish students tend to make these transitions at a late stage in spelling development.

Discussion

Links between grammar and spelling appear to be difficult to learn. In the present study, no group below the high school level performed near ceiling on any of the five Danish spelling problems assessed, and it seemed that fourth graders were only just beginning to cope with these problems. This was somewhat surprising because studies of other orthographies had indicated that at least some grammatically defined spellings are learned at an earlier age. The apparent difference may be due to the fact that more strict measures of grammatical spelling competence were employed in the present study. It seems an interesting question whether the mastery of spellings such as the *-ed* spelling in English is in fact achieved later than it appears from previous studies (Nunes, Bryant & Bindman 1997a, 1997b). As noted in the introduction, one previous study has demonstrated problems with grammatically defined spellings even in English-speaking adults (Kemp & Bryant 2003).

Our results suggest that mastery of the links between grammar and spellings in Danish students is typically acquired as late as around the age of 15 (between grades 8 and 10). This should be confirmed by longitudinal data, of course, but the present results do raise the question why these links appear to be so difficult.

One possibility is, of course, that participants in our study had not received adequate spelling instruction. We collected no information on specific instructional practices used, but most of the teachers of our participants reported that they did focus on the grammatical spelling problems in our study, especially the 'classic' Problems 1, 2, and 5. Another possibility is that the very idea that pseudo-words can have a grammatical function relevant to their spelling is so odd that it did not occur to participants. However, in an experiment where sixth graders' performances on Problems 1 and 2 were assessed with real word items, results were remarkably similar to those obtained here (Juul submitted). In any

case, even if pseudo-word performances are poorer than real word performances, this only changes the question slightly. Why did the oldest, but not the younger participants in our experiment tend to generalise their knowledge of grammar-spelling links to pseudo-word spelling?

Assuming, then, that a genuine cognitive hurdle is involved, we suggest that this hurdle could be located in three different areas, corresponding to the three connections depicted in Figure 1 above. First, the problem may be to discover the ambiguity of phonemes, and the fact that other spellings than phonemically 'simple' spellings some times have to be used. Second, the problem may be to categorize words according to grammatical type. And third, the problem may be to actually make the connections between knowledge of possible spellings and knowledge of grammatical categories. We will consider these three possibilities in turn.

1) If knowledge of the relevant phoneme-grapheme-correspondences is poor, then the links between grammar and spelling are bound to remain obscure. Thus, when the younger participants in our study often failed to use conditional spellings, the reason could simply be that they were not aware that these spellings exist. However, this explanation seems most unlikely in the case of Problem 5 (upper case marking of proper names), as presumably all spellers knew the distinction between upper and lower case letters. Likewise, the use of silent *d* (Problem 2) is a frequently occurring irregularity of Danish orthography which is usually pointed out at an early point in spelling instruction.

It seems more likely that participants preferred to use simple spellings until they had a positive reason to do otherwise. The observation that few spellers alternated at random between a simple and a conditional spelling supports this interpretation. Participants tended either not to use a specific conditional spelling, or to use it often (Figure 5). However, although we find it unlikely that participants were completely unaware of the conditional spellings, it remains possible that those participants who often used conditional spellings had a better understanding of the problem that certain phonemes have ambiguous spellings. This may be why mastery of grammatically defined spellings (except upper case marking of names) was significantly related to mastery of another type of 'conditional' spellings, viz. spellings sensitive to the phonological context.

2) If awareness of grammatical categories is inadequate, then, again, the links between grammar and spellings are bound to remain obscure. This is the possibility which has received most attention in the literature, and its relevance is supported by the finding that grammatical awareness predicted the use of the *-ed*

ending in English children over and above phonological awareness (Nunes et al. 1997a). Again, however, the poor performances on upper case marking of proper names in the present study (Problem 5) are puzzling. Although one should think that even fourth graders were perfectly able to distinguish names from non-names, all groups except grade 10 performed below ceiling on this measure. Holmes and Castles (2001) make a similar observation concerning English words such as *misspell* and *infinite*, suggesting that poor spellers do not think to bring the requisite morphological knowledge to bear in the spelling process, although they do have this knowledge.

Another puzzle is the fact that the intercorrelations between performances on the five spelling problems were so weak. If performances on the problems had all depended on the participants' general awareness of grammatical categories, then strong intercorrelations would have been expected. Indeed Bryant, Nunes and Aidinis (1999) reported a strong correlation between the use of the -ed spelling for past tense verbs and the wh- spelling for interrogatives. However, grammatical awareness is a kind of linguistic awareness which has not been studied much. One explanation of our results could be that the different aspects of grammatical awareness relevant to the five spelling problems were not strongly intercorrelated either. It is not evident, for instance, that awareness of present participles (Problem 2) should be strongly related to awareness of definite nouns (Problem 4). If awareness of different aspects of grammar develops independently, then the same could be the case for knowledge of different grammar-spelling links. In this connection it is interesting to note that a grammatical awareness task which focussed specifically on past tense verbs predicted the use of the -ed ending in Canadian fourth graders better than it predicted their use of other inflections, such as the plural -s (Kirby et al. 2003).

3) The last possibility to be discussed is that spellers do possess adequate knowledge of the relevant phoneme-grapheme-correspondences and grammatical categories, but still fail to discover and reproduce the links between grammar and spelling. This could be the case for a number of reasons. Most people would probably agree that the prime function of alphabetic writing is to represent lexical entities (words) via the representation of phonological entities (phonemes). Seen in this perspective, the relevance of grammatical categories and inflectional morphemes, may be far from obvious. Further, it should be noted that the orthographic marking of grammatical categories is largely redundant when texts are read. The upper case marking of proper names, for instance, may help readers identify words as names, but the marking is not absolutely necessary for successful word identification. Obviously, this may be one reason why spellers

some times deliberately use simple spellings, for instance omitting the upper case marking of proper names. However, such non-standard spellings are usually confined to special contexts, such as personal sms- and mail-messages. In the context of the dictation test used in the present study it seems unlikely that participants deliberately chose to use simple spellings. A more important consequence of the redundancy of grammar-spelling links may be that they are not easily discovered through reading. Indeed, only performances on one of the five spelling problems (Problem 5) were significantly related to word reading.

Another problem in discovering the links between grammar and spelling may be that one link does not lead to the next. In this respect grammar-spelling links are fundamentally different from links between phonemes and letters. One can be pretty confident that every new letter learned can be linked to a particular phoneme, and that every new phoneme identified can be linked to some particular letter. However, not all grammatical categories have special spellings, and not all phoneme-grapheme-ambiguities can be explained by reference to grammatical categories. For instance, discovering the link between regular past tense verbs and the *-ed* spelling does not provide the English speller with a clue as to where the next link between grammar and spelling can be found. This may be a reason why performances on the five Danish spelling problems were not strongly interrelated.

While the results on the five spelling problems were roughly parallel, two problems stood out (cf. Figure 2 above). Even the oldest participants scored below ceiling on Problem 3 (past participles), and even the youngest participants scored well above floor on Problem 4 (definite nouns). In the case of Problem 3, we found that the many participants in grade 10 still overgeneralised the conditional spelling - word final / $\text{ə}\text{ð}$ / represented by the spelling *-et* - to simple items. We suggest that this was so because *t* is in fact the more common spelling for / ð / in word final position when following / ə /. In other phonological contexts the simple *d* spelling is the more common - and usually the only - spelling for / ð /. Thus, many of the older participants may have linked the *t* spelling to a particular phonological context rather than to a particular grammatical category (past participles). None of the other conditional spellings were dominant in their respective phonological contexts.

