KØBENHAVNS UNIVERSITET
DET HUMANISTISKE FAKULTET

God, bædre, best

Om ortografisk viden og ortografisk indlæring hos danske børn på skolens begynder- og mellemtrin

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Indholdsfortegnelse

Abstract

This dissertation presents three research studies concerning *orthographic knowledge* and *orthographic learning* among Danish children. The studies, presented as research papers, are supplemented by two reports on pilot studies that preceded the main studies. The dissertation further includes an introduction to the studies' theoretical and empirical background, an overall discussion of the main results, and future perspectives on research and education. A main purpose of the dissertation is to investigate whether the acquisition of orthographic knowledge in later phases of literacy development is a mere extension of the acquisition of phonological knowledge in earlier phases of literacy development. Another main purpose is to investigate the significance of different aspects of preexisting orthographic knowledge for general spelling skills and for orthographic learning.

Study 1 is a longitudinal study concerning the development of spelling skills in a sample of 140 children. The results indicate that the acquisition of orthographic knowledge between Grade 2 and 5 is partly based on skills different from those necessary for the acquisition of phonological knowledge in earlier phases of spelling development. Spelling skills in Grade 2 was by far the strongest predictor of later spelling skills in Grade 5. However, a paired associate learning task with nonwords measured in Grade 0 (Kindergarten) explained additional unique variance in Grade 5 spelling. The result suggests a specific link between verbal learning and the acquisition of orthographic knowledge. *Study 2* is a correlational study looking at the current relations between different aspects of orthographic knowledge and general spelling skills in a sample of 133 fifth graders. The study demonstrates that a newly developed measure of knowledge of spelling patterns conditioned by phonological context explains unique variance in spelling skills beyond measures of phonological decoding, word specific orthographic knowledge, and graphotactic knowledge. The result indicates that children are drawing on their knowledge of conditional spelling patterns when spelling complex words. The training study in *study 3* further supports this finding. The study with 42 third graders shows that preexisting knowledge of conditional spelling patterns supports orthographic learning of new words during independent reading. Half of the children received training targeting conditional spelling patterns. Next, all children participated in a word learning task in which they were exposed to new words (nonwords) containing trained spelling patterns. Subsequently, children receiving training were better at identifying target word spellings in an orthographic choice task and they were markedly better at spelling the new words compared to children who did not receive training. The finding supports the view that larger spelling patterns (the level between simple letter-sound-units and whole words) play an important role when children learn new word spellings during independent reading.

Overall, the results suggest that children's memory for new word spellings can be enhanced by closely linking spelling instruction to activities with independent reading. Furthermore, the results suggest that different aspects of orthographic knowledge should be subject to direct spelling instruction, including knowledge of conditional spelling patterns.

Resumé

Afhandlingen præsenterer tre forskningsstudier, der beskæftiger sig med *ortografisk viden* (viden om skriftsprogets indretning) og *ortografisk indlæring* (tilegnelse af nye ords stavemåde) hos danske børn. De tre studier præsenteres i artikelform og suppleres med to rapporter om forudgående pilotstudier. Afhandlingen omfatter desuden en introduktion til studiernes teoretiske og empiriske baggrund, en samlet diskussion af hovedresultaterne samt en perspektivering til fremtidig forskning og undervisning. Et hovedformål med afhandlingen er at undersøge, hvorvidt tilegnelse af ortografisk viden hos elever på mellemtrinnet blot er en forlængelse af tilegnelse af fonologisk viden i tidligere faser af den skriftsproglige udvikling. Et andet hovedformål er at undersøge, hvilken betydning forskellige aspekter af eksisterende ortografisk viden har for det generelle staveniveau og for ortografisk indlæring.

Afhandlingens *studie 1* er en langtidsundersøgelse, der ser på staveudviklingen hos 140 børn. Undersøgelsen indikerer, at tilegnelse af ortografisk viden i 2.-5. klasse er delvist baseret på andre færdigheder end dem, der er nødvendige for tilegnelse af fonologisk viden tidligere i staveudviklingen. Stavefærdighed i 2. klasse var langt den stærkeste prædiktor af stavefærdighed i 5. klasse. Men derudover var børnenes evne til at indlære nye fonologiske former (nonord) og associere dem med figurer målt i 0. klasse ligeledes en unik prædiktor. Resultatet tyder på et specifikt link mellem verbale indlæringsfærdigheder og senere tilegnelse af ortografisk viden. Afhandlingens *studie 2* er en her og nu-undersøgelse, der ser på sammenhængen mellem forskellige aspekter af ortografisk viden og generelt staveniveau hos 133 børn fra 5. klasse. Undersøgelsen viser, at et nyudviklet mål for kendskab til fonologisk betingede stavemønstre kan forklare unik variation i stavefærdighed udover mål for fonologisk afkodning, ordspecifik ortografisk viden og grafotaktisk viden. Resultatet tyder på, at børn trækker på deres kendskab til betingede stavemønstre, når de skal stave komplekse ord. Træningsundersøgelsen i afhandlingens *studie 3* underbygger dette resultat yderligere. Undersøgelsen med 42 børn fra 3. klasse viser, at eksisterende viden om betingede stavemønstre fremmer tilegnelse af nye ords stavemåde under selvstændig læsning. Halvdelen af børnene blev undervist i seks forskellige stavemønstre. Dernæst deltog alle børn i en ordindlæringsopgave, hvor de i korte tekster mødte nye ord (nonord), der indeholdt trænede stavemønstre. Efterfølgende var de børn, der havde modtaget undervisning, bedre til at genkende de nye ords stavemåde blandt homofone distraktorer og markant bedre til at stave ordene end de børn, der ikke havde modtaget eksperimentel undervisning. Resultatet støtter den antagelse, at større stavemønstre (niveauet mellem simple bogstav-lyd-forbindelser og hele ord) spiller en væsentlig rolle, når børn tilegner sig nye ords stavemåde gennem selvstændig læsning.

Samlet set peger resultaterne på, at børns tilegnelse og hukommelse for nye ords stavemåde kan fremmes gennem en systematisk sammentænkning af staveundervisning og aktiviteter med selvstændig læsning. Og at staveundervisning bør sigte specifikt på at udvikle forskellige aspekter af ortografisk viden, herunder stavemønstre betinget af fonologisk kontekst.

Studier i afhandlingen

1. Nielsen, A.-M. V. & Juul, H. (2015). Predictors of early versus later spelling development in Danish. *Reading and Writing: An Interdisciplinary Journal*, *29*(2), 245-266. doi: 10.1007/s11145-015-9591-y

2. Nielsen, A.-M. V. (2016). Knowledge of conditional spelling patterns supports word spelling among Danish fifth graders. *Journal of Research in Reading.* Advance online publication. doi: 10.1111/1467-9817.12067

3. Nielsen, A.-M. V. (2016). Boosting orthographic learning during independent reading. *Reading Research Quarterly*. Advance online publication. doi:10.1002/rrq.140

Dataindsamlingen i studie 1 og studie 2 var støttet af Københavns Universitet (*Program of excellence*) som led i forskningsprojektet *Development of Speed in Reading* gennemført ved Center for Læseforskning 2009-2013 under ledelse af Professor Carsten Elbro.

Introduktion

Når børn begynder i skole, begynder også deres udvikling mod at blive sikre læsere og stavere, der kan honorere de skriftsproglige krav, de møder i skolen og i fritiden. Overgangen fra børns begyndende forståelse af, at bogstaver repræsenterer sproglyde og er en kode til at afkode og stave ord, til de opnår effektiv ordafkodning og stavning, er blevet betegnet *ortografisk indlæring* (Castles & Nation, 2006). Begrebet ortografisk indlæring bruges også til at betegne indlæringen af specifikke ords stavemåde under selvstændig læsning (fx Share, 1999). I løbet af børns udvikling af skriftsproglige færdigheder tilegner de sig *ortografisk viden,* dvs. viden om skriftsprogets indretning på både leksikalt og subleksikalt niveau. På det leksikale niveau er der tale om ortografiske enheder i form af ord, der kan stå alene og i sig selv bærer betydning (fx *sol*, *lege*). På det subleksikale niveau er der tale om en række ortografiske enheder, der ikke kan stå alene og ikke i sig selv bærer betydning. Det drejer sig om mulige bogstavkombinationer (fx *sk*- ordinitialt men aldrig *sg*-), komplekse grafemer (fx *fa<u>ld</u>e*), fonologisk betingede stavemønstre (fx *vi<u>sk</u>e*), morfologisk betingede stavemønstre (fx *sny<u>d</u>t*), stavelser (fx *ti-vo-li*), rimdele (fx *fl<u>æng</u>e*), bøjningsmorfemer (fx *hus<u>et</u>*) og forstavelses- og afledningsmorfemer (fx *<u>und</u>være*, *mandi<u>g</u>*). Stavefejlene i afhandlingens titel "God, bædre, best" refererer til den type viden, det er en fordel at besidde, når man skal stave adjektiverne *bedre* og *bedst*. Når ordet *bedre* skal staves, er der støtte at hente i den fonologiske kontekst; da vokallyden [ɛ] følges af lyden [ð], er sandsynligheden for at [ɛ] repræsenteres af *e* fremfor *æ* meget stor (ud af 208 forekomster staves [ɛð] *ed* i 86% af tilfældene, bogstavlyd.ku.dk). Når ordet *bedst* skal staves, er der støtte at hente i den morfologiske kontekst; stavemønstret *ed*, der repræsenterer [ɛ], er forudsigelig ud fra relationen mellem de to adjektiver *bedre* og *bedst*.

Ortografisk indlæring og ortografisk viden er under et blevet betegnet *ortografisk processering* (fx Cunningham, Nathan, & Raher, 2011; Deacon, Benere, & Castles, 2012; Rothe, Cornell, Ise, & Schulte-Körne, 2015). Ortografisk processering er afhandlingens overordnede tema. Det er et forskningstema, der internationalt har været og fortsat er i rivende udvikling. Eksempelvis dedikerer *The Society of the Scientific Studies of Reading* (SSSR) i 2017 et særnummer af deres tidsskrift til temaet under overskriften "*Orthographic learning and representations in literacy acquisition*". Ortografisk processering har hidtil ikke været genstand for stor opmærksomhed i danske forskningsundersøgelser. Afhandlingen behandler dermed et tema, der har stor international bevågenhed, og som ikke mindst mangler at blive belyst i en dansk kontekst.

Den centrale del af afhandlingen udgøres af tre forskningsstudier, der med udgangspunkt i forskellige datasæt og metoder beskæftiger sig med ortografisk indlæring og ortografisk viden. I afhandlingen sættes særlig fokus på tilegnelse og betydning af én type ortografisk viden i form af *viden om betingede stavemønstre*. Dvs. stavemønstre, der indeholder komplekse og inkonsistente grafem-fonem-forbindelser (fx *ig* i *igle*; *um* i *skum*). Der er tale om stavemønstre, der er uregelmæssige på enkeltfonemniveau, men (mere) regelmæssige hvis konteksten tages i betragtning under læsning (øvrige grafemer) og stavning (øvrige fonemer).

Regelmæssighederne eksisterer over enkelt grafem-fonem-niveau, men under morfem- og ordniveau (Elbro, 2006; Juul, 2005). Det er oplagt, at betingede stavemønstre kan gøre relationen mellem tale og skrift sværere at gennemskue for børn, der skal lære at beherske skriftens kode (Juul, 2008). En undersøgelse med deltagelse af engelske og danske elever fra 3. og 4. klasse har da også vist, at grafem-fonem-forbindelser, der afviger fra det basale alfabetiske princip om én-til-én sammenhæng mellem grafemer og fonemer, mestres senere end lydrette forbindelser (Elbro, 2006).

Engelsk ortografi afviger i særlig høj grad fra en én-til-én sammenhæng mellem grafemer og fonemer og er blevet kaldt en "outlier-ortografi" (Share, 2008a). Ved at beskrive en række kontekstbetingede regler for grafem-fonem-forbindelser var Venezky (1967, 1970) en af de første til at demonstrere, at inkonsistensen i grafem-fonem-forbindelser i engelsk ortografi reduceres kraftigt, når betingede stavemønstre medtages (eksempelvis kan udtalen af dobbelt-o forudsiges ud fra den efterfølgende konsonant som i *boot* [bu:t] vs. *book* [bʊk]). Denne pointe er yderligere understøttet af studier, hvori man har beregnet, i hvor høj grad ét element i en stavelse (begyndelse, vokal, slutning) påvirkes af de øvrige to elementer i såvel læse- som staveretningen. Dermed kan man demonstrere, hvor meget mere regelmæssige simple fonem-grafem- / grafem-fonem-forbindelser bliver, når andre dele af stavelsen tages i betragtning (Kessler & Treiman, 2001). Beregninger med et stort korpus af amerikanske ord viser, at den overordnede konsistens af grafem-fonem / fonem-grafem-forbindelser bliver betydelig forbedret, når mål for betingede stavemønstre medtages (Kessler & Treiman, 2001; Treiman, Kessler, & Bick, 2002). Juul (2008) har vha. beregninger i overensstemmelse med Kessler og Treiman (2001) fundet tilsvarende resultater med et stort korpus af danske ord.