In the case of Problem 4, it seems highly likely that the success of the youngest participants was due to the fact that the conditional spelling - a word final / n / represented by the spelling *-en* - could be predicted from a more distinct pronunciation of the pseudo-words than the one presented. In the conditional items the word final / n / represented an inflectional ending, applying to definite nominals, which is pronounced / $\text{ə}\text{n}$ / when a more distinct level of pronunciation

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is adopted. Apparently, even the fourth graders were able to insert the schwa vowel - /ə/ - where appropriate. Interestingly, this could only happen if they actually distinguished the pseudo-words that contained the inflectional ending from those that did not. Thus, although they may not have linked the conditional spelling specifically to the category of definite nouns, it appears that they did access grammatical information (the presence of the inflection) in order to identify the phonemes of the pseudo-words presented. This result is somewhat similar to the finding, previously referred to, that the availability of grammatical information (the presence of an inflection) helped American beginners to spell final consonant clusters more accurately (Rubin 1988; Treiman & Cassar 1996). In the case of definite nouns in Danish it appears that participants did not just use grammatical information to identify the phonemes to be spelled, but even used it to reinterpret the phonemic structure of the dictated pseudo-words, as they reinserted a schwa phoneme which was not heard when the pseudo-words were presented.

Conclusion

In this paper we have presented evidence that knowledge of the links between grammar and spelling are not very well established in Danish students below the high school level. A question raised for future research is whether the acquisition of such links is unusually protracted in Danish when compared to other deep orthographies.

We identified three possible problems in learning about the links between grammar and spellings: the problem of knowing the relevant spelling possibilities, the problem of knowing the relevant grammatical categories, and the problem of actually making connections between knowledge of spellings and grammatical categories. Clarifying the relative importance of these problems may help us understand why the links between grammar and spelling appear so hard to learn.

Acknowledgements

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Appendix A

Sample test sentences illustrating sentences where conditional vs. simple spellings were appropriate. The pseudo-words to be spelled are given in IPA with appropriate spellings added in parenthesis (target spellings in bold). The grammatical functions of pseudo-words are specified (in square brackets) in the English translations of the sentences.

Problem 1

Conditional: Jeg /'fɑmʌ/ (fam**er**) lige et stykke brød. 'I [present tense verb] a slice of bread.'

Simple: Den kniv kan ikke /'fɑmʌ/ (fam**re**). 'That knife cannot [infinitive].'

Problem 2

Conditional: Hun kom /'femənə/ (fimm**ende**) ned ad gaden i sin nye kjole. 'She came [present participle] down the street in her new dress.'

Simple: Alle /'femənə/ (fimm**ene**) var nye og flotte. 'All the [plural noun] were new and good-looking.'

Problem 3

Conditional: Hun har /'flu:səð/ (flus**et**) fem hotdogs, så derfor har hun fået ondt i maven. 'She has [past participle] five hotdogs, that is why she has got a stomach ache.'

Simple: Han fik den nye /'flu:səð/ (flus**ed**) i julegave. 'He was given the new [singular noun] as a Christmas present.'

Problem 4

Conditional: Jeg mødte engang en *smo*. /smo³n/* (Smo**en**) kunne ikke tale, så jeg gik hurtigt min vej. 'Once I met a *smo* [indefinite pseudo-noun]. The *smo* [definite singular pseudo-noun] could not talk, so I left after a short while.'

Simple: En /smo³n/ (smo**n**) kan føde op til 50 unger på et halvt år. 'A [indefinite singular noun] can have as many as 50 babies in half a year.'

Problem 5

Conditional: Den nye pige i klassen hedder /'hilə/ (**Hille**). 'The new girl in class is called [proper name].'

Simple: Den nye zebra elsker at /'hilə/ (**hille**). 'The new zebra loves to [infinitive].'

* The apostrophe represents the prosodic feature 'stød' (a kind of creaky voice) which often occurs in Danish words.

Appendix B

Pseudo-word items used for the measure of spellings sensitive to the phonological context. IPA transcriptions of the items are given in the first column. The second column lists spellings which would be conventional for these items. The third column lists spellings which would be phonemically adequate for the 15 target phonemes (underlined), but which are not usually used to spell the target phonemes in these particular phonological contexts.

<i>Items (IPA)</i>	<i>Conventional spellings</i>	<i>Unconventional, but phonemically adequate spellings</i>
sbɔmə	spumme, spomme	s <u>b</u> umme, spåmme, spum <u>e</u>
fa'mæ:çə	fam(m)age, famache	fama <u>s</u> je
sdɔŋə	stunge, stonge	s <u>d</u> unge, st <u>å</u> nge
sgʁʌbə	skroppe, skrobbe	sgroppe, skr <u>å</u> ppe, skrope
blɔŋgə	blunke, blonke	bl <u>å</u> nke, blunge/blung <u>ke</u>
sgæ:jə	skage	sgage, skaje
sbɛ'b	spæb	s <u>b</u> æb, spæp

STUDY 5

Grammatical awareness and the spelling of inflectional morphemes in Danish

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Abstract

Danish sixth graders (N = 32, mean age 12;7 years) spelled words with inflectional endings which had a grammatically unique, but phonemically ambiguous spelling: present tense verbs and present participles. As found in a previous study with pseudo-words (Juil & Elbro, in press), such grammatically defined spellings were a major spelling problem. The present study showed that in spite of a weak intercorrelation, scores on both types of inflections correlated with grammatical awareness. This supports the relevance of grammatical awareness to grammatical spelling competence also demonstrated in studies of English 8- to 10-year-olds (e.g. Nunes et al. 1997a). The present study extended previous findings by distinguishing two aspects of grammatical awareness: Awareness of word class distinctions and awareness of inflections. The latter aspect was specifically related to the spelling of present tense verbs, while the former aspect was specifically related to the spelling of participles. Thus, grammatical awareness and grammatical spelling competence appear to be heterogenous concepts. The study introduced group based word oddity tasks as measures of grammatical awareness.

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Introduction

In alphabetic writing system spellings are determined by the phonemic structure of words. It is well-known, however, that this is a truth with many modifications. In several orthographies - English and Danish among them - it is very common that words have spellings which are not entirely predictable from phonology. Such spellings are often word-specific, i.e., they have to be learned word by word. However, there are also cases where spellings are predictable from the morphological structure of words. The *ea* spelling common to the morphologically related words *heal* and *health* is a standard English example of a morphologically defined spelling.

Word-specific and morphologically defined spellings continue to be a source of spelling problems beyond the elementary grades (Carlisle, 1988; Fischer, Shankweiler, & Liberman, 1985). This is understandable, perhaps, because the morphemes and words which are difficult to spell have a very low frequency of occurrence compared to phonemes. However, even when one considers morphemes with a very high frequency of occurrence, misspellings of phonemes with ambiguous spellings are still common. English children, for instance, have considerable problems with the highly frequent genitive and past tense inflections (Bryant, Nunes, & Bindman, 1997; Nunes, Bryant, & Bindman, 1997a, 1997b). They tend to omit the phonemically redundant apostrophe of genitive words like *boy's* - and they tend to use phonemically simpler spellings such as *pind* and *mist* for past tense verbs like *pinned* and *missed*. Spelling problems of this sort are not specific to English. Apparently they can be found whenever derivational and inflectional morphemes have phonemically ambiguous spellings, e.g. also in Danish, Dutch, French, Greek and Portuguese (Bryant, Nunes, & Aidinis, 1999; Frisson & Sandra, 2002; Juul & Elbro, in press; Pacton & Fayol, 2003).

Recent studies show that even adults have problems with the spelling of inflectional morphemes in spite of their high frequency of occurrence. Using a task with plural pseudo-nouns, Kemp and Bryant (2003) found that adults did not always use the correct *-s* spelling for the /z/ of English plural nouns. Phonemically plausible alternatives such as *-z* and *-se* were also used, especially in a phonological context where the *-s* spelling is not statistically favoured, viz. when the plural /z/ is preceded by a long vowel (as in *please* and *bees*). In Dutch similar problems with the *-t* spelling of third person singular present tense verbs have been demonstrated even in 18-year-olds in verbs where the third and first person singular forms are homophones - e.g. third person *rijdt* 'rides' and first person *rijd* 'ride' (Frisson & Sandra, 2002).

Thus, it seems that spellers have very persistent problems when they need to

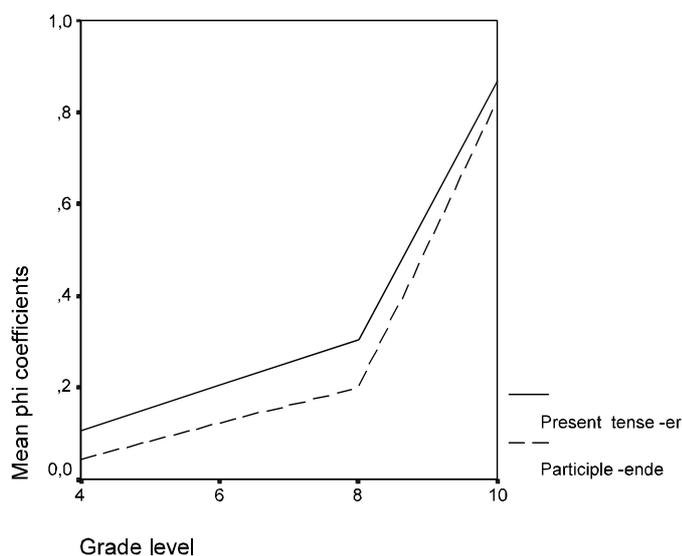
make links between spellings and inflectional morphemes. This is also the case in Danish where two classic spelling problems are the present tense *-er* inflection and the present participle *-ende* inflection. Present tense *-er* represents exactly the same unstressed vowel as the infinitive *-e* marker in approximately 1500 Danish verbs with a stem final /r/ (Jacobsen, 1998). For instance, the present tense verb form *stirrer* 'stare' and the infinitive *stirre* of the same verb are homophones. The *-ende* present participle inflection has a silent *d* which makes it confusable with the *-ene* spelling of definite plural nouns. For instance, the present participle *legende* 'playing' and the definite plural noun *legene* 'the games' are homophones.

In a previous study with children from grades 4, 6, 8 and 10, we found that only the 10th graders (high schoolers) used grammatically defined spellings consistently (Juil & Elbro, in press). The results on present tense *-er* and present participle *-ende* are shown in Figure 1. These results were based on pseudo-words presented in meaningful contexts from which the presence of the inflections could be inferred. Roughly similar patterns were found for three other grammatically defined spellings.

An important methodological feature of our study was that the frequency of overgeneralisations (e.g. the *-er* ending used inappropriately for infinitives or the *-ende* ending used inappropriately for plural definite nouns) was controlled by including sentences with pseudo-words which functioned as infinitives or definite plural nouns. In these pseudo-words, the simpler spellings (*-e* and *-ene*, respectively) would be correct. Overgeneralisations are interesting because they indicate that the correct spelling is known, but that the speller does not know exactly when to use it. Thus, the fact that a speller uses the correct spelling does not necessarily indicate that he or she knows that there is a link between the spelling and a particular inflection (Richards & Siegler, 1982). To solve this problem we asked how strongly each spellers' use of particular spellings (e.g. the *-er* and *-e* endings) correlated with particular inflections (e.g. present tense verbs and infinitives) and used these correlations as measures of grammatical spelling competence. The correlations (cf. Figure 1) were phi coefficients because both variables (the type of spelling and the type of inflection) were dichotomous. Thus, in the case of present tense *-er*, the maximal phi coefficient of 1 would reflect that the *-er* ending was always preferred over the simple *-e* ending for present tense verbs, while overgeneralisations of the *-er* ending to infinitives did not occur.

The present paper reports a new study of the two Danish spelling problems just described. While the previous study was purely descriptive and based on pseudo-words, the new study was based on words and asked how grammatical spelling competence relates to grammatical awareness.

Figure 1. Correlations (phi coefficients) showing how strongly the *-er* spelling was linked to present tense items and the *-ende* spelling to present participle items in Danish children. Participants were 26 fourth-graders, 38 sixth-graders, 30 eighth-graders, and 37 tenth-graders (high schoolers). From Juul & Elbro (in press).



Longitudinal studies of English-speaking children have indicated that grammatical awareness can predict later developments in grammatical spelling competence. The use of the genitive apostrophe and the past tense *-ed* spelling in eight- to ten-year-olds has been predicted from their scores on a word analogy task at a younger age (Bryant, Nunes, & Bindman, 2000; Nunes et al., 1997a, 1997b). In the eight trials of this task the participants had to change the tense inflection of a verb (e.g. *walk* > *walked*, *shake* > ??) or to change a word into a different word class (e.g. *sing* > *song*, *live* > ??). Nunes et al. (1997a) found that a task in which participants had to make present > past tense sentence transformations also predicted the use of the past tense *-ed* spelling although not as strongly as the word analogy task. The same sentence transformation task predicted Canadian fourth graders' spelling of nine pseudo-words with inflectional morphemes (four of which were the past tense inflection) over a period of two years (Kirby, Bell, & Deacon, 2003).

The relations between grammatical awareness measures and later grammatical spelling competence in these studies were significant, but not particularly strong. However, it should be noted that the awareness measures were based on just eight trials, and that the word analogy task appeared to be quite difficult. Possibly, more sensitive grammatical awareness measures would have yielded even stronger correlations with spelling development.

In the light of these findings, one might suspect that the use of the present

tense *-er* and the present participle *-ende* spellings in Danish both depend on grammatical awareness, and that, as a consequence, scores on the use of the two spellings would correlate strongly. Yet, in our previous Danish study we did not find strong correlations. In the sixth-graders, for instance, the correlation was only .20 (*n.s.*, $N = 38$). This low correlation does not necessarily imply that grammatical spelling competence in Danish is not influenced by the spellers' level of grammatical awareness, of course. Grammatical awareness could be relevant to the acquisition of both the present tense *-er* and the participle *-ende* spellings, but not at the same time. However, as shown in Figure 1 the scores on the two spellings were remarkably parallel, suggesting that they tend to be learned at about the same time. It could also be the case that different aspects of grammatical awareness are relevant to the spelling of present tense verbs and present participles, respectively. As explained above, present tense verbs need to be distinguished from infinitives, i.e., from another form of the same word, suggesting that awareness of inflectional categories is especially relevant. Participles need to be distinguished from plural definite nouns, i.e., from words of a different word class, suggesting that awareness of word class differences is especially relevant.

On the other hand, although grammatical awareness is clearly necessary for the development of grammatical spelling competence, the persistence of grammatical spelling problems in older children may have other causes than a lack of grammatical awareness. It is possible, for instance, that spellers tend to forget that grammatical categories can be relevant to spelling, even though their level of grammatical awareness is adequate. Such a tendency could be especially strong for pseudo-word spelling where participants may focus primarily on representing an unfamiliar sequence of phonemes. Indeed, it seems unlikely that the adult participants in the study by Kemp and Bryant (2003) were unable to distinguish singular from plural nouns. Nevertheless these adults often failed to use the correct *-s* spelling for English pseudo-word plurals.

A basic problem in learning to use grammatically defined spellings is, of course, to discover the possible spellings of the relevant phonemes. However, insufficient knowledge of possible spellings can hardly explain the persistency of grammatical spelling problems. There can be no doubt, for instance, that the adults studied by Kemp and Bryant (2003) knew that *-s* is a possible spelling of a final /z/ in English words. Likewise, in our study we found that even some Danish high schoolers did not always use initial capitals for proper names although it was beyond doubt, of course, that the distinction between capital and small letters was known to them. Again, it could be the case that spellers, especially when spelling pseudo-words, focus on representing phonemes. Thus, in spite of knowing the relevant grammatical categories as well as the relevant spellings, spellers may still fail to

make the appropriate links between grammar and spelling.