Baseret på ovenstående synes tilegnelse og udnyttelse af viden om betingede stavemønstre at være et kritisk element for afkodnings- og stavefærdighed i uregelmæssige ortografier. Flere forskere har da også peget på, at det vil være relevant at inddrage betingede stavemønstre i læse- og staveundervisning (Juul, 2005; Kessler, 2009; Treiman & Kessler, 2013, 2014). Anbefalingen bygger bl.a. på studier, der har vist, at såvel børn som voksne udnytter viden om betingede stavemønstre i både afkodning og stavning af ord (Hayes, Treiman, & Kessler, 2006; Juul, 2005; Treiman & Kessler, 2006; Treiman et al., 2002; Varnhagen, Boechler, & Steffler, 1999). Ligeledes indlæres mange stavemønstre først relativt sent i skoleforløbet, og i mange tilfælde anvendes de indlærte mønstre ikke ligeså hyppigt, som de måske burde (Kessler, 2009). Der er ikke dansk tradition for at undervise direkte i betingede stavemønstre, hvorfor de primært må læres indirekte gennem skriftsprogserfaring (Elbro, 2014; Juul, 2005). Et af hovedformålene med denne afhandling er at undersøge betydningen af viden om betingede stavemønstre for den fortsatte læse- og staveudvikling blandt danske børn. Et andet hovedformål med afhandlingen er at belyse en række centrale spørgsmål, der relaterer sig til begreberne ortografisk processering, ortografisk viden og ortografisk indlæring. Følgende spørgsmål belyses:

Ortografisk processering

- Hvordan defineres ortografisk processering i forskningslitteraturen?

- Hvilke test anvendes i forskningsstudier som mål for individuel variation i ortografisk processering?

Ortografisk viden

- Hvilke typer ortografisk viden kan bidrage selvstændigt til at forklare individuel variation i afkodnings- og stavefærdigheder?
- Er individuel variation i ortografisk viden blot en afspejling af individuelle forskelle i skriftsprogserfaring?
- Er ortografisk viden en prædiktor for, eller en følge af udviklingen af afkodnings- og stavefærdigheder?

Ortografisk indlæring

- Hvilke faktorer spiller en rolle for graden og kvaliteten af indlæring af nye ords stavemåde under selvstændig læsning?
- Er tilegnelse af ortografisk viden i senere faser i den skriftsproglige udvikling blot en forlængelse af tilegnelse af fonologisk viden i tidligere faser i den skriftsproglige udvikling? Dvs. bygger tilegnelse af fonologisk og ortografisk viden på det samme kognitive fundament?

Sammenhængen mellem ortografisk viden og ortografisk indlæring

- Hvilken rolle spiller allerede eksisterende ortografisk viden for indlæring af nye ords stavemåde under selvstændig læsning?

Ovenstående spørgsmål søges belyst gennem en gennemgang og diskussion af eksisterende teorier om ortografisk indlæring samt en gennemgang og diskussion af forskningsstudier, der har undersøgt betydningen af ortografisk viden for udviklingen af afkodnings- og stavefærdighed og faktorer af betydning for indlæring af nye ords stavemåde under selvstændig læsning. Ligeledes søges spørgsmålene belyst gennem tre selvstændige forskningsstudier, der har særlig fokus på ortografisk viden og ortografisk indlæring blandt danske børn.

Studierne i afhandlingen er eksempler på de vel nok tre vigtigste designs inden for kvantitative forskningsstudier: *her og nu-undersøgelser*, *langtidsundersøgelser* og *træningsundersøgelser*. De tre typer designs genererer forskellige grader af evidens, og valget af design har derfor stor betydning for, hvilke konklusioner man kan drage på baggrund af undersøgelsernes resultater (Elbro & Poulsen, 2015).

I en *her og nu-undersøgelse* ser man typisk på en række samtidige korrelationer. Fx kan man spørge, hvorvidt et mål for ordspecifik ortografisk viden har sammenhæng med stavefærdighed blandt elever i 5. klasse. Dette design kan ikke sige noget om, hvorvidt der er tale om en årsagssammenhæng, da *omvendt påvirkning* ikke kan udelukkes (at fremgang i stavefærdighed er årsag til fremgang i ordspecifik ortografisk viden og ikke omvendt), eller at

der er *bagvedliggende årsager*, man ikke har kontrolleret for, der kan forklare den observerede sammenhæng (fx at variation i skriftsprogserfaring kan forklare sammenhængen mellem ordspecifik ortografisk viden og stavefærdighed). Et her og nu-undersøgelsesdesign blev anvendt i afhandlingens *studie 2*. I studiet undersøges de samtidige korrelationer mellem fire typer fonologisk/ortografisk viden og stavefærdighed i et udsnit med 133 dansktalende børn fra 5. klasse. Studiet bygger på en antagelse om, at børn trækker på forskellige typer ortografisk viden, når de skal stave ord med komplekse stavemåder, de endnu ikke har lagret i hukommelsen som ordspecifikke ortografiske repræsentationer. Det centrale forskningsspørgsmål er, hvorvidt et nyudviklet mål for kendskab til fonologisk betingede stavemønstre kan forklare unik variation i stavefærdighed udover mål for fonologisk afkodning, ordspecifik ortografisk viden og grafotaktisk viden. At opnå en større indsigt i den viden, børn trækker på, når de skal stave ord med komplekse stavemåder, er afgørende for at kunne udvikle undervisning, der kan understøtte den fortsatte staveudvikling hos elever, der har tilegnet sig fonologiske stavefærdigheder.

I en *langtidsundersøgelse* ser man typisk på, hvorvidt en række tidlige prædiktorer kan forudsige færdigheder på et senere tidspunkt. Fx kan man spørge, hvorvidt bogstavkendskab og fonemopmærksomhed i 0. klasse forudsiger senere stavefærdighed i 2. klasse. Hvis prædiktorerne er målt, inden eleverne er i stand til at stave ord, kan designet udelukke omvendt påvirkning, men det kan ikke udelukke bagvedliggende årsager, man ikke har taget højde for. Der er dermed tale om et design, der kan generere en højere grad af evidens sammenlignet med en her og nu-undersøgelse. Det er ligeledes indbygget i designet, at det er det mest ressourcekrævende af de to, da de samme deltagere skal følges over tid og testes af to eller flere omgange. Et langtidsundersøgelsesdesign blev anvendt i afhandlingens *studie 1*. I studiet undersøges langtidsrelationerne mellem en række sproglige mål indsamlet i slutningen af 0. klasse og senere stavefærdigheder målt i begyndelsen af 2. og 5. klasse i et udsnit med 140 dansktalende børn. Formålet er at afdække, hvad der adskiller elever, der udvikler automatiserede stavefærdigheder, fra elever der oplever vanskeligheder. Undersøgelsen bygger på en antagelse om, at det primære fokus i den tidlige staveudvikling (1. og 2. klasse) er tilegnelse af fonologisk viden (viden om fonem-grafem-forbindelser, der gør børn i stand til at producere fonologisk adækvate stavemåder), mens fokus i den senere staveudvikling (efter 2. klasse) er tilegnelse af ortografisk viden. Det kritiske spørgsmål er, hvorvidt de tidlige sproglige mål *specifikt* prædicerer tilegnelse af ortografisk viden, dvs. hvorvidt de kan bidrage til prædiktionen af stavefærdighed i 5. klasse, når der kontrolleres for stavefærdighed i 2. klasse. En bedre forståelse af det kognitive grundlag for tilegnelsen af ortografisk viden, der er kritisk for udvikling af automatiseret stavefærdighed, kan være med til at bane vejen for mere kvalificeret staveundervisning.

I en *træningsundersøgelse* ser man typisk på, hvorvidt træning af en gruppe elever fører til større fremgang hos denne gruppe sammenlignet med en eller flere matchede kontrolgrupper, der enten har modtaget en anden type træning (trænet kontrolgruppe) eller ingen træning (ikke-trænet kontrolgruppe). Hvis der er tale om en træningsundersøgelse af høj kvalitet, kan dette design udelukke omvendt påvirkning og bagvedliggende årsager. Det er dermed også det

af de tre designs, der kan generere den højeste grad af evidens. Og det er et design, der kan være meget ressourcekrævende at gennemføre. Et træningsundersøgelsesdesign blev anvendt i afhandlingens *studie 3*. I studiet undersøges overføringseffekten fra direkte undervisning målrettet betingede stavemønstre til graden og kvaliteten af ortografisk indlæring af nye ord indeholdende trænede stavemønstre under selvstændig læsning. Det centrale forskningsspørgsmål er, hvorvidt eksisterende viden om betingede stavemønstre fremmer ortografisk indlæring under selvstændig læsning hos dansktalende børn i 3. klasse. Toogfyrre elever udvalgt fra et udsnit med 72 elever blev matchet i par baseret på mål for ordlæsning og stavning, hvorefter hvert par blev tilfældigt splittet i en eksperiment- og en kontrolgruppe. Mens eksperimentgruppen modtog undervisning i seks betingede stavemønstre, fungerede kontrolgruppen som en ikke-trænet kontrolgruppe. Undersøgelsen bygger på en antagelse om, at kendskab til betingede stavemønstre støtter dannelsen af forbindelser mellem udtaler og stavemåder af nye ord i hukommelsen. Hvis denne antagelse kan underbygges empirisk, vil det være et stærkt belæg for, at undervisning målrettet betingede stavemønstre med fordel kan inkorporeres i den fortsatte læse- og staveundervisning.

Tabel 1 viser en oversigt over de tre studiers fokus, design og deltagere.

Tabel 1 Fokus, design og deltagere i studie 1, 2 og 3

Studie	*Fokus*	*Design*	*Deltagere*
1	Langtidsprædiktion af stavefærdighed i 2. og 5. klasse med tidlige sproglige mål	Langtidsundersøgelse	140 børn fulgt fra 0. til 5. klasse
2	Samtidig prædiktion af stavefærdighed i 5. klasse med mål for ortografisk viden	Korrelationsundersøgelse	133 børn fra 5. klasse
3	Betydningen af viden om betingede stavemønstre for indlæring af nye ords stavemåde under selvstændig læsning	Træningsundersøgelse	72 børn fra 3. klasse; heraf blev 42 elever udvalgt, matchet i par og tilfældigt fordelt på en eksperiment- og en kontrolgruppe

I det følgende baggrundsafsnit præsenteres den teoretiske og den empiriske baggrund for de tre studier i afhandlingen. Dele af dette baggrundsafsnit kan genfindes i artiklen "*Ortografiske færdigheder og den tidlige læseudvikling*" bragt i Pædagogisk Psykologisk Tidsskrift (Nielsen, 2014). Baggrundsafsnittet kan betragtes som en udvidelse og opdatering af artiklens indhold. Efter baggrundsafsnittet følger præsentationen af de tre studier i artikelform. Artiklerne er publiceret i eller indsendt til engelsksprogede tidsskrifter og indgår i deres originale engelsksprogede form i afhandlingen. Som baggrund for artiklerne om studie 2 og 3 indgår en rapport, der beskriver udviklingen af tre danske test af ortografisk viden, der blev anvendt i

begge studier. Som baggrund for artiklen om studie 3 indgår en rapport, der beskriver en pilotundersøgelse, der gik forud for træningsundersøgelsen. Resultaterne fra pilotundersøgelsen fik afgørende betydning for udformningen af den endelige træningsundersøgelse i studie 3. Efter de tre artikler følger en opsummering og en fælles diskussion af studiernes hovedresultater. Afhandlingen afsluttes med en perspektivering til fremtidig forskning og en perspektivering til fremtidig undervisning.

Baggrund

Når elever afslutter 4. klasse i den danske folkeskole, er det målet, at de skal have opnået skriftsproglige færdigheder, der gør dem i stand til at *læse tekster* med henblik på oplevelse og faglig viden og skriftsproglige færdigheder, der gør dem i stand til at *udtrykke sig på skrift* i velkendte faglige situationer (Ministeriet for Børn, Undervisning og Ligestilling). En forudsætning, for at elever i 4. klasse kan læse sig til viden, er, at de ikke skal bruge mange ressourcer på at *afkode* de enkelte ord i teksten. Og en forudsætning, for at de kan udtrykke sig på skrift, er, at de ikke skal bruge mange ressourcer på at *stave* de enkelte ord. Det er derfor helt afgørende at forstå, hvilke processer der er i spil i udviklingen af automatiserede afkodnings- og stavefærdigheder.