If this reasoning is correct, it could be the case that the problem of using grammatically defined spellings is especially large in pseudo-word spelling. Possibly, scores on grammatical spelling are better in words where meaning and pronunciation are known to spellers in advance. Scores on words could also be better because of a lexicality effect. Pseudo-words have been used in previous studies for precisely this reason, so that grammatical spelling knowledge could be studied in the absence of lexical (word-specific) spelling knowledge. The question is whether some of the baby has gone out with the bath water.

Interestingly, a lexicality effect on grammatical spelling is in fact not always to be expected. In the case of English genitives (*boy's*), Dutch third person singular present tense verbs (*rijdt* 'rides'), and Danish present tense verbs (e.g., *stirrer* 'stare') other inflectional forms of the very *same* words are spelled without the apostrophe, the final *-t*, and the final *-r*, respectively, (cf., the English plural *boys*, the Dutch first person singular *rijd*, and the Danish infinitive *stirre*). If word-by-word learning is to be of any avail, then, one needs to learn these spellings for a particular inflectional form of a word. And this form cannot be identified by phonology because it shares its pronunciations with another inflectional form of the same word. Thus, there seems to be no way around identifying the inflections even if these grammatically defined spellings are to be learned word by word. This means that the use of pseudo-words may not be strictly necessary for the assessment of grammatical spelling competence. In fact, a central problem with grammatically defined spellings could be that word-by-word learning is not always a helpful spelling strategy.

Another interesting consequence of this situation is that some grammatical errors do not give themselves away very easily. When errors result in existing words (e.g. *boys* instead of *boy's*), visual feedback does not uncover them in the absence of a grammatical analysis. Nor does a computerised spell check. For English past tense verbs the situation is mixed in this respect. The misspelling *mist* for *missed* happens to be a word, while *kist* for *kissed* happens not to be. Such a mixed situation is also found for Danish present participles, some errors yielding existing words, and some not (cf. the Method section below). The limited value of lexical spelling knowledge and visual feedback suggests that the problem of using grammatically defined spellings is similar for words and pseudo-words. However, this does not rule out the possibility that the use of grammatically defined spellings could be easier in words for other reasons, as suggested above.

The present study was set up to answer three main questions. First, it was asked whether results on the two classic grammatical spelling problems in Danish - present

tense *-rer* and present participle *-ende* - would be better when based on word items than in the previous study where pseudo-word items were used. The new study was based on participants from Grade 6, as this left plenty of room for improvement (cf. Figure 1).

Second, it was asked whether the finding that scores on the two grammatically defined spellings were weakly correlated could be replicated with words.

Third, it was asked how scores on the two spellings related to grammatical awareness. Two measures of grammatical awareness were devised, one focussing on inflectional categories, and one focussing on word class differences. It was hypothesised that awareness of inflectional categories was especially relevant to the use of present tense *-er*, and that awareness of word class differences was especially relevant to the use of participle *-ende*. This was because the present tense verbs had to be distinguished from other inflectional forms of the same verb (viz. infinitives), whereas the participles had to be distinguished from words of a different word class (viz. definite plural nouns).

Two measures of lexical spelling knowledge - i.e., knowledge of spellings that cannot be inferred from phonology or grammar - were included to control whether *specific* relations could be found between grammatical spelling knowledge and grammatical awareness. A relation between grammatical awareness and lexical spelling knowledge could certainly not be excluded (Muter & Snowling, 1997). Also, it was possible that scores on the grammatical spelling tasks would to some extent reflect lexical spelling knowledge (but cf. above). Thus, correlations between scores on grammatical spelling and grammatical awareness could result from a shared relation with lexical spelling knowledge.

Method

Participants

Two groups of sixth graders from the same school participated in the study. In all, there were 32 participants, 16 girls and 16 boys. All participants spoke Danish as their first language. The mean age was 12 years, 7 months (SD = 4 months). The school was located in a non-deprived socially mixed suburban area of Copenhagen.

Measures

Grammatical spelling. The mastery of two grammatical spelling problems was assessed (cf. the introduction):

- 1) The use of the present tense inflectional ending *-er* in verbs where the

present tense is homophonous with the infinitive ending *-e*, viz. verbs which have a stem final /r/. Both the *-er* and the *-e* endings are pronounced /ʌ/ in this context. Thus, the final *-r* of these present tense verbs is ‘silent’ because it does not affect pronunciation. After other stems the infinitive *-e* is pronounced /ə/, while present tense *-er* is still pronounced /ʌ/.

2) The use of the present participle inflection *-ende*. This inflection has a silent *d* as it is pronounced /ənə/. An inflectional ending with the same pronunciation is found in definite plural nouns, but this ending is spelled *-ene*, i.e., without the silent *d*.

A total of 32 items were used to assess grammatical spelling, 16 per spelling problem (cf. Appendix A). The items were divided equally between experimental words where the ‘complex’ spellings (spellings including a silent *d* or *r*) were correct (8 present tense verbs and 8 present participles) and control words where the ‘simple’ spellings (spellings without silent *d* or *r*) were correct (8 infinitives and 8 plural definite nouns). Thus, it was possible to observe whether the complex spellings were used specifically for words where they were correct or whether they were also overgeneralised to words where they were not correct. Experimental and control words were similar with respect to phonological structure and word frequency (cf. Appendix A).

Some Danish present participles are homophonous with plural definite nouns, e.g. *legende* ‘playing’ and *legene* ‘the games’, so that a spelling error can yield an existing word. Others do not have a noun homophone, e.g. *baksende* ‘struggling’. Half of the participles used had a noun homophone and vice versa. Items were selected in this way in order to check whether error frequencies would be affected by error status (word or nonword, cf. the introduction).

Lexical spelling. Performances were also assessed for two kinds of spellings that have to be learned word by word (lexical spellings) because they cannot be inferred from grammar or phonology:

1) The use of medial *rr*. Medial *rr* is a word-specific spelling in modern Danish, because words spelled with and without a doublet *rr* are homophones, e.g. *sparre* vb. ‘spar’ and *sparre* ‘economise’, *burre* ‘burr’ and *burre* ‘cages’. It should be noted that the use of *rr* is predictable from a conservative Danish pronunciation where the general spelling rule applies that consonants in intervocalic position are represented by a doublet if they follow a short stressed vowel. The distinction between short and long vowels has vanished before medial /r/ in Modern Danish, rendering the doubling rule invalid.

2) The use of silent *d*. In many Danish words the use of silent *d* is word-specific, cf. homophonous word pairs such as *fjord* ‘bay’ and *fjor* ‘last year’, *skind*

'skin' and *skin* 'shine'.

A total of 32 items were used to assess lexical spelling, 16 per spelling problem (cf. Appendix A). The items were divided equally between words where the complex spellings (spellings with a silent *d* or doublet *rr*) were correct, and control words where the simple spellings (spellings without a silent *d* or with a single medial *r*) were correct. Thus, it was possible to observe whether the complex spellings were used specifically for words where they were correct or whether they were overgeneralised to words where they were not correct. Experimental and control words were similar with respect to phonological structure and word frequency (cf. Appendix A).

As explained above, the lexically defined spellings were spelled either with or without a silent *r* (just like the present tense verbs and infinitives in *-rer* or *-re*) or with or without a silent *d* (just like the present participles and definite plural nouns in *-ende* or *-ene*). This similarity ensured that formal differences between grammatically and lexically defined spellings would be less likely to affect the results.

Awareness of word class differences. A word oddity task was used where the odd one out differed from three other words with respect to word class (cf. Appendix B). For instance the noun *frakke* 'coat' was presented with the three verbs *slippe* 'let go', *hente* 'fetch' and *vælge* 'choose'. The four words were similar with respect to phonological and orthographic structure, so that neither pronunciation nor spelling could be used to identify the correct answer. The words were presented in writing, and the position of the correct answer was randomised.

Before testing proper began, three practice trials were given with feedback, demonstrating that the meaning or function of words should be considered, rather than formal features such as pronunciation or spelling.

There were 25 trials, but the first trial was a dummy which was disregarded in the scoring. This was a simple trial (three numerals and a noun) included with the purpose of allowing all participants a minimal success on the task. Thus the maximal score was 24. Participants were given 3½ minutes to solve as many trials as possible.

The trials were divided equally between three types: verb-noun trials, verb-adjective trials, and adjective-noun trials. Within each trial type, the odd words were divided equally between the two word classes. Trials of the three types alternated, with the trials thought to be most difficult given last.

Awareness of inflections. This task was a word oddity task, quite parallel to awareness of word class distinctions (cf. above). In this task, however, the word class was the same for all four words, but one word differed from the other three

with respect to inflectional category. For instance, the singular noun *søster* 'sister' was presented with the three plural nouns *fliser* 'flagstones', *skoler* 'schools', and *lamper* 'lamps'. Again, the odd word did not stand out with respect to pronunciation or spelling.

Before testing proper began, participants were given three practice trials with feedback. After that there were 24 trials (no easy starter this time), again with a time limit of 3½ minutes. This time the trials were divided between the following three types: plural-singular trials, case trials (e.g. nominative-genitive), and verbal inflection trials (e.g. present tense-past tense). As before, trials of the three types alternated, with the trials thought to be most difficult given last.

Word reading. To measure word reading the test *OS 400* (Søegård & Petersen, 1968) was given with a time limit of 5 minutes. Controlling the reading level was important because participants had to read the stimuli used for the grammatical awareness tasks (cf. above), and thus a correlation between grammatical awareness and spelling could simply reflect that both grammatical awareness and spelling scores were associated with reading.

Procedure

Tests were administered on a group basis in the participants' own classrooms. The spelling test was given first. Awareness of word class differences was given before awareness of inflections.

Spelling was assessed with a dictation task. Words were presented in sentence contexts which were printed on the test sheets. Sentence contexts were designed to facilitate word identification. The test leader read out each sentence once and then twice repeated the word to be filled. In addition to the 64 items relevant to the present study (cf. above) the dictation included another 52 items. The sentences were presented in a fixed random order. To avoid fatigue the spelling test was divided into three parts.

In the grammatical awareness tasks participants simply had to circle the odd one out. They were told that they were allowed to make a guess if they were not sure that they knew the right answer.

Results

Spelling

Table 1 and 2 show the scores on grammatical and lexical spelling, respectively. The first two columns show the frequencies with which the complex spellings were used

correctly and the frequencies with which they were overgeneralised. Added in the third columns of Table 1 and 2 are the mean correlations (phi coefficients) between the type of spelling produced (complex vs. simple spelling) and the type of inflection (complex vs. simple spelling correct). As explained in the introduction, the purpose of computing these correlations was to obtain a single measure that reflected the frequency of correct responses as well as overgeneralisations.

As the phi coefficients were based on phonemically adequate spellings only, it was essential that participants did in fact produce a reasonable number of such spellings. The results of two participants (one boy and one girl) were excluded because they did not always produce a minimum of four phonemically adequate spellings (of eight possible) for both experimental and control words. Results on all measures are reported only for the remaining 30 participants.

To assess the reliability of the measures experimental and control items were scored separately as correct vs. all other response types. The coefficients (alpha) were as follows (experimental/control items): present tense *-er* .79/.73, participle *-ende* .82/.62, lexical medial *rr* .83/.56, lexical silent *d* .60/.35. The low reliability of the lexical control items, was probably due to the fact that the majority of items were never misspelled.

The results reported in Table 1 indicate that Danish sixth graders have considerable problems with words that feature grammatically defined spellings. The mean phi coefficient of .22 for present tense *-er* was close to the coefficient of .20 (SD .32) found on the pseudo-word spelling task in our previous study (cf. Figure 1).

For present participle *-ende* the performances were better in the present study, the mean phi coefficient being .45 in the present study as against .12 (SD .26) in the previous study with nonwords, but even from the present study it is evident that the use of the *-ende* spelling is a major problem in sixth graders.

When the number of correct spellings is compared, performances on present tense *-er* and participle *-ende* were similar. However, the *-er* spelling was overgeneralised more often than the *-ende* spelling. As a consequence the phi coefficients for the *-ende* spelling were significantly higher than for the *-er* spelling ($t(29) -2.876, p < .01$). This difference points to the relevance of using derived measures such as the phi correlations to compare performances, rather than the number of correct spellings.

The comparison with results from the previous experiment with pseudo-words is tentative, as the previous study was based on a different group of sixth-graders. However, both groups took the word reading test, and scores were fairly similar, suggesting that a comparison is not completely unwarranted. The mean

Table 1. Grammatical spelling. Mean number of correct and overgeneralised spellings (with SDs) and mean phi coefficients. $N = 30$.

	Correct (/8)	Overgeneralised (/8)	Phi coefficients
Present tense <i>-er</i>	4.1 (2.5)	2.5 (2.1)	.22 (.36)
Participle <i>-ende</i>	4.5 (2.6)	1.3 (1.7)	.45 (.33)

Table 2. Lexical spelling. Mean number of correct and overgeneralised spellings (with SDs) and mean phi coefficients. $N = 30$.

	Correct (/8)	Overgeneralised (/8)	Phi coefficients
Medial <i>rr</i>	3.2 (0.3)	0.9 (1.2)	.33 (.27)
Silent <i>d</i>	6.5 (1.5)	0.8 (0.9)	.75 (.19)

number of correct responses on word reading in the present study was 166 (SD = 23) against 176 (SD = 25) in the previous study; the difference between the groups was not significant (Mann-Whitney U (30, 38) = 439.5).

For the two types of lexical spellings (Table 2) the frequency of overgeneralisations was almost the same. Here, however, silent *d* was used correctly much more often than medial *rr*, yielding a significant difference in the phi coefficients obtained ($t(29) -8.774$, $p < .001$). This difference is noteworthy because the average frequency of items was almost the same across item type, and for both types the focus was the use of a complex consonant grapheme immediately following a stressed vowel. The poor results on medial *rr* suggests a specific spelling problem with consonant doublets (Juul, submitted; Juul & Sigurðsson, in press). The items with silent *d* and medial *rr* differed somewhat with respect to structure, as the former were monosyllabic, while the latter had an unstressed second syllable, but it is hard to see how this structural difference could account for the dramatic difference in spelling accuracy.

It did not make sense to compare scores on grammatical and lexical spellings, because the frequency of items was not equated (cf. Appendix A). Equating items in a convincing way did not seem possible. If one equates at the level of the morpheme, one ignores the fact that the stems, to which the lexical spellings applied, and the inflections, to which the grammatical spellings applied, are very different types of morphemes. Considered on their own, the inflections *-er* and *-ende* are much more frequent than the stems used to assess lexical spelling, but in contrast

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to the stems they cannot occur in isolation, and they have a more abstract meaning. On the other hand, if one equates at the level of the word, it is ignored that the word-specific spellings apply to stems regardless of the specific inflectional form, and that the spellings of inflections apply regardless of the specific stems with which they appears.

As explained in the method section, phonemically acceptable errors of half of the participles and plural nouns (-ene for -ende or vice versa) would result in existing words, while the other half would not. However, the difference in the possibility of detecting errors through visual feedback did not appear to affect the scores. Errors occurred only slightly more often when errors resulted in words than when they did not. On average participants made 2.2 phonemically acceptable errors (SD = 1.4) which resulted in words against 2.0 phonemically acceptable errors (SD = 1.3) which did not result in words, and the difference was not significant ($t(29) = 0.776$).