Børn, hvis afkodning ikke er effektiv, dvs. upræcis og/eller langsom, kæmper med at høste udbyttet af læsning; at forstå og tilegne sig viden gennem de tekster, de møder i hverdagen. Afkodningsfærdighed er den stærkeste prædiktor for læseforståelse fra 1. til mindst 3. klasse og forklarer en stor del af variationen i læseforståelse gennem hele skoletiden (Cunningham et al., 2011). Færdigheden i at stave ord korrekt er et afgørende element i succesfuld skriftlig kommunikation. Hvis et barn skal bruge mange ressourcer på at stave enkeltord korrekt, betyder det, at der er færre ressourcer tilgængelige til øvrige aspekter af et skriftligt produkt såsom indholdets kvalitet og tekstens struktur (Treiman & Kessler, 2013). Undersøgelser har vist, at elever med dårlige stavefærdigheder producerer færre ord og producerer tekster af dårligere kvalitet end elever med gode stavefærdigheder (Abbott, Berninger, & Fayol, 2010; Moats, Foorman, & Taylor, 2006). Derfor er det afgørende at få viden om, hvordan undervisning bedst understøtter udviklingen fra kendskab til bogstaver og deres lyde tidligt i den skriftsproglige udvikling til automatiseret *genkendelse* af skrevne ord og til automatiseret *genkaldelse* af ords stavemåde i den senere skriftsproglige udvikling.

Automatiseret afkodningsfærdighed

Som første skridt i udviklingen af afkodningsfærdighed skal begynderlæsere etablere et system af forbindelser mellem grafemer i skrevne ord og fonemer i talte ord. Dvs. de skal blive bekendte med det grundlæggende princip bag alfabetiske skriftsystemer; til hvert grafem hører et fonem. En stor mængde forskning har fundet, at fonologisk opmærksomhed, og i særlig grad evnen til at kunne skelne og manipulere fonemer i talte ord, sammen med bogstavkendskab udgør de væsentligste forudsætninger for tilegnelse af afkodningsfærdighed hos børn i indskolingen på tværs af ortografier (fx Scarborough, 1998). Skriftsprog som dansk og engelsk er uregelmæssige i læseretningen, idet der er mange afvigelser fra simple en-til-en forbindelser mellem grafemer og fonemer. For at blive en effektiv afkoder af disse skriftsprog kan man ikke udelukkende forlade sig på simpel omkodning fra enkeltgrafem til enkeltfonem, men må tilegne sig et hurtigt og fleksibelt ordgenkendelsessystem, der trækker på viden om såvel regelmæssighederne som uregelmæssighederne i skriftsproget (Castles & Nation, 2006). Ifølge Perfetti (1992) er et sådant fleksibelt ordgenkendelsessystem kendetegnet ved, at læseren har

opbygget et mentalt leksikon, der indeholder fuldt specificerede ortografiske repræsentationer. Perfetti og Hart (2002) har introduceret begrebet leksikal kvalitet (*lexical quality*) til at beskrive variationen i repræsentationer af skrevne ord i hukommelsen. Et ord, der har en høj leksikal kvalitet, kan ses som bestående af forbindelser af ortografisk, fonologisk og semantisk information af høj kvalitet. Repræsentationer af høj kvalitet gør læseren i stand til at genkende skrevne ord og få adgang til deres udtale og betydning umiddelbart uden at skulle gøre brug af den omkringstående tekst og uden at blive i tvivl om, hvilke mulige leksikale repræsentationer der kunne være tale om. Med et dansk eksempel betyder det, at man umiddelbart er i stand til at genkende og skelne mellem fx hyppige, uregelmæssige småord som *den* og *det*. Ehri (2005) peger endvidere på, at umiddelbar genkendelse af skrevne ord er karakteriseret ved, at den foregår automatisk og ubevidst. Man kan ikke slå sin evne til at læse ord til eller fra (jf. den såkaldte *stroop-effekt*, Stroop, 1935), og det er ikke en proces, man har kontrol over.

Automatiseret stavefærdighed

Udviklingen af stavefærdighed beskrives i en række teorier som en gradvis udvikling kendetegnet ved flere karakteristiske faser (Ehri, 1987; Frith, 1985; Gentry, 1982; Henderson & Templeton, 1986). Det fælles udgangspunkt for teorierne er en forståelse af, at forskellige typer viden og forskellige processer er dominerende i forskellige faser i staveudviklingen (Joshi & Carreker, 2009). Antallet af faser og navngivningen af dem er ikke ens på tværs af teorierne, men fælles for dem er, at de overordnet opererer med tre faser i udviklingen af automatiseret stavefærdighed: 1) en *præalfabetisk* fase hvor børn endnu ikke har en forståelse af, at bogstaver repræsenterer lyde, 2) en *alfabetisk* fase hvor børn generelt forsøger at forbinde fonemer og grafemer og 3) en *ortografisk* fase hvor børn analyserer ord i større ortografiske enheder (Sharp, Sinatra, & Reynolds, 2008). Essentielt for udviklingen af fonologisk stavefærdighed i den alfabetiske fase er fonemopmærksomhed og bogstavkendskab. Dette er empirisk understøttet af, at man på tværs af ortografier finder, at fonologisk opmærksomhed og bogstavkendskab er stærke prædiktorer for udvikling af stavefærdighed i indskolingen (fx Caravolas, Lervåg, Mousikou, Efrim, Litavský, Onochi-Quintanilla et al., 2012; Furnes & Samuelsson, 2009, Juul, 2007; Leppänen, Niemi, Aunola, & Nurmi, 2006; Lervåg & Hulme, 2010). Dansk er et af flere skriftsprog, hvor der i staveretningen ses mange afvigelser fra simple en-til-en forbindelser mellem fonemer og grafemer. Det betyder, at danske børn skal lære at beherske mange komplekse stavemåder. Kompleksiteten kan fx være fonologisk betinget (*d<u>un</u>* → *p<u>uf</u>*), morfologisk betinget (*fed* → *fe<u>dt</u>*), der kan indgå komplekse grafemer (*<u>hj</u>ælp*), eller stavemåden kan være exceptionel (*v<u>ejr</u>*). Det betyder, at børn ud over at trække på fonologisk viden også må trække på morfologisk og ortografisk viden for at kunne stave en lang række ord korrekt (Joshi & Carreker, 2009). Flere forskere har peget på, at selvom der er belæg for den generelle ide om et udviklingsmæssigt skifte fra en primær afhængighed af fonologisk viden til større afhængighed af morfologisk og ortografisk viden, så trækker begynderstavere på alle tre typer viden, når de staver ord (Bourassa & Treiman, 2014; Treiman & Kessler, 2014; Walker & Hauerwas, 2006). Dermed kan staveudviklingen betragtes som en kontinuerlig

sammensmeltning af fonologisk, morfologisk og ortografisk viden (Joshi & Carreker, 2009). Som for automatiseret læsning gælder det, at automatiseret stavning afhænger af, at staveren har tilegnet sig et mentalt leksikon, der indeholder fuldt specificerede ortografiske repræsentationer (Ehri, 1997; Perfetti, 1997).

Sammenhængen mellem udvikling af afkodnings- og stavefærdighed

Udviklingen af afkodnings- og stavefærdighed er blevet beskrevet som to sider af samme sag (Ehri, 1997; Perfetti, 1997). Denne beskrivelse bygger på en antagelse om, at præcis og effektiv genkendelse og genkaldelse af skrevne ord beror på de samme ortografiske repræsentationer i hukommelsen på såvel et leksikalt niveau som et subleksikalt niveau. Empirisk støttes antagelsen af fundet af høje korrelationer (r = ,77 - ,86) mellem mål for afkodning og mål for stavning på tværs af undersøgelser (Moll & Landerl, 2009). Ligeledes har undersøgelser vist overføring fra træning i ordafkodning til stavning og overføring fra træning i stavning til ordafkodning (fx Conrad, 2008; Ehri & Wilce, 1986; Share, 2004).

Der hersker bred enighed om, at stavning af enkeltord generelt er vanskeligere end afkodning af enkeltord og kræver ortografiske repræsentationer af højere kvalitet (Ehri, 1997; Perfetti, 1997). I en række studier med engelske begynderlæsere trænede eleverne afkodning af specifikke ord under forskellige forhold, hvorefter de blev bedt om at stave ordene. I de fleste tilfælde sås overføring fra afkodning til stavning, men der sås en lavere præcision i stavning end i afkodning (70%-80% korrekt i afkodning vs. 30%-40% korrekt i stavning; Ehri, 1997). Et væsentligt spørgsmål er så, hvilke kompleksiteter der kan gøre stavemåder svære at genkalde sig under stavning, men mulige at afkode? Forskere har bl.a. peget på fonemer, der kan repræsenteres af flere grafemer på tværs af ord (jf. det danske /ɔ/ *på, d<u>u</u>kke, b<u>o</u>mbe*), grafemer, der ikke kan kobles direkte til ords udtale (*fal<u>d</u>*) og sjældne eller unikke stavemåder (*<u>ot</u>te*) (Ehri, 1997; Treiman & Kessler, 2014).

Efter denne generelle introduktion til udvikling af afkodnings- og stavefærdigheder sætter de følgende afsnit fokus på de centrale spørgsmål om ortografisk processering, ortografisk viden og ortografisk indlæring, afhandlingen har til formål at belyse (se s. 8-9).

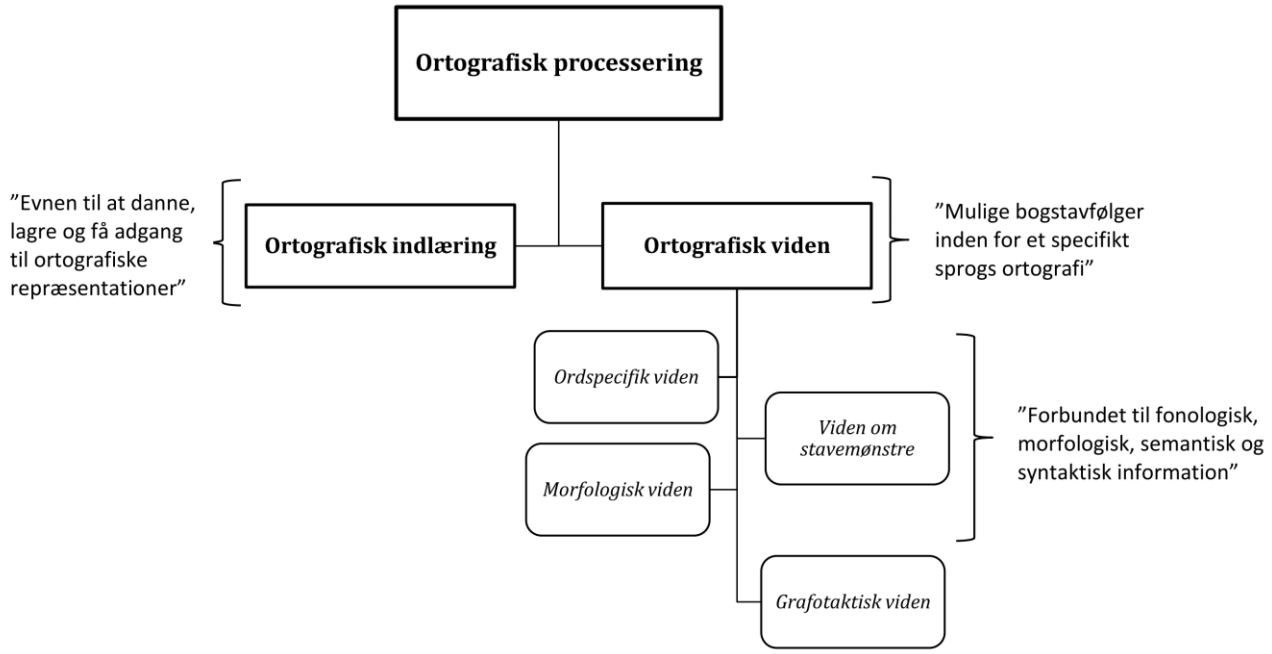
Ortografisk processering

I forskningslitteraturen er det ikke entydigt, hvordan ortografisk processering skal defineres, og hvordan man måler individuel variation i ortografisk processering. Forskellene er bl.a. betinget af, hvorvidt man har fokuseret på evnen til at tilegne sig viden: "*evnen til at danne, lagre og få adgang til ortografiske repræsentationer*" (Stanovich & West, 1989, s. 404), "*evnen til at repræsentere den unikke følge af bogstaver der definerer et skrevet ord så vel som generelle aspekter ved skriftsystemet såsom viden om, hvilke bogstaver der kan følge hinanden, hvilke bogstavfølger der optræder hyppigt på tværs af ord, frekvensen med hvilken bogstaver optræder i forskellige positioner i ord og så videre*" (Vellutino, Scanlon, & Tanzman, 1994, s. 314), eller på

viden her og nu: "*den viden en læser har om mulige bogstavfølger*" (Perfetti, 1984, s. 47), "*hukommelse for specifikke visuelle mønstre/stavemønstre der udgør individuelle ord eller orddele på den trykte side*" (Barker, Torgesen, & Wagner, 1992, s. 335).

Cunningham et al. (2011, s. 263) argumenterer for at anvende en bred definition, der inkluderer både evnen til at tilegne sig viden samt viden her og nu: "*Ortografisk processering er evnen til at danne, lagre og få adgang til ortografiske repræsentationer, der a) specificerer mulige bogstavfølger inden for et specifikt sprogs ortografi, og b) i sig selv er tæt forbundet til fonologisk, semantisk, morfologisk og syntaktisk information inden for det sprog, de optræder i.*" Det er først i denne brede definition, det bliver tydeliggjort, at ortografisk processering omfatter det at danne *forbindelser* mellem bogstavfølger og fonologisk, syntaktisk og semantisk information. I de øvrige definitioner er det ikke klart, hvorvidt ortografisk processering udelukkende omfatter tilegnelse og genkendelse af visuelle mønstre. Figur 1 illustrerer de overordnede komponenter i ortografisk processering baseret på definitionen af Cunningham et al. (2011). Tre af de fire typer ortografisk viden, der er skitseret i modellen, kan forbindes til sproglig information på forskellige niveauer. På det leksikale niveau har bl.a. Perfetti & Hart (2002) beskrevet, hvordan fuldt specificerede repræsentationer består af forbindelser mellem ords stavemåde (ortografisk information), udtale (fonologisk information), og betydning (semantisk og syntaktisk information). Ligeledes kan man forestille sig, at der til repræsentationer af morfemer, knytter sig de samme typer sproglig information, men på subleksikalt niveau, mens der til stavemønstre knytter sig fonologisk og i nogle tilfælde morfologisk information (ved morfologisk betingede stavemønstre, fx *bi<u>d</u>t*). Endelig er der grafotaktisk viden; her er der umiddelbart tale om en ren bogstavkombinatorisk viden, fx at *sp*- er en hyppig bogstavkombination ordinitialt modsat *sb*-.

Studierne i denne afhandling bygger på den brede definition af ortografisk processering, hvor dannelsen af forbindelser mellem bogstavfølger, udtale og semantisk information står centralt. Det samme gælder de teorier om tilegnelse af ortografisk viden, studierne i afhandlingen bygger på (se afsnittet "Teorier om ortografisk indlæring" nedenfor).



Figur 1 Komponenter i ortografisk processering baseret på definitionen af Cunningham et al. (2011)

Test af ortografisk processering

De forskellige definitioner af ortografisk processering beskrevet ovenfor afspejles også i de forskellige typer test, man typisk anvender til at måle ortografisk processering. Testene kan overordnet inddeles i tre typer: 1) test af *ordspecifik* ortografisk viden, 2) test af *generel* ortografisk viden, 3) test af ortografisk *indlæring*.

Med *ordspecifik ortografisk viden* menes viden om de unikke bogstavfølger, der udgør skrevne ord. Forskellige typer test har været anvendt til at måle denne type viden. Ofte skal deltageren vælger den stavemåde af to mulige, der matcher et specifikt ord. Distraktoren er enten et rigtigt ord (fx hvilket er et dyr? *krave / krage*) eller lydligt ækvivalente stavemønstre (fx hvilken stavemåde er korrekt? *blin / blind*). Fælles for testene er, at de er følsomme for deltagernes evne til at genkende ordspecifikke stavemåder uden at trække på fonologisk viden (Cunningham et al., 2011; Hagialiassis, Pratt, & Johnston 2006).

Med *generel ortografisk viden* menes opmærksomhed på generelle egenskaber ved skriftsproget (ibid.). Forskellige versioner af *The nonword choice task* har været anvendt som et mål, der er følsomt for deltagernes *grafotaktiske viden* (fx Siegel, Share, & Geva, 1995; Treiman, 1993). I denne type test bliver deltagerne præsenteret for et nonordspar og bliver bedt om at vælge den stavemåde, der ligner et rigtigt ord mest. Nonordet, der fungerer som målord, er i overensstemmelse med et eksisterende grafotaktisk mønster i den givne ortografi, mens distraktoren er i modstrid med eksisterende grafotaktiske mønstre (fx nnøse / nøsse).

I test af *ortografisk indlæring*, *Orthographic learning tasks*, lader man almindeligvis børn læse korte tekststykker højt, der indeholder ord, der er nye for eleverne (typisk nonord). Efterfølgende anvendes forskellige test til at afgøre, hvorvidt eleverne har indlært målordenes

stavemåde. De mest almindelige mål for ortografisk indlæring er: *orthographic choice test* hvor deltageren skal vælge den korrekte stavemåde blandt målordet samt fonologiske og ortografiske distraktorer; *højtlæsning* hvor deltageren skal højtlæse målordene og en række homofone alternativer højt, samt *stavning* hvor deltageren skal stave målordene. Fremgangmåden er bl.a. hyppigt anvendt i studier af David Share (fx 1999, 2004, 2008b).

I afsnittet "Udvikling af danske gruppetest af ortografisk viden" (s. 58) beskrives udvikling og afprøvning af tre test af henholdsvis a) ordspecifik ortografisk viden, b) grafotaktisk viden samt c) viden om betingede stavemønstre. De to første test (a og b) er udviklet på baggrund af engelsksprogede forlæg, mens den tredje test (c) er et nyudviklet mål, der ikke findes et egentligt forlæg til. De tre test af ortografisk viden indgår i studie 2 og 3. I studie 3 anvendes desuden en test af ortografisk indlæring, der bygger på forlæg fra en række tidligere studier (fx Cunningham, 2006; Share, 1999; Wang, Nickels, Nation, & Castles, 2013).

Er ortografisk viden en selvstændig komponent i afkodnings- og stavefærdighed?

Adskillige undersøgelser har fundet, at mål for ortografisk viden kan forklare unik variation i ordafkodning udover variation forklaret af fonologiske færdigheder (fx Barker et al., 1992; Bjaalid, Hoien, & Lundberg, 1996; Conrad, Harris, & Williams, 2013; Cunningham, Perry, & Stanovich, 2001; Roman, Kirby, Parrila, Wade-Woolley, & Deacon, 2009). Ligeledes har enkelte undersøgelser fundet, at mål for ortografisk viden kan forklare unik variation i stavning udover variation forklaret af fonologiske færdigheder (Arab-moghaddam & Sénéchal, 2001; Conrad et al., 2013; Rothe, Schulte-Körne, & Ise, 2014). Studierne synes dermed at pege på, at ortografisk viden er en selvstændig komponent i afkodnings- og stavefærdighed. Der knytter sig dog en række kritiske spørgsmål til undersøgelsernes resultater, som diskuteres nedenfor.

Kan ortografisk viden inddeles i en ordspecifik og en generel komponent?

I flere undersøgelser skelnes mellem test af ordspecifik ortografisk viden og test af generel ortografisk viden. Men man kan spørge, om der faktisk er grund til at operere med denne opdeling. Her er resultaterne ikke entydige. I en undersøgelse af Hagialiassis et al. (2006) gennemførte en gruppe på 177 engelsktalende børn fra 3., 4., og 5. klasse bl.a. fem forskellige test af ortografisk viden. Fire test var målrettet ordspecifik ortografisk viden (*orthographic verification test, homophone verification test, afkodning og stavning af uregelmæssige ord*) mens en *nonlexical choice test* var målrettet generel ortografisk viden. Målet for generel ortografisk viden korrelerede kun moderat med testene af ordspecifik viden (r = ,37-,47), men en faktoranalyse gav ikke anledning til at opdele de ortografiske test svarende til en ordspecifik og en generel komponent. Derimod understøtter resultater fra korrelationsundersøgelser med engelsktalende elever fra 1.-3. klasse inddelingen i en ordspecifik og en generel komponent. For det første viser også disse undersøgelser, at mål for ordspecifik ortografisk viden og mål for generel ortografisk viden kun korrelerer moderat med hinanden (r = ,27-,52). For det andet

forklarer begge mål forskellig og unik variation i ordafkodning efter kontrol for fonologiske færdigheder (Conners, Loveall, Moore, Hume, & Maddox, 2011; Conrad et al., 2013) og efter kontrol for fonologiske færdigheder, ordforråd og nonverbal problemløsning (Deacon et al., 2012) samt i stavning efter kontrol for fonologiske færdigheder (Conrad et al., 2013).

Kan ortografisk viden adskilles fra erfaring med skriftsprog?

Det er relevant at spørge, hvorvidt individuel variation i ortografisk viden blot er en afspejling af individuelle forskelle i erfaring med skriftsprog, da de observerede sammenhænge mellem mål for ortografisk viden og afkodnings- og stavefærdigheder i så fald fuldt ud kan forklares af en bagvedliggende årsag. På tværs af undersøgelser med børn har man fundet, at erfaring med skriftsprog kan forklare mellem 7-28% af variationen i mål for ortografisk viden, efter der er kontrolleret for fonologisk afkodning og mål for øvrige fonologiske færdigheder (Burt, 2006). Cunningham og Stanovich (1990) gennemførte en undersøgelse med elever i 3.-4. klasse. De ønskede bl.a. at finde ud af, hvorvidt forskelle i erfaring med skriftsprog målt med en titelgenkendelsestest hænger sammen med variation i ortografisk viden, der ikke kan forklares af variation i fonologiske færdigheder. De fandt, at titelgenkendelsestesten kunne forklare unik variation i ortografisk viden efter kontrol for alder og fonologiske færdigheder. Forfatterne konkluderer dermed, at der ikke kan være tale om, at fonologiske færdigheder er indirekte årsag til variationen i ortografisk viden gennem forskelle i erfaring med skriftsprog – i så fald ville titelgenkendelsestesten ikke forklare unik variation efter kontrol for fonologiske færdigheder. Cunningham og Stanovich (1993) har senere fundet parallelle resultater med elever i 1. klasse. I en lignende undersøgelse med elever i 3. klasse undersøgte man betydningen af ortografisk viden for fem forskellige mål for læsefærdighed (Barker et al., 1992). Man fandt, at ortografisk viden bidrog til at forklare variation i alle mål for læsefærdighed efter kontrol for fonologiske færdigheder. Derudover fandt man, at individuelle forskelle i erfaring med skriftsprog kunne forklare nogen, men ikke al variation i ortografisk viden. Det får forfatterne til at konkludere, at selvom erfaring med skriftsprog bidrager til udviklingen af ortografisk viden, eksisterer der væsentlig variation i ortografisk viden uafhængig af mængden af skriftsproglig erfaring. De påpeger dog, at enhver konklusion om betydningen af skriftsproglig erfaring må drages med forsigtighed, da titelgenkendelsestesten ikke er følsom for de forskelle i læseerfaring, der fx akkumuleres i løbet af den daglige undervisning i skolen. I det hele taget er det med de eksisterende test af læseerfaring ikke muligt at udelukke, at variation i ortografiske færdigheder fuldt ud kan forklares af forskelle i erfaring med skriftsprog. Det skyldes, at det uanset metode er vanskeligt at måle, hvor meget elever egentlig læser på egen hånd både i skolen og i fritiden, hvilket betyder, at de sammenhænge, der findes, bliver behæftet med en vis usikkerhed (Nielsen & Juul, 2012).

Er ortografisk viden en prædiktor for udviklingen af skriftsproglige færdigheder?