Grammatical awareness

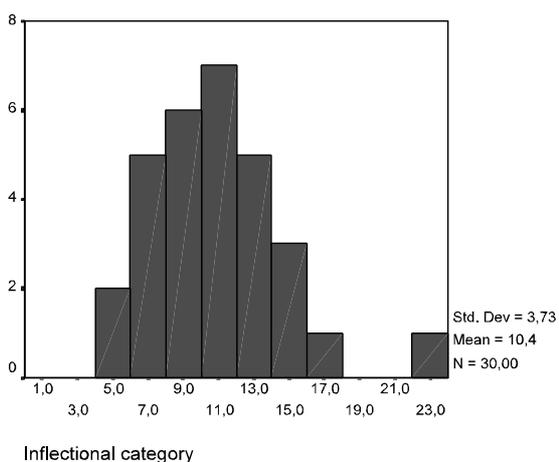
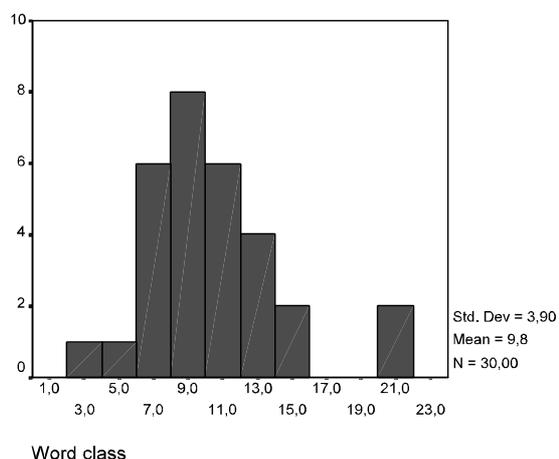
The results on the two grammatical awareness tasks are shown in Figure 2. The mean number of correct responses was 9.8 for awareness of word class differences, and 10.4 for awareness of inflections, while the mean number of solved trials was 21 for word class differences and 22 for inflections. Please recall that the word class awareness included an initial dummy trial which had to be solved within the allotted 3½ minutes, but which did not contribute to the score. Thus, the levels of performances on the two tasks were highly similar, both when accuracy and time taken per trial was considered. The reliability coefficients (alpha) were .69 for awareness of word class differences and .65 for awareness of inflections.

The chance score on the two tasks was 6 correct (or less for those participants who did not solve all 24 trials). The scores on both tasks were significantly above 6, suggesting that participants in general did have some awareness of the relevant grammatical distinctions (word class differences: $t(29) = 5.389$, inflections: $t(29) = 6.416$, $p < .001$ in both cases). However, as the histograms show, about a fourth of the participants on both tests had scores close to the chance level (7 correct responses or below).

Correlations between grammatical awareness and spelling

To assess the interrelations between grammatical awareness, grammatical spelling and lexical spelling at a general level, the means were computed for the (normalised) scores on the two grammatical awareness measures, the two measures of grammatical spelling and the two measures of lexical spelling. When negative phi

Figure 2. Histograms showing the frequency of correct responses on the tests of awareness of word class differences (top) and awareness of inflections (bottom).



coefficients occurred, these were set to zero on the assumption that differences in the negative range reflected random variation rather than true differences in spelling competence.

The correlations between these combined measures, and their correlations with word reading, are shown in Table 3. A strong relation was found between grammatical awareness and grammatical spelling. The partial correlations were also strong, both when word reading was controlled ($r = .67$, $df = 27$, $p < .001$), and when lexical spelling was controlled ($r = .59$, $df = 27$, $p = .001$).

Table 3. Correlations between combined measures. $N = 30$.

	1. Grammatical awareness	2. Grammatical spelling	3. Lexical spelling	4. Word reading
1	-	.70**	.55*	34
2		-	.51*	25
3			-	22
4				-

* $p < .01$, ** $p < .001$

Table 4 in an elaboration of Table 3 showing the correlations between the individual measures. Here, it is especially interesting to note that, as in the previous experiment with pseudo-words, the correlation between the two grammatical spelling measures was not significant in spite of their shared grammatical basis. Nevertheless, both measures did correlate with measures of grammatical awareness.

As hypothesised the use of present tense *-er* was related most strongly to awareness of inflectional categories, whereas the use of participle *-ende* was related most strongly to awareness of word class differences. When awareness of word class differences was controlled, the partial correlation between awareness of inflections and the use of present tense *-er* was still significant ($r = .48$, $p < .01$). Likewise, the partial correlation between awareness of word class differences and the use of participle *-ende* was still significant when controlling for awareness of inflections ($r = .40$, $p < .05$). This suggests that different aspects of grammatical awareness are relevant to different types of grammatically defined spellings.

Controlling for reading level did not affect the correlations much. The use of present tense *-er* was still significantly related to awareness of inflections ($r = .61$, $p < .001$) as well as word class differences ($r = .48$, $p < .01$), and the use of participle *-ende* was still significantly related to awareness of word class differences ($r = .44$, $p < .05$). Thus although reading was required to solve the grammatical awareness tasks, reading did not account for the correlations with grammatical spelling.

Grammatical awareness also showed significant correlations with lexical spelling. However, the correlations between grammatical awareness and grammatical spelling were found to be independent of lexical spelling. When the use of lexically defined medial *rr* was controlled, the use of present tense *-er* was still significantly related to awareness of inflections ($r = .50$, $p < .01$) and marginally significantly to awareness of word class differences ($r = .33$, $p = .07$). Thus, grammatical awareness was related specifically to the use of the present tense *-er* spelling, and not just

Table 4. Correlations between individual measures. $N = 30$.

	Grammatical awareness		Grammatical spelling		Lexical spelling		7. Word reading
	1. Word class	2. Inflections	3. Present tense <i>-er</i>	4. Participle <i>-ende</i>	5. Medial <i>rr</i>	6. Silent <i>d</i>	
1	-	.56**	.48**	.50**	.44*	27	.44*
2		-	.61***	.33	.46*	.46*	16
3			-	.20	.51**	.45*	13
4				-	.09	.27	26
5					-	.39	0
6						-	.41*
7							-

* $p < .05$, ** $p < .01$, *** $p < .001$

generally to the use of the letter *r* in words where it cannot be predicted from phonology. Likewise, awareness of word class differences was related specifically to the use of the participle *-ende* spelling, and not just to the use of silent *d*'s in general. When the use of lexically defined silent *d*'s was controlled, awareness of word class differences and the use of participle *-ende* still correlated significantly ($r = .46$, $p = .01$).

Discussion

The study concerned sixth graders' mastery of two 'classic' grammatical spelling problems in Danish: 1) the use of the present tense *-er* ending, which is confusable with the infinitive *-e* ending in verbs with a stem-final /*r*/, and 2) the use of the present participle *-ende* ending, which is confusable with the definite plural noun ending *-ene*. Two findings from a previous study of grammatical spelling were replicated.

First, it was found that these classic spelling problems are indeed major problems even when the assessment is based on genuine words. In the introduction it was suggested that when spelling pseudo-words, spellers may focus primarily on the

representation of phonological information and tend forget about letters which are not predictable from phonology, but only from (inflectional) morphology. However, on present tense *-er* spelling the participants in the present study performed on the same level as the sixth graders in the previous study with pseudo-words, in spite of the fact that the two groups performed on approximately the same level on a test of word reading. On the participle *-ende* ending performances in the present study were better than in the previous study, but still far below ceiling.

Interestingly, lexical spelling knowledge could be relatively more helpful for the spelling of participles because the phonemically equivalent *-ende* and *-ene* spellings apply to different lexemes, whereas the *-er* and *-e* spellings of present tense verbs and infinitives apply to the same lexemes. This may be why the word based results were better for the participles, but not for the present tense verbs. On the other hand, the scores on participles did not correlate strongly with lexical spelling, whereas scores on present tense verbs did - so the interpretation is not clear. It does seem clear, however, that Danish children's problems with grammatically defined spellings are remarkably persistent, and that this is true for the spelling of words as well as pseudo-words.