Vellutino, Scanlon og Tanzman (1994) har påpeget, at test der kræver kendskab til ordspecifikke stavemåder, sådan som det fx måles i en *orthographic choice test*, snarere er et mål for skriftsproglige færdigheder end en prædiktor af skriftsproglige færdigheder. For at kunne løse opgaver af den type med succes, kræves som det mindste en fuldt specificeret ortografisk repræsentation, der kan adskilles fra konkurrerende kandidater. Castles og Nation (2006) fremhæver, at sammenhængen mellem test af generel ortografisk viden og skriftsproglige færdigheder kan betragtes som mindre direkte end sammenhængen mellem test af ordspecifik ortografisk viden og skriftsproglige færdigheder, hvorfor mål for generel ortografisk viden er en mere lovende prædiktor. Fremfor at måle resultatet af ortografisk indlæring, er det muligt, at en test som *the non lexical choice test* måler en forudsætning for ortografisk indlæring og dermed udvikling af afkodnings- og stavefærdigheder. Spørgsmålet er blevet direkte adresseret i to nyere undersøgelser. I en langtidsundersøgelse med engelsktalende elever fulgt fra 1. til 3. klasse fandt Deacon et al. (2012), at individuel variation i ordafkodning prædicerede tilegnelse af både ordspecifik ortografisk viden (målt med en *orthographic choice test*) og generel ortografisk viden (målt med en *nonword choice task*) efter kontrol for ordforråd, nonverbal problemløsning og fonologisk opmærksomhed. Derimod kunne målene for ortografisk viden ikke prædicere fremgang i ordafkodningsfærdighed. Et lignende resultat er fundet i en langtidsundersøgelse af Rothe et al. (2014) med tysktalende elever fulgt fra 0. til 1. klasse. Deltagernes præstation på to *nonword choice tasks* i slutningen af 1. klasse forklarede unik variation i deres samtidige afkodningsfærdighed (11%) og stavefærdighed (7%) efter kontrol for fonologisk opmærksomhed, hurtig seriel benævnelse (RAN), verbal korttidshukommelse, bogstavkendskab og nonverbal IQ. Derimod så man ingen sammenhæng mellem deltagernes generelle ortografiske viden i 0. klasse og deres senere stavefærdigheder. Disse resultater tyder på, at børn på de første klassetrin tilegner sig ortografisk viden gennem erfaring med skriftsprog, og at variation i de anvendte mål for ortografisk viden ikke er årsagsforbundet med tilegnelse af afkodnings- og stavefærdigheder.

Teorier om ortografisk indlæring

Adskillige teorier er blevet udviklet for at forklare, hvordan børn tilegner sig ortografiske repræsentationer på leksikalt og subleksikalt niveau i alfabetiske skriftsprog. Studierne i afhandlingen refererer til tre teorier, der har det tilfælles, at processen, hvor udtale og stavemåde *forbindes*, er kritisk for dannelsen af ortografiske repræsentationer af høj kvalitet. Dvs. at fonologiske færdigheder, særlig fonemopmærksomhed, sammen med skriftsprogserfaring er de centrale elementer i dannelsen af ortografiske repræsentationer. De tre teorier er *faseteorien* (Ehri, 1999, 2005, 2014), *selvindlæringshypotesen* (Share, 1995, 2008b) og *teorien om statistisk indlæring* (*statistical learning*; Treiman & Kessler, 2006, 2013, 2014). I de følgende afsnit præsenteres teorierne kort, herunder det empiriske belæg for centrale dele af teorierne.

Faseteorien

Linnea Ehri (1999, 2005, 2014) har fremsat en teori, der beskriver, hvordan børn udvikler færdighed i umiddelbar genkendelse af skrevne ord kaldet *sight word reading* samt umiddelbar stavning af ord vha. ortografiske repræsentationer lagret i hukommelsen. Ifølge Ehri involverer indlæringen af ortografiske repræsentationer, at barnet kobler ords stavemåde med deres udtale og betydning i hukommelsen. Det muliggør, at skrevne ord kan genkendes automatisk vha. hukommelsen frem for, at der anvendes en afkodningsstrategi. Og det muliggør, at ordspecifikke stavemåder kan genereres automatisk fra hukommelsen under stavning. Faserne i Ehris teori er kendetegnet og adskilt fra hinanden ved de dominerende typer af forbindelser, der sikrer sight words i hukommelsen på forskellige trin i udviklingen. Teorien beskriver den *præ-,* den *delvise,* den *fuldt* og den *konsoliderede* alfabetiske fase.

Børn i den præalfabetiske fase har kun begrænset viden om bogstavnavne og lyde, så de danner forbindelser på basis af fremtrædende visuelle egenskaber ved ordene og deres betydning, og deres staveforsøg er ikke fonologisk baserede. Børn i den delvise alfabetiske fase kan kun i begrænset grad segmentere ord i enkeltfornemer og har kun begrænset kendskab til bogstaver og lyde. De danner derfor fortrinsvis forbindelser mellem første og sidste bogstav i ord for at huske, hvordan de læses. Deres staveforsøg er delvist fonologisk betingede, og deres hukommelse for korrekte stavemåder er svag. I den fuldt alfabetiske fase kender barnet størstedelen af grafem-fonem-forbindelserne og kan derigennem lagre sight words i hukommelsen ved at danne komplette forbindelser mellem grafemer og fonemer. Deres staveforsøg er primært lydbevarende, og deres hukommelse for korrekte stavemåder er voksende. Børn i den konsoliderede fase har yderligere tillært sig viden om bogstavfølger og stavemønstre på tværs af ord og kan dermed anvende ortografiske mønstre til at sikre sight words i hukommelsen. Det er ikke før den konsoliderede fase, at begynderlæsere overvejende anvender ortografiske mønstre til at indlære ord. Hvorvidt alle grafemer i et ord forbindes til udtalen i hukommelsen afhænger ikke kun af uregelmæssigheder i stavemåden, men også barnets viden om det alfabetiske system. Hvis barnet ikke kender til specifikke stavemønstre, når de optræder i nye ord, vil ordets stavemåde og udtale ikke blive koblet komplet i hukommelsen. Viden om grafem-fonem-relationer må læres *direkte* gennem læse- eller staveundervisning eller *indirekte* gennem erfaring med skriftsproget, før en komplet kobling kan opstå. Efterhånden som barnet lærer om stavemønstre, der optræder på tværs af ord, anvendes disse til at danne forbindelser mellem skrevne og talte ord i hukommelsen og til at stave ord, der endnu ikke er lagret som sight words i hukommelsen. Sådanne større forbindelser udgøres af små ord i større ord, hyppige bogstavfølger, morfemer og stavelser. Alle ord, der afkodes tilstrækkeligt mange gange, bliver et sight word lagret i hukommelsen, der genkendes under læsning og genkaldes under stavning.

Faseteorien forudsiger, at gentagen succesfuld afkodning af hyppige ord vil føre til, at der dannes sikre forbindelser mellem ordenes udtale og deres ortografiske repræsentationer i hukommelsen, hvilket muliggør umiddelbar genkendelse af skrevne ord. Dvs. at ordene læses som enheder uden pauser mellem orddele, kaldet *unitization*. At det forholder sig sådan, er bl.a.

underbygget af en undersøgelse af Ehri og Wilce (1983). De fik deltagerne til at afkode kendte navneord (fx bog, mand, bil), korte nonsensord (fx baf, jad, nel) og benævne enkeltcifre (fx 4, 6, 3). De målte latenstiden for benævnelse af hver type stimulus. Der var tale om en yngre og en ældre gruppe elever, der læste svarende til 2. og 4. klasse. Begge grupper afkodede de kendte ord meget hurtigere end nonordene, hvilket viser fordelen ved at genkende ord vha. hukommelsen frem for at omkode nye ord. De bedste læsere i begge grupper afkodede de kendte ord ligeså hurtigt som de kunne benævne cifre. Det indikerer, at ordene blev genkendt som enheder. I en undersøgelse med engelske og tyske børn i alderen 7-9 år fandt man, at de 7-8-årige børn kunne benævne cifre hurtigere end de kunne afkode de tilsvarende skrevne tal. Derimod var forskellen i hastighed minimal hos de 9-årige børn, hvilket forfatterne tolker som, at de ældste børn kunne få direkte adgang til tallenes udtale i hukommelsen, uanset om de var repræsenteret som cifre eller skrevne tal (Wimmer & Goswami, 1994).

Resultater fra undersøgelser med forskellige aldersgrupper underbygger faseteoriens antagelse om, at kendskab til større ortografiske enheder som stavelser og stavemønstre støtter indlæringen af nye ord undervejs i læseudviklingen. I en undersøgelse af McKay og Thompson (2009) lod man børn i 1. til 3. klasse afkode matchede nonord, der henholdsvis delte og ikke delte ortografiske mønstre med ord i deres ordforråd. Der var en lille, men konstant positiv effekt på afkodningspræcision af at afkode nonord, der havde ortografiske mønstre tilfælles med rigtige ord, hos deltagere der læste på et niveau svarende til 6-8 årige børn. Hos deltagere, der læste på et niveau svarende til 8-10 årige børn, øgedes den positive effekt kraftigt. Det kan tolkes som, at børnene i denne periode i højere grad bliver i stand til at udnytte viden om bogstavfølger og stavemønstre på tværs af ord. Bhattacharya og Ehri (2004) gennemførte en træningsundersøgelse med elever fra 6. til 10. klasse, der læste under niveauet for deres klassetrin. Én gruppe trænede afkodning af 100 ord ved at analysere dem i stavelser, en anden gruppe trænede afkodning af de samme ord, men som helheder, og endelig deltog en kontrolgruppe, der ikke modtog nogen undervisning. Der sås en positiv effekt af træningen i at analysere ord i stavelser på afkodning og stavning af trænede ord. Der sås ligeledes positiv overføringseffekt til afkodning af nye ord. Overføringseffekten peger på, at deltagerne trænet i at analysere ord i stavelser havde forbundet de trænede stavelsers stavemåde og udtale i hukommelsen, og at disse stavemønstre fremmede den ortografiske indlæring af nye flerstavelsesord (Bhattacharya & Ehri, 2004; Ehri, 2014).

Selvindlæringshypotesen

Selvindlæringshypotesen er en teori om mekanismerne bag udviklingen af stabile ortografiske repræsentationer (Share, 1995, 2008b). Hypotesen hævder, at detaljerede ortografiske repræsentationer primært selvindlæres under selvstændig læsning. Fonologisk afkodning er den afgørende mekanisme bag selvindlæringen. Når læseren støder på et ukendt ord på skrift, selvindlærer han eller hun den ordspecifikke stavemåde ved at anvende eksisterende viden om grafem-fonem-forbindelser til at generere mulige kandidatudtaler, der matches med kendte ord i det talte ordforråd. Afkodes ordet med succes, giver det læseren mulighed for at tilegne

sig ordspecifik, ortografisk information. Den omhyggelige omkodning fra grafem til fonem vil resultere i dannelsen af velspecificerede ortografiske repræsentationer. For læsere med en normal udvikling vil blot nogle få succesfulde afkodninger af et ord være tilstrækkelig til, at ordet lagres som en ortografisk repræsentation i hukommelsen. Mekanismen gælder for såvel regelmæssige som uregelmæssige ord. Uregelmæssige ord vil ofte have tilstrækkelig regelmæssighed mellem grafemer og fonemer til, at fonologisk afkodning vil føre til, at den rette udtale findes blandt et sæt kandidater i hukommelsen. Vel at mærke når ordene præsenteres i naturlig kontekst. Tekstsammenhængen kan ifølge hypotesen være en hjælp til at afklare usikkerheder i den udtale, der er resultatet af omkodningen.

I takt med at den ortografiske viden øges gennem erfaring med skriftsproget, bliver viden om simple grafem-fonem-forbindelser udbygget. Der er tale om en proces, der konstant forandres og forfines. Afkodningen af ord bliver mere og mere tilpasset den givne ortografi i et samspil mellem afkodningsfærdigheder og ortografisk viden. Denne leksikaliseringsproces resulterer i afkodningsfærdigheder, der er langt mere avancerede end simpel viden om grafem-fonem-forbindelser. Det understreges derfor, at faktorer ud over fonologisk afkodning har betydning for ortografisk indlæring under selvstændig læsning. Det gælder bl.a. kvantiteten og kvaliteten af erfaring med skriftsprog og evnen til at være opmærksom på og huske ortografiske detaljer. Der, hvor selvindlæringshypotesen i særlig grad adskiller sig fra faseteorien, er, at automatiseret ordafkodning er karakteristisk for *specifikke ord* og ikke for en bestemt fase i den skriftsproglige udvikling. (Cunningham et al., 2011).

Selvindlæringshypotesen forudsiger, at for læsere med en normal udvikling vil kun få succesfulde afkodninger af et ord være tilstrækkelig til, at ordet lagres som en ortografisk repræsentation i hukommelsen. Flere undersøgelser har underbygget antagelsen. Fx fandt Share (1999), at 8-årige hebraisktalende børn valgte målordet fem gange så hyppigt som homofone distraktorer i en *orthographic choice test* efter at være blevet præsenteret for nonordene fire til seks gange i et kort tekststykke. De højtlæste ligeledes målordene hurtigere end homofone distraktorer, og de var i højere grad tilbøjelige til at vælge målordets stavemåde frem for andre alternativer, når de blev bedt om at stave dem. Det gav ingen forskel i præstationerne, om målordene var blevet præsenteret fire eller seks gange.

At fonologisk afkodning er den afgørende mekanisme bag selvindlæringen er blevet underbygget af undersøgelser, hvor man har fundet, at jo mere præcise deltagernes fonologiske afkodning af målordene er, jo bedre ortografisk indlæring opnår de (fx Cunningham, 2006; Cunningham, Perry, Stanovich, & Share, 2002). Dog har Nation, Angell og Castles (2007) i en undersøgelse med 8-9-årige engelsktalende børn vist, at deltagerne i flere tilfælde kunne genkende ord i en *orthographic choice test*, de ikke havde afkodet korrekt, ligesom de i flere tilfælde havde afkodet ord korrekt, men ikke kunne genkende dem efterfølgende. Forfatterne peger derfor på, at der er andre faktorer involveret i ortografisk indlæring, end hvorvidt man er i stand til at afkode målordet korrekt. Share (1999) gennemførte en undersøgelse med det formål at undersøge, hvorvidt visuel eksponering er tilstrækkelig til, at ortografisk indlæring kan finde sted. Deltagerne var elever i 2. klasse, der blev præsenteret for strenge af ikke-

alfabetiske symboler (fx X-$Δ). Hver målstreng blev præsenteret seks gange blandet med en række distraktorer. Efterfølgende blev deltagernes genkendelse af symbolstrengene testet vha. en *orthographic choice test*. Succesraten for deltagernes svar var kun 7,6% højere end chanceniveau. Denne kan sammenlignes med en undersøgelse med indlæring af nonord præsenteret i korte tekster, hvor succesraten for deltagernes svar var 52,5% over chanceniveau. Det peger på, at visuel eksponering kun har begrænset indflydelse på ortografisk indlæring sammenlignet med fonologisk afkodning. I en undersøgelse af de Jong, Bitter, Setten og Marinus (2009) deltog hollandske børn i 2. klasse. Deltagerne blev inddelt i to grupper, der gennemførte den samme *lexical decision test* men under to forskellige betingelser. Begge grupper skulle afgøre, hvorvidt en bogstavfølge præsenteret på en skærm udgjorde et rigtigt ord eller et nonord. Hvert nonord blev præsenteret fem gange blandet med en række rigtige ord. Under den første betingelse skulle deltagerne gentage nonordet "dubba", fra bogstavfølgen blev præsenteret, til de afgav deres svar. Den anden gruppe skulle derimod banke hånden let i bordet gentagne gange. Hypotesen var, at den ledsagende artikulation ville undertrykke den fonologiske afkodning, mens det ikke ville være tilfældet for kontrolbetingelsen. Resultatet viste, at ledsagende artikulation førte til lavere genkendelse af målordenes stavemåde i en *orthographic choice test*. Deltagernes præstation var dog stadig over chanceniveau, hvorfor ortografisk indlæring havde fundet sted. Der sås ingen effekt af træningsbetingelse på højtlæsning af målordenes stavemåde sammenlignet med homofone stavemåder. Forfatterne konkluderer på den baggrund, at samtidig artikulation ikke forstyrrer fonologisk afkodning fuldstændigt. At der sås en effekt på genkaldelse og ikke genkendelse kan muligvis forklares med, at stavning er mere afhængig af fuldt specificerede ortografiske repræsentationer end læsning. Tilsvarende resultater er fundet af Kyte og Johnson (2006) med børn i 4. og 5. klasse.

Teorien om statistisk indlæring

Teorien om statistisk indlæring (Treiman & Kessler, 2006, 2013, 2014) tager primært udgangspunkt i tilegnelse af stavefærdigheder. Det antages, at børn tilegner sig både viden om ordspecifikke stavemåder samt generel viden om stavemønstre, der optræder på tværs af ord. Børn lærer såvel *sandsynligheder* for stavemåder som *regler* for stavemåder. Når børn skal stave et nyt ord, kan de trække på viden om adskillige mønstre, der optræder inden for det enkelte ord. Indlæring af stavemønstre involverer kobling mellem grafiske former og talesproglige enheder. Mønstrene kan involvere forskellige typer af sproglig viden såsom fonologisk og morfologisk viden. For at kunne lære mønstrene i en specifik ortografi, får børn enten kendskab til mønstene gennem uformel eller formel instruktion, eller de anvender deres evner for *statistisk indlæring*. Statistisk indlæring er en indirekte proces, hvor børn observerer og indoptager den relative frekvens, med hvilken bogstaver eller stavemønstre optræder, når de bliver eksponeret for skrift (Samara & Caravolas, 2014).

Som faseteorien, hævder teorien om statistisk indlæring, at tilegnelse af ortografisk viden afhænger af præcis viden om ords skrevne form samt stærke, velspecificerede forbindelser mellem visuelle enheder og sproglige enheder. Men teorien adskiller sig fra faseteorien ved at

hævde, at børn lærer nogle af de mere nærliggende ortografiske mønstre i en tidlig alder. Hvor faseteorien forudsiger en grad af konsistens for et barns produktion af stavemåder på et givent tidspunkt i staveudviklingen, forudsiger teorien om statistisk indlæring, at barnet staver forskellige typer af ord ganske forskelligt på det samme tidspunkt i staveudviklingen (Treiman & Kessler, 2014).

Når børn har fanget det alfabetiske princip, bruger de deres evner til statistisk indlæring til at tilegne sig forbindelserne mellem fonemer og grafemer. De udleder kontekstbetinget information, som at bestemte stavemåder for et givent fonem er almindelig i én kontekst, og at en anden stavemåde er almindelig i en anden kontekst. Disse mønstre anvendes derefter i børns egne staveforsøg. Børn tilegner sig kontekstbetingede mønstre gradvist, selvom mange af dem ikke er genstand for direkte instruktion (Treiman & Kessler, 2013). Selvom børn gradvist tilegner sig statistiske mønstre, der involverer forbindelser mellem fonemer og grafemer, er deres statistiske indlæring ikke perfekt. Det tager tid at lære om kontekstbetingede stavemønstre, og selv stavere med mange års erfaring har ikke fuldt ud tilegnet sig viden om de mange stavemønstre, der optræder i de skrevne ord, de er blevet eksponeret for.

Adskillige undersøgelser har fundet, at børn på et meget tidligt stadie i deres skriftsproglige udvikling er opmærksomme på ortografiske mønstre og kan udnytte denne information i læsning og stavning. Eksempelvis har Treiman (1993) vist, at stavemåder produceret af elever i første klasse afspejlede statistiske tendenser i sproget. Eleverne var i højere grad tilbøjelige til at bruge dobbeltbogstaver, der forekommer hyppigt i engelsk, end dobbeltbogstaver, der forekommer sjældent. I et senere undersøgelse fandt Cassar og Treiman (1997), at yngre engelsktalende børn var følsomme for ulovlige dobbeltkonsonanter i begyndelsen af nonord. Deltagerne skulle vælge det af to nonord, de syntes lignede et rigtigt ord mest. Elever i slutningen af 0. klasse valgte nonord med dobbeltkonsonant finalt (fx *pess*) oftere end nonsensord med dobbeltkonsonant initialt (fx *ppes*). Det samme gjorde sig gældende for elever i 1. klasse, der yderligere valgte nonord med lovlige dobbeltkonsonanter finalt (fx *yill*) oftere end nonsensord med ulovlige dobbeltkonsonanter finalt (fx *yihh*). Her scorede eleverne i 0. klasse på chanceniveau. Resultaterne er blevet repliceret med fransktalende børn (Pacton & Fayol, 2004), finsktalende børn (Lehtonen & Bryant, 2005) og tysktalende børn (Rothe et al., 2014). Wright og Ehri (2007) har fundet, at begynderlæsere i 0. og 1. klasse lærte at læse ord med dobbeltkonsonant finalt lige så let som enkeltkonsonanter, mens det tog dem længere tid at lære at læse ord med dobbeltkonsonant placeret ulovligt initialt. Deres hukommelse for ordene målt i en stavetest var næsten lige så god for dobbeltkonsonanter finalt som for enkeltkonsonanter. Derimod var deres hukommelse for dobbeltkonsonanter initialt meget dårlig sammenlignet med de øvrige typer. Disse resultater peger på, at begynderlæsere processerer og husker ortografiske egenskaber ved ord, der ikke er bestemt af ordenes lydlige struktur. Børn synes altså meget tidligt i udviklingen at være følsomme for tilladte bogstavkombinationer i deres pågældende skriftsprog, eller meget tidligt at have tilegnet sig et basalt niveau af ortografisk viden. Flere forskere forklarer resultaterne med, at børn tilegner

sig grafotaktisk viden gennem statistisk indlæring (fx Deacon, Conrad, & Pacton 2008; Pollo, Treiman, & Kessler, 2007; Treiman & Kessler, 2013).

Martinét, Valdois og Fayol (2004) har fundet, at fransktalende børn i 1. klasse, der kun havde modtaget begrænset undervisning i læsning, var i stand til at stave nonord ved brug af analogi til rigtige ord, de tidligere var blevet præsenteret for. Et lignende resultat er fundet med franske børn i 1. og 2. klasse af Bosse, Valdois og Tainturier (2003). I deres træningsundersøgelse lærte eleverne først en række referenceord. Efterfølgende sås en analogieffekt til stavning af nonord, der indeholdt elementer fra referenceordene. Disse resultater peger på, at børn meget tidligt er i stand til at anvende viden om ortografiske mønstre i kendte ord til stavning af nye ord.

Studier har vist, at børn og voksne stavere gør brug af den fonologiske kontekst, når de skal stave flertydige fonemer, dvs. fonemer der kan repræsenteres af flere forskellige grafemer afhængig af konteksten (Hayes et al., 2006; Treiman, Kessler, & Bick, 2002; Treiman & Kessler, 2006; Varnhagen et al., 1999). I et studie med danske elever fra 4. til 6. klasse anvendte Juul (2005) en stavetest, der sammenlignede deltagernes evne til at stave ord på tværs af tre niveauer af ortografisk gennemskuelighed: 1) fonologisk mulige stavemåder = kun én fonologisk mulig stavemåde af målfonemet (flise: /s/, lime: /m/), 2) kontekstbetingede stavemåder = to eller flere fonologisk mulige stavemåder af målfonemet, dvs. at målfonemet optrådte i en fonologisk kontekst, hvor en af de mulige stavemåder næsten udelukkende anvendes (basse: /s/, svømmet: /m/), 3) ordspecifikke stavemåder = to fonologisk mulige stavemåder af målfonemet, men ingen af dem kunne udelukkes på basis af den fonologiske kontekst (kolossal: /s/, ballon /l/). Antagelsen var, at hvis deltagerne var mere præcise til at stave fonemer med kontekstbetingede stavemåder end fonemer med ordspecifikke stavemåder, så anvendte de den fonologiske kontekst til stavning af flertydige fonemer. Resultaterne viste, at deltagerne stavede fonemer med kontekstbetingede stavemåder mere præcist end fonemer med ordspecifikke stavemåder. Desuden var det sværere for eleverne at anvende de kontekstbetingede stavemåder sammenlignet med de fonologisk mulige stavemåder. Det peger på, at viden om kontekstbetingede stavemønstre tilegnes senere end viden på fonemniveau.

Faktorer af betydning for ortografisk indlæring

Et af de helt centrale spørgsmål, der ønskes belyst i afhandlingen, er, hvilke faktorer der kan formodes at påvirke selvindlæringen af nye ords stavemåde under selvstændig læsning. Adskillige studier har set på betydningen af forskellige faktorer, og de væsentligste af disse præsenteres nedenfor.

Eksponering

I en undersøgelse med hebraisktalende børn i 3. klasse fandt Share (2004), at der ikke sås forskel i indlæringen, om målordene var præsenteret en, to eller fire gange i en *orthographic*

learning task. Positiv effekt af antal eksponeringer er dog fundet i undersøgelser med engelske begynderlæsere, hvor indlæringen af nye ord steg som funktion af, om nonordene blev præsenteret en, to eller fire gange (Nation et al., 2007), og om ordene blev præsenteret fire eller otte gange (Bowey & Muller, 2005). Forskellen i resultaterne kan muligvis forklares med forskelle i ortografiernes dybde (Cunningham et al., 2011). Undersøgelser af ortografisk indlæring gennemføres oftest med opgaver, hvor deltagerne højtlæser tekster med indlejrede nonord. Resultater herfra synes dog at kunne overføres til stillelæsning. de Jong og Share (2007) lod hollandske elever i 3. klasse højt- eller stillelæse korte historier med indlejrede nonord. Efterfølgende test af ortografisk indlæring viste, at ortografisk indlæring havde fundet sted under begge betingelser. Tilsvarende resultater er fundet med engelske børn i 3. klasse (Bowey & Muller, 2005).