Second, it was found that scores on the two grammatical spelling problems were only weakly related to each other. Although the use of both spellings require attention to grammar, it appears that the present tense *-er* and the participle *-ende* spellings are learned independently of each other.

The present study extended the previous study by including two measures of grammatical awareness. The results indicated that the weak correlation between scores on the two grammatically defined spellings cannot be taken to imply that grammatical spelling competence is not associated with grammatical awareness. Rather, scores on the two spellings were weakly correlated because they depend on different aspects of grammatical awareness. Scores on present tense *-er* were related specifically to awareness of inflections, while scores on participle *-ende* were related specifically to awareness of word class differences. Lexical spelling competence and word reading skill did not explain these correlations.

Although lexical spelling did not explain the correlation between grammatical spelling and grammatical awareness, lexical and grammatical spelling did correlate. This relation may reflect that both the lexically defined and the grammatically defined spellings required spellers to consider meanings as well as phonology in order to identify the particular words or inflections to be spelled. It is puzzling, however, that the relation with lexical spelling was much stronger for present tense *-er* than for participle *-ende*.

From the mere correlation between grammatical spelling competence and

grammatical awareness one cannot conclude that the development of grammatical spelling competence *depends* on grammatical awareness. Grammatical awareness can be a consequence of spelling development rather than a cause (Bryant, 1995). Yet, the distinctions relevant to the grammatical awareness tests were often quite elementary grammatical distinctions, e.g. between adjectives and nouns or between genitive and nominative nouns. It is not very obvious why learning to spell participles and present tense verbs should enhance awareness of these distinctions. An effect in the opposite direction seems more plausible. Indeed, if a speller is not sensitive to the distinction between adjectives and nouns, for instance, then he or she can hardly be expected to identify a somewhat more sophisticated grammatical category such as the category of present participles.

Developing awareness of grammatical categories may be a cognitive hurdle comparable to the hurdle of developing awareness of phonemes. Neither form of awareness is necessary for everyday communicative purposes, and both require that elements of linguistic structure are isolated from the particular communicative purposes for which they are used. For an adult who knows how to segment words into phonemes it can seem quite surprising when children find such an analysis difficult. The situation for what may seem to be very simple grammatical analyses may be similar to the situation found for phonemic analysis, except that the grammatical awareness hurdle seems to be overcome at a much later age than the phonemic awareness hurdle.

For the present study two new tests of grammatical awareness based on word oddity tasks were developed. A practical feature of these tests was that they could be administered on a group basis. It was a little surprising that about a fourth of the participants performed at, or close to, chance level on both of these tests. This does not imply that these participants lacked grammatical awareness altogether as the task was quite demanding. In order to spot the odd one out, e.g. an adjective among nouns, participants would either have to consider rather abstract semantic features or to consider plausible syntactic contexts for adjectives vs. nouns. This is probably a much more difficult task than the analogy tasks used with younger children in earlier studies of grammatical awareness (cf. the introduction).

On the other hand, being twelve years of age, the participants in the present study not only face the challenge of learning to use grammatically defined spellings, but also the challenge of learning foreign languages. It seems likely that both these challenges will be difficult for participants who show little sensitivity to basic grammatical distinctions. Indeed, this is what the results of the present study suggests for grammatical spelling competence. As for second language learning it is a much discussed issue whether explicit knowledge of grammar is necessary or even useful (Ellis, 1994). In this connection it should be pointed out that the awareness

tasks used in the present study did not require explicit grammatical knowledge. In principle, it would be enough for participants to sense that the odd words out were somehow different from the other words.

An important implication for instruction is that pupils with a good mastery of one grammatically defined spelling may still be in need of extensive training when it comes to other grammatically defined spellings. Grammatical awareness and grammatical spelling competence appear to be heterogenous concepts. Nevertheless it is of obvious importance to ask how sensitivity to grammatical categories and distinctions can best be stimulated. Traditional tasks such as listing words in various inflectional forms may be of limited value. A classic Danish task, for instance, is to list nouns in the singular, the definite singular, the plural, and the definite plural form. Presumably, the well-known attitude that grammar is boring owes a lot to activities like this. The problem is that a strong focus on formal differences between inflectional forms easily misses the more general purpose of bringing about an understanding of the function of inflections, and of concepts such as number and definiteness.

The function of inflections is often hard to describe, and this is an obstacle that has to be overcome in instruction. The structure of compounds and derivations - and the function of compounding and deriving words - may be easier to understand, and it is possible to make quite an early start with these aspects of morphology in instruction (Arnbak & Elbro, 2000; Henry, 1993; Lyster, 2002). Learning about compounds and derivations may pave the way for grammatical awareness.

Another possible obstacle is that instructional materials tend to underestimate the amount of training needed by children before simple grammatical categorisation tasks actually become simple. It is not enough that children learn to distinguish between adjectives, nouns and verbs. They should be able to do so quickly and without effort, and some children may need a *lot* of practice. Some interesting new possibilities come with the introduction of computer based grammar games - such as shooting all the adjectives of sentences occurring on the screen (e.g. <http://visl.sdu.dk>)!

In future studies it would be of great interest to follow the development of both grammatical awareness and grammatical spelling competence in a longitudinal design. In the present study an attempt was made to distinguish two aspects of grammatical awareness, viz. awareness of word class differences and awareness of inflections. The fact that these aspects were associated with different aspects of grammatical spelling competence points to the relevance of analysing the concept of grammatical awareness in more detail than has previously been done. Both with respect to awareness of word class differences and awareness of inflections it was found that great differences exist among Danish twelve-year-olds. It is to be hoped

that a better understanding of the concept of grammatical awareness and its consequences for spelling development can help us make grammatical spelling problems less persistent.

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Appendix A

Items used to assess grammatical spelling, critical spellings in bold. The bottom line reports the mean frequency of the word forms (logarithmic frequencies with SDs).

Present tense verbs	Infinitives	Present participles	Plural nouns
parrer 'pair'	narre 'fool'	hængende 'hanging'	sengene 'the beds'
snurrer 'spin'	spore 'trace'	væltende 'falling over'	teltene 'the tents'
forstyrer 'disturb'	bestyre 'be in charge of'	baksende 'struggling'	saksene 'the scissors'
knurrer 'growl'	dirre 'tremble'	festende 'partying'	hestene 'the horses'
klarer 'cope with'	spare 'economise'	stegende 'frying'	legene 'the games'
moret 'amuse'	lure 'eavesdrop'	fiskende 'fishing'	piskene 'the whips'
spirer 'sprout'	stirre 'stare'	sukkende 'sighing'	kyssene 'the kisses'
afskærer 'cut off'	afspærre 'block'	skålende 'touching glasses'	kælkene 'the sledges'
4.87 (1.08)	4.70 (1.66)	2.84 (1.84)	2.63 (2.24)

Notes: The present tense verbs and infinitives were also used to assess the use of medial *rr/r*, cf. below. Frequency counts are based on *Den Danske Ordbogs Korpus*, a text corpus of approximately 36.6 million Danish words (available from www.dsl.dk).

Items used to assess lexical spelling, critical spellings in bold. The bottom line reports the mean frequency of the word forms (logarithmic frequencies with SDs).