Den omkringstående tekst

I flere undersøgelser har man ønsket at undersøge den omkringstående teksts betydning for indlæring af nye ords stavemåde. Ønsket bunder bl.a. i, at et centralt element i selvindlæringshypotesen (Share, 1995, 2008b) er, at konteksten hvori fx uregelmæssigt stavede ord optræder, ofte vil være en hjælp til at afklare usikkerheder i den udtale, barnet er nået frem til ved hjælp af bogstavlyd-omkodning. Resultaterne af undersøgelserne er ikke entydige. I en af undersøgelserne lod man 8-9-årige engelske børn læse nye ord isoleret eller i sammenhængende tekst. Efterfølgende test af ortografisk indlæring viste ingen forskel på de to betingelser, hvilket får forfatterne til at konkludere, at ortografisk indlæring ikke er afhængig af information fra den omkringstående tekst (Nation et al., 2007). I en anden undersøgelse fandt man, at den omkringstående tekst fremmer ortografisk indlæring. Her lod man engelske elever i 2. klasse læse ord i sammenhængende tekst eller isoleret. Ordmaterialet var rigtige ord, man tidligere havde fundet, at gennemsnitlige læsere i 2. klasse ikke kunne genkende på skrift. Eleverne indlærte flere ord trænet i sammenhængende tekst end isoleret. Hukommelsen for indlærte ord målt otte dage efter træningen var dog ens for begge betingelser (Martin-Chang, Levy, & O'Neill, 2007). I to senere undersøgelser har man undersøgt, hvorvidt effekten af omkringstående tekst er afhængig af, om de nye ord, der skal indlæres, er regelmæssige eller uregelmæssige. Her lod man først elever i 2. klasse lære udtalen og betydningen af otte nye ord, før eleverne blev præsenteret for ordenes stavemåde. Det gjorde det muligt at tilskrive de nye ord enten en regelmæssig eller en uregelmæssig stavemåde. Eleverne skulle efterfølgende indlære ordenes stavemåder gennem læsning af korte historier eller gennem læsning af ordlister. Man fandt ingen signifikant effekt af den omkringstående tekst på indlæring af regelmæssige ord, men derimod en positiv effekt på indlæring af uregelmæssige ord. Resultaterne får forfatterne til at konkludere, at konteksten kun er vigtig for ortografisk indlæring af ord, der indeholder uregelmæssige grafem-fonem-forbindelser (Wang, Castles, & Nickels, 2012; Wang, Castles, Nickels, & Nation, 2011).

Semantisk information

I to undersøgelser har man set på betydningen af semantisk information for ortografisk indlæring. I den første deltog engelsktalende børn fra 4. klasse. Deltagerne skulle indlære 10 nonord, hvoraf fem blev præsenteret med semantisk information. Alle ord blev præsenteret enkeltvis, men halvdelen blev efterfulgt af en kort, mundtlig definition samt en illustration. Efterfølgende sås en positiv effekt af semantisk information på ortografisk indlæring målt med en *orthographic choice test*, men ingen effekt på elevernes stavning af målordene. Forfatterne begrunder dette resultat med lofteffekt på stavemålet (Ouellette & Fraser, 2009). På den baggrund blev samme fremgangsmåde og ordmateriale afprøvet på elever i 2. klasse. Hos denne yngre gruppe så man, at nonord præsenteret med semantisk information oftere blev stavet korrekt end ord, der udelukkende blev præsenteret ortografisk (Ouellette, 2010).

Eksisterende ortografisk viden

Flere undersøgelser har fundet, at eksisterende ortografisk viden har betydning for ortografisk indlæring under selvstændig læsning. En undersøgelse med elever i 2. klasse viste, at et mål for ordspecifik ortografisk viden målt med en *orthographic choice test* kunne forklare variation i ortografisk indlæring af nonord præsenteret i korte tekster efter kontrol for antal korrekt afkodede målord (Cunningham et al., 2002). Et tilsvarende resultat blev fundet i en undersøgelse med deltagelse af elever i 1. klasse. Her forklarede et kompositmål bestående af to test af ordspecifik ortografisk viden og en test af grafotaktisk viden indlæring af rigtige ord indlejret i korte historier (kendt i tale men ikke på skrift) efter kontrol for generel afkodningsfærdighed (Cunningham, 2006). Wang et al. (2013) gennemførte et studie med engelsktalende elever fra 2. og 3. klasse. I en *orthographic learning task* blev deltagerne præsenteret for nonord, der enten blev tilskrevet en regelmæssig eller uregelmæssig stavemåde. Eksisterende ortografisk viden blev målt som deltagernes præcision i afkodning af uregelmæssige ord. Resultaterne viste, at målet for ortografisk viden bidrog unikt til målet for ortografisk indlæring efter kontrol for fonologisk afkodning, uanset om målordene var regelmæssigt eller uregelmæssigt stavede. Da der i undersøgelserne er tale om samtidige korrelationer mellem mål for ortografisk viden og ortografisk indlæring under selvstændig læsning, kan resultaterne ikke svare på, hvorvidt forskelle i ortografisk viden er årsagsrelateret til graden og kvaliteten af ortografisk indlæring. Resultaterne kalder derfor på træningsundersøgelser, der kan afdække årsagsrelationen nærmere, hvilket bl.a. var motivationen for at gennemføre træningsundersøgelsen i studie 3.

Stavning som redskab til ortografisk indlæring

Flere forskere har peget på stavning som redskab til ortografisk indlæring og fremsat den hypotese, at stavning vil føre til etablering af stærkere ortografiske repræsentationer end læsning. Shahar-Yames og Share (2008) afprøvede denne hypotese med hebraisktalende elever

i 3. klasse. Deltagerne skulle indlære en række nonord gennem såvel læsning som stavning. Under stavebetingelsen læste deltageren målordet i to sætninger og skulle derefter stave ordet ud fra hukommelsen. Under læsebetingelsen indgik ordene i de samme sætninger som under stavning, men hver sætning blev læst to gange. Der sås efterfølgende en signifikant stærkere, positiv effekt af stavebetingelsen sammenlignet med læsebetingelsen på stavning af målordene, mens der ikke sås forskel af betingelserne på deltagernes præstation på en *orthographic choice test*. Resultatet understøttes af to studier med engelsktalende børn fra 2. klasse. I et studie af Conrad (2008) fandt man, at både gentagen læsning og gentagen stavning af ord gav anledning til positiv effekt på indlæring af trænede ord, men også overføringseffekt til nyt ordmateriale. Gentagen stavning syntes dog at etablere mere præcise repræsentationer, idet overføringseffekten fra stavning til læsning af ord var signifikant større end overføringseffekten fra læsning til stavning af ord. I et studie af Oullette (2010) fandt man ligeledes, at såvel gentagen stavning som gentagen læsning af ord var en effektiv metode til indlæring af målordenes stavemåde målt som præcision i stavning. Men også her var effekten størst for gentagen stavning.

Dansk ortografi

De tre studier i afhandlingen har særlig fokus på ortografisk viden og ortografisk indlæring i en dansk kontekst. Det er derfor relevant med en kort beskrivelse af de væsentligste karakteristika ved dansk ortografi.

Dansk ortografi er uregelmæssig med mange komplekse grafemer og mange inkonsistente forbindelser mellem grafemer og fonemer i såvel læse- som staveretningen (Elbro, 2006; Juul & Sigurðsson, 2005). Dette adskiller dansk ortografi fra ortografierne i de øvrige nordiske lande (fx norsk og islandsk) og gør dansk mere sammenlignelig med engelsk. Et studie af den tidlige læseudvikling i 13 europæiske ortografier inklusiv dansk og engelsk indikerede, at danske og engelske elever er langt efter elever fra de øvrige lande ved slutningen af første skoleår (Seymour, Aro, & Erskine, 2003). Kompleksiteterne i engelsk og dansk ortografi er formodentlig en af årsagerne til dette mønster (Elbro, 2006). Juul (2008) har fundet konsistensmål (på en skala fra 0 til 1) på ,378/,672 for danske vokaler og ,713/,750 for konsonanter i henholdsvis læse- og staveretningen. Disse værdier illustrerer, at den korrekte udtale af et grafem og den korrekte stavemåde af et fonem generelt er ganske svære at forudsige. De tilsvarende værdier for konsistensen af vokaler på engelsk er henholdsvis, 717 i læseretningen og, 529 i staveretningen (Treiman & Kessler, 2001).

Årsagerne til kompleksiteterne i bl.a. den danske og den engelsk ortografi er flere. For det første er skriftsproget mere konservativt end det talte sprog. Det betyder, at ændringer af ords stavemåde typisk er langt bagefter ændringer af ords udtale. Samtidig har begge ortografier optaget mange udenlandske låneord og har dermed importeret mange ortografiske kompleksiteter. Endelig repræsenterer begge ortografier i nogen grad morfologisk information i ords stavemåde. Et eksempel på en morfologisk betinget stavemåde på engelsk er (*heal* → *health*) og på dansk (*vide* → *vidst*). Uregelmæssige ortografier adskiller sig fra mere

regelmæssige ortografier ved at afspejle morfologisk information, selv når det er i konflikt med simple grafem-fonem-forbindelser (Elbro, 2006; Treiman & Kessler, 2014).

Hovedspørgsmål og hypoteser i afhandlingens studier

I den resterende del af afhandlingen præsenteres og diskuteres de tre forskningsstudier, der blev gennemført som led i afhandlingen. Denne del indledes med en kort præsentation af de hovedspørgsmål og hypoteser, studierne belyser.

Et fundamentalt spørgsmål i studiet af ortografisk processering er, hvorvidt tilegnelse af ortografisk viden i senere faser af børns skriftsproglige udvikling blot er en forlængelse af tilegnelse af fonologisk viden i tidligere faser af deres skriftsproglige udvikling. Dvs. i hvilken grad tilegnelse af fonologisk og ortografisk viden bygger på det samme kognitive fundament. Dette spørgsmål blev belyst i studie 1 med fokus på prædiktion af stavefærdighed i en tidlig og en senere fase i staveudviklingen hos danske elever. Det første forskningsspørgsmål, studiet belyser, er, hvorvidt fund fra andre ortografier kan repliceres med danske elever, når det gælder langtidsprædiktion af tidlig (fonologisk) staveudvikling. Mere specifikt undersøges det, hvorvidt mål for fonemopmærksomhed, bogstavkendskab, hurtig seriel benævnelse (*rapid automatized naming*, RAN) og indlæring af associationspar med ord og nonord (*paired associate learning*, PAL) indsamlet i slutningen af 0. klasse kan forklare selvstændig variation i stavefærdighed i begyndelsen af 2. klasse. Det andet forskningsspørgsmål, studiet belyser, er, hvorvidt mål for PAL med ord og nonord kan bidrage selvstændigt til at prædicere stavefærdigheder i 2. og 5. klasse. Det centrale forskningsspørgsmål, studiet belyser, er, hvorvidt prædiktorerne fra slutningen af 0. klasse kan forklare variation i en senere ortografisk fase i staveudviklingen (fra 2. til 5. klasse). Baseret på fund fra andre ortografier er det forventningen, at fonemopmærksomhed og bogstavkendskab vil være de stærkeste prædiktorer af stavefærdighed i den tidlige fase i udviklingen, mens det er et åbent spørgsmål, hvorvidt PAL kan bidrage unikt til prædiktionen. Når det gælder prædiktionen af senere stavefærdigheder er det forventningen, at samtlige prædiktorer vil falde i styrke pga. af det længere tidsspænd. Desuden er hypotesen, at denne tendens vil være mindre for tidlige sproglige mål associeret med tilegnelse af ortografisk viden sammenlignet med tidlige sproglige mål associeret med tilegnelse af fonologisk viden. Det er ligeledes en hypotese, at hvis et eller flere af de tidlige sproglige mål er specifikt relateret til tilegnelse af ortografisk viden, vil det eller de mål prædicere unik variation i stavefærdighed i 5. klasse efter kontrol for stavefærdighed i 2. klasse.

Et af hovedformålene med afhandlingen er at undersøge betydningen af viden om betingede stavemønstre for den fortsatte læse- og staveudvikling blandt danske børn. Her og nu-undersøgelsen i studie 2 fokuser på betydningen af viden om betingede stavemønstre for stavefærdighed blandt elever i 5. klasse, mens træningsundersøgelsen i studie 3 fokuserer på

betydningen af viden om betingede stavemønstre for indlæring af nye ords stavemåde under selvstændig læsning blandt elever i 3. klasse.