<i>Medial rr</i>	<i>Medial r</i>	<i>Silent d</i>	<i>No silent d</i>
parrer 'pair'	klar er 'cope with'	stald n. 'stable'	smal adj. 'narrow'
snurrer 'spin'	spare 'economise'	told n. 'costums'	mol n. 'the minor key'
forstyr rrer 'disturb'	bestyre 'be in charge of'	skynd imp. 'hurry'	nyn imp. 'hum'
knurrer 'growl'	spore 'trace'	stands imp. 'stop'	dans imp. 'dance'
narre 'fool'	morer 'amuse'	krud t n. 'gun powder'	sprut n. 'booze'
afspær re 'block'	afskær er 'cut off'	krid t n. 'chalk'	sprit n. 'alcohol'
dir re 'tremble'	lure 'eavesdrop'	fjor d n. 'fjord'	klor n. 'chlorine'
stir re 'stare'	spirer 'sprout'	mord n. 'murder'	snor n. 'string'
4.19 (1.06)	5.38 (1.42)	5.53 (0.75)	5.13 (1.72)

Notes: *adj.* = adjective, *imp.* = imperative, *n.* = noun. All the items with medial *rr/r* are verbs. These items were also used to assess the use of inflectional *-e* vs. *-er*, cf. above. Frequency counts are based on *Den Danske Ordbogs Korpus*, a text corpus of approximately 36.6 million Danish words (available from www.dsl.dk).

Appendix B

Oddity tasks used to assess awareness of word class differences. The odd words out are underlined. Trial zero was an easy starter which was not scored.

Practice trials			
1	Mona Hanne <u>Viggo</u> Lise	(4 common Danish personal names)	girl's names - boy's name
2	fem <u>fisk</u> seks syv	'five, <u>fish</u> , six, seven'	numerals - noun
3	dem den det <u>del</u>	'them, it, it, <u>part</u> '	pronouns - noun
Trials			
0	syv <u>kop</u> to ni	'seven, <u>cup</u> , two, nine'	numerals - noun
1	slippe hente <u>frakke</u> vælge	'let go, fetch, <u>coat</u> , choose'	verbs - noun
2	kvinden pletten flisen <u>gnaven</u>	'the woman, the spot, the flagstone, <u>bad-tempered</u> '	nouns - adjective
3	<u>flyv</u> blid smuk grøn	' <u>fly</u> (imp.), gentle, beautiful, green'	adjectives - verb
4	flise gryde <u>slæbe</u> kjole	'flagstone, pot, <u>drag</u> , dress'	nouns - verb
5	<u>tingest</u> skørest dummost blødest	' <u>contraption</u> , craziest, most stupid, softest'	adjectives - noun
6	haste snyde køre <u>store</u>	'hurry, cheat, drive, <u>big</u> '	verbs - adjective
7	byt <u>hund</u> kom find	'change (imp.), <u>dog</u> , come (imp.), find (imp.)'	verbs - noun
8	<u>gul</u> kat søm sol	' <u>yellow</u> , cat, nail, sun'	nouns- adjective

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9	stærk tysk paf <u>skyd</u>	'strong, German, dumbfounded, <u>shoot</u> (imp.)'	adjectives - verb
10	hest blik <u>husk</u> skat	'horse, tin/glance, <u>remember</u> (imp.), treasure'	nouns - verb
11	stor <u>stær</u> mør rar	'big, <u>starling</u> , tender, pleasant'	adjectives - noun
12	lånt smagt glemte <u>langt</u>	'borrowed, tasted, forgotten, <u>long</u> '	verbs - adjective
13	snyde købe <u>spade</u> måle	'cheat, buy, <u>spade</u> , measure'	verbs - noun
14	<u>træt</u> hat ven plads	' <u>tired</u> , hat, friend, space'	nouns - adjective
15	smalle grønne flotte <u>skaffe</u>	'narrow, green, fine, <u>provide</u> '	adjectives - verb
16	vågner gætter <u>søster</u> halter	'wakes up, guesses, <u>sister</u> , limp'	verbs - noun
17	klog <u>flæsk</u> grøn trist	'wise, <u>pork</u> , green, sad'	nouns - adjective
18	gro <u>grimme</u> svømme stå	'grow, <u>ugly</u> , swim, stand'	verbs - adjective
19	<u>huske</u> knive maske gave	' <u>remember</u> , knives, mask, gift'	nouns - verb
20	stalde hammer moster <u>triste</u>	'stables, hammer, aunt, <u>sad</u> '	nouns - adjective
21	<u>bragt</u> smart smukt trist	' <u>brought</u> , smart, beautiful, sad'	adjectives - verb
22	skjulte snakke <u>kvinder</u> drikker	'concealed, talk, <u>women</u> , drink'	verbs - noun
23	<u>gæst</u> bange blåt raske	' <u>guest</u> , afraid, blue, healthy'	adjectives - noun

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24	roste <u>stolte</u> vælte blæste	'praised, <u>proud</u> , overturn, blew'	verbs - adjective
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Oddity tasks used to assess awareness of inflectional categories. The odd words out are underlined.

Practice trials

1	katte <u>bamse</u> pelse telte	'cats, <u>teddy bear</u> , furs, tents'	plural nouns - singular
2	Karens Søren's Monas <u>Jonas</u>	Karen's, Søren's, Mona's, <u>Jonas</u>	genitive proper names - nominative
3	<u>snød</u> går kan tror	' <u>cheated</u> , walk, can, think'	present tense verbs - past tense

Trials

1	<u>mænd</u> tand grund brønd	' <u>men</u> , tooth, reason, well'	singular nouns - plural
2	læste knuste glemte <u>hente</u>	'read, broke, forgot, <u>fetch</u> '	past tense verbs - infinitive
3	hals <u>kamps</u> saks dans	'neck, <u>fight</u> 's, scissors, dance'	nominative nouns - genitive
4	sange drenge <u>pige</u> dage	'songs, boys, <u>girl</u> , days'	plural nouns - singular
5	lagt <u>vent</u> rost kørt	'placed, <u>wait</u> , praised, gone'	past participle verbs - imperative
6	jeg hun han <u>dig</u>	'I, she, he, <u>you</u> '	nominative pronouns - accusative
7	<u>telte</u> pande tante pølse	' <u>tents</u> , forehead/frying pan, aunt, sausage'	singular nouns - plural
8	fik slog <u>står</u> var	'got, punched, <u>stand</u> , was'	past tense verbs - present tense
9	skibs hats brors <u>pels</u>	'ship's, hat's, brother's, <u>fur</u> '	genitive nouns - nominative

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10	fliser <u>søster</u> skoler lamper	'flagstones, <u>sister</u> , schools, lamps'	plural nouns - singular
11	malede gik <u>vælde</u> snød	'painted, went, <u>overtun</u> , cheated'	past tense verbs - infinitive
12	<u>hun</u> dig ham mig	' <u>she</u> , you, him, me'	accusative pronouns - nominative
13	<u>kasser</u> sommer bule måne	' <u>boxes</u> , summer, bulge, moon'	singular nouns - plural
14	pynte haste sulte <u>tabte</u>	'decorate, hurry, starve, <u>lost</u> '	infinitives - past tense verb
15	vores <u>den</u> min deres	'our, <u>it</u> , mine, their'	possessive pronouns - demonstrative pronoun
16	skruer gulve <u>hammer</u> døre	'screws, floors, <u>hammer</u> , doors'	plural nouns - singular
17	skyd hent klip <u>sagt</u>	'shoot, fetch, cut, <u>said</u> '	imperatives - past participle verb
18	du <u>jer</u> vi jeg	'you (sing. nom.), <u>you</u> (plur. acc.), we, I'	nominative pronouns - accusative
19	<u>dåsen</u> børn skoene heste	' <u>the can</u> , children, the shoes, horses'	plural nouns - singular
20	ser kan <u>var</u> vil	'see, can, <u>was</u> , will'	present tense verbs - past tense
21	<u>bilens</u> toget hestene æslerne	' <u>the car's</u> , the train, the horses, the donkeys'	nominative nouns - genitive
22	mig ham dig <u>jer</u>	'me, him, you (sing. acc.), <u>you</u> (plur. ac.)'	singular pronouns - plural
23	blæse grine <u>skulle</u> flette	'blow, laugh, <u>should</u> , plait'	infinitives - past tense verb
24	dem <u>jeg</u> dig jer	'them, <u>I</u> , you (sing. acc.), you (plur. acc.)'	accusative pronouns - nominative

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