Det centrale forskningsspørgsmål i studie 2 er, hvorvidt et nyudviklet mål for kendskab til betingede stavemønstre kan forklare unik variation i samtidig stavefærdighed ud over mål for fonologisk afkodning, grafotaktisk viden og ordspecifik ortografisk viden. Forventningen er, at såvel fonologisk afkodning som ordspecifik ortografisk viden vil være stærkt korreleret med stavefærdighed, da fonologisk afkodning antages at være kritisk for tilegnelsen af ortografiske repræsentationer, og da fuldt specificerede ortografiske repræsentationer, som målet for ordspecifik ortografisk viden netop er følsomt for, antages at være en forudsætning for automatiseret stavefærdighed. Yderligere er hypotesen, at både målet for grafotaktisk viden og målet for fonologisk betingede stavemønstre vil være unikke prædiktorer af stavefærdighed efter kontrol for fonologisk afkodning og ordspecifik ortografisk viden. Hypotesen bygger på en antagelse om, at deltagerne vil trække på deres subleksikale ortografiske viden i de tilfælde, hvor de ikke har adgang til fuldt specificerede ortografiske repræsentationer af de ord, de bliver præsenteret for i stavetesten.

Det centrale forskningsspørgsmål i studie 3 er, hvorvidt direkte undervisning i betingede stavemønstre vil resultere i overføringseffekt til ortografisk indlæring af nye ord indeholdende trænede stavemønstre under selvstændig læsning. Hypotesen er, at elever, der modtager direkte undervisning, vil danne forbindelser mellem udtale og stavemåde af de trænede stavemønstre og lagre dem i hukommelsen som ortografiske repræsentationer. Kendskab til de trænede stavemønstre vil fremme dannelsen af forbindelser mellem udtalen og stavemåden af målordene under selvstændig læsning, hvorved ortografiske repræsentationer af højere leksikal kvalitet bliver etableret sammenlignet med elever, der ikke har modtaget eksperimentel undervisning. En yderligere hypotese er, at den største gruppeforskel vil optræde, når eleverne skal stave målordene. Hypotesen er baseret på en antagelse om, at den korrekte gengivelse af komplekse stavemåder kræver ortografiske repræsentationer af høj leksikal kvalitet.

Studie 1

Predictors of early versus later spelling development in Danish

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Abstract

The present study examined phoneme awareness, phonological short term memory, letter knowledge, rapid automatized naming (RAN), and visual-verbal paired associate learning (PAL) as longitudinal predictors of spelling skills in an early phase (Grade 2) and a later phase (Grade 5) of development in a sample of 140 children learning to spell in the opaque Danish orthography. Important features of the study were the inclusion of PAL measures and the fact that the children were followed up to Grade 5. Findings from other orthographies were replicated, in that phonological processing (awareness and memory) and RAN accounted for unique variance in early spelling skills. For later spelling skills, Grade 2 spelling was by far the most powerful predictor. PAL-nonwords was the only measure to explain additional unique variance. It is suggested that PAL-nonwords taps the ability to establish representations of new phonological forms and that this ability is important for the acquisition of orthographic spelling knowledge.

Keywords
Spelling development, Danish, Longitudinal prediction, Paired associate learning (PAL), Orthographic knowledge

Introduction

The ability to spell words correctly is an important part of successful written communication. Allocating a great amount of mental resources to the spelling of single words means that fewer resources will be available for higher-level aspects of writing (Treiman & Kessler, 2013). Indeed, poor spellers have been found to write fewer words and produce lower quality compositions than good spellers (Abbott, Berninger, & Fayol, 2010; Moats, Foorman, & Taylor, 2006). Hence, it seems important to explore what it takes to become a proficient speller. A common way do this is to search for longitudinal predictors of spelling ability in order to find out what distinguishes students who go on to become proficient spellers from those who do not. The present study investigated whether findings from this line of research could be replicated for the opaque Danish orthography. It also sought to extend previous findings by including predictors that have received little attention in the past, and by examining the power of predictors beyond the early phases of spelling development.

A widespread account of spelling development is that the focus of early development (typically in Grades 1 and 2) is the acquisition of phonological spelling knowledge, while the focus of later spelling development (typically beyond Grade 2) is the acquisition of orthographic and morphological spelling knowledge. This developmental pattern is the backbone of several models of stages or phases in the acquisition of spelling skills (e.g., Ehri, 1989, 2014; Frith, 1985; Gentry, 1982). For instance, Linnea Ehri's (1989, 2014) theory of early literacy development distinguishes four overlapping developmental phases (*prealphabetic*, *partial alphabetic*, *full alphabetic* and *consolidated alphabetic*), each characterized by the predominant type of connections linking spellings of words to their pronunciations in memory. According to this theory, children in the early phases of spelling development (from prealphabetic to full alphabetic) learn how to represent the sound structure of words in a plausible but not necessarily conventional way (i.e., they acquire phonological spelling knowledge), while children in the later phases (from full to consolidated alphabetic) exhibit a growing memory for correct spellings, relying more and more on their knowledge of recurring orthographic patterns in the form of rime spellings, spellings of syllables and spellings of individual words and morphemes (i.e., they acquire orthographic spelling knowledge).

Stage theories have been criticized however, for oversimplifying the developmental patterns somewhat (e.g., Bourassa & Treiman, 2014; Bourassa & Treiman, 2001; Walker & Hauerwas, 2006). It is argued that, although there is support for the general idea of a developmental shift from reliance on phonological knowledge to reliance on morphological and orthographic knowledge, even beginning spellers draw to some degree on orthographic and morphological knowledge when spelling words. Moreover, it is pointed out that within each domain (phonological vs. orthographic and morphological knowledge) children progress from simple to increasingly complex spelling patterns. Thus, apparently no sharp distinction between early and later spelling development can be made.

One may also wonder whether a sharp distinction can be made between phonological and orthographic spelling knowledge. Learning to use specific letters or letter sequences for

specific words (word-specific orthographic knowledge) may be something completely different from learning to spell words phoneme by phoneme (phonological spelling knowledge). But, on the other hand, orthographic spelling rules may be of essentially the same kind as the more general phoneme-grapheme correspondences on which phonological spelling is based, only with a more restricted scope (e.g., applicable only to a specific set of words). In other words, orthographic spelling may be a mere extension of phonological spelling, building on the same cognitive foundations.

There is, however, some evidence indicating that phonological and orthographic spelling knowledge can be viewed as at least partially distinct constructs. For instance, Hagiliassis, Pratt, and Johnston (2006) administered a battery of phonological and orthographic knowledge tasks to children in Grades 3, 4, and 5. Factor analyses showed that the orthographic tasks loaded onto one factor, while the phonological tasks loaded onto a second factor. Cunningham, Perry, and Stanovich (2001) found similar results with a sample of children in Grade 1. Moreover, a few studies have shown that measures of orthographic knowledge contribute unique variance to word spelling skills above and beyond phonological knowledge (Arab-Moghaddam & Sénéchal, 2001; Conrad, Harris, & Williams, 2013; Rothe, Schulte-Körne, & Ise 2014). For instance, Conrad et al. (2013) investigated the concurrent prediction of spelling among 7-9 year old English-speaking children. A composite measure of orthographic knowledge (graphotactic knowledge and word-specific orthographic knowledge) explained a significant amount of unique variance in children's word spelling skills (29%) after controlling for age and phonological skills.

If the acquisition of orthographic spelling knowledge is based on skills different from those necessary for phonological spelling, then one would expect the power of longitudinal predictors to change over time as students become more proficient spellers and rely relatively more on orthographic knowledge. Presumably, such shifts in predictive patterns will be most easily observable in opaque orthographies, such as English or Danish, where multiple instances of inconsistent mappings between sounds and letters make the acquisition of orthographic spelling knowledge more important than in transparent orthographies, and where rates of development are likely to be slowed down (Caravolas, 2004). However, few longitudinal studies have examined predictors of spelling skills beyond Grade 2, and it is generally not very clear whether predictors of early spelling development play a similar role for later spelling development after accounting for the powerful autoregressive effects of early spelling skills. A major purpose of the present study is to contribute to the filling of this gap by examining the predictive power of preschool predictors (taken at the end of Danish kindergarten) for early vs. later spelling development (Grade 2 vs. Grade 5).

In the following section we review the theoretical basis and the empirical evidence for a range of predictors of spelling skills which have been examined in previous longitudinal studies: phonological awareness, letter knowledge, verbal/phonological short term memory, rapid automatized naming, and paired associate learning. All of these were also included in the present study.

Predictors of spelling development

Phonological awareness (PA) and **letter knowledge (LK)** are generally held to be essential for understanding the alphabetic principle, i.e., for learning how phonemes and graphemes can be connected (cf. Juul, Poulsen, & Elbro, 2014). For spelling development, this is supported by several longitudinal studies that have found both PA and LK to be strong predictors of spelling skills in the early grades across orthographies (e.g., Caravolas, Hulme, & Snowling, 2001; Caravolas, Lervåg, Mousikou, Efrim, Litavský, Onochi-Quintanilla et al., 2012 [English]; Leppänen, Niemi, Aunola, & Nurmi, 2006 [Finnish]; Lervåg & Hulme, 2010 [Norwegian]; Furnes & Samuelsson, 2009 [English and Norwegian/Swedish]). Hence, PA and LK seem indispensable as predictors in longitudinal studies of early spelling development in any alphabetic orthography. In a study conducted in the relatively transparent German orthography, Landerl and Wimmer (2008) found that PA measured at the beginning of Grade 1 predicted later spelling skills in Grades 4 and 8, after controlling for nonverbal IQ, LK, and RAN-objects in Grade 1. Hence, it was of particular interest to observe whether PA would emerge as a long-term predictor of spelling in the current study of the more opaque Danish orthography.

Especially for learning to spell phonologically, one might expect measures of **verbal/phonological short term memory (VSTM/PSTM)** to play a significant role, because, in the absence of fully specified orthographic representations of word spellings, children have to remember and analyze the sound structure of words and syllables. Lervåg and Hulme (2010) found that VSTM measured with four different memory-span tests (colors, objects, digits, letters) 10 months before start of formal reading instruction (mean age 6;4 years) uniquely accounted for Norwegian children's spelling skills 14 months later, after controlling for PA, LK and RAN. However, Caravolas and Snowling (2001) did not find VSTM (repeating lists of familiar monosyllabic words) measured four months after school entry (mean age 5;1 years) to be predictive of spelling skills 6 and 12 months later among English speaking children when controlling for PA and LK. Several factors such as task requirements, ages of school entry and assessments, and type of orthographies might lie behind these mixed results. In the present study it was of particular interest to observe, whether PSTM would turn out as a significant predictor in Grade 2 where children were expected to rely mainly on phonological spelling knowledge, and whether PSTM would lose power in Grade 5 where children were expected to rely more on orthographic spelling.

Rapid automatized naming (RAN), referring to the speed with which children can name objects, colors, digits, or letters has been included in several longitudinal studies of spelling skills across orthographies. In the following studies RAN was measured *before* the beginning of formal reading and spelling instruction. Caravolas et al. (2012) found that non-alphanumeric RAN (a composite score of RAN-objects and RAN-colors) was a significant predictor of spelling 10 months later across four languages varying in orthographic transparency (English, Spanish, Slovak, and Czech), after controlling for initial spelling ability, PA, LK and VSTM. Mean ages in

the four groups ranged from 5;0 - 6;0 years when RAN was assessed. Georgiou et al. (2012) found that beyond the effects of LK, non-alphanumeric RAN (colors) predicted unique variance in spelling in Grade 2 among English and Greek children but not among children learning to spell in the highly transparent Finnish orthography. Mean ages in the three groups was around 5;6 years when RAN was assessed. Lervåg and Hulme (2010) found that non-alphanumeric RAN (a composite score of RAN-objects and RAN-colors) was a unique predictor of spelling 14 months later in Norwegian children above PA, LK and VSTM. The mean age was 6;4 years when RAN was assessed. Furnes and Samuelsson (2011) found that a latent construct of alphanumeric RAN (RAN-letters and RAN-digits) was a significant predictor of spelling in Grade 1 across languages (Norwegian/Swedish and English) after controlling for the autoregressive effect of Kindergarten literacy skills, vocabulary and PA. Mean ages in the two groups ranged from 6;2 – 6;9 years when RAN was assessed. Thus, across studies and across orthographies varying in orthographic depths RAN has proven to be a significant predictor of the development of spelling skills in the very early phases of literacy development.

According to some researchers, RAN taps into the ability to form orthographic representations (e.g., Conrad & Levy, 2007; Manis, Seidenberg, & Doi, 1999; Wolf & Bowers, 1999). When letter identification is slow (as reflected by poor RAN performance), orthographic representations of words or word parts cannot be stored efficiently. If these ideas are correct, one would expect RAN to be a better predictor of spelling in opaque (vs. transparent) orthographies, contrary to the findings of some of the studies summarized above. Another challenge comes from studies showing that RAN accounts for similar amounts of variance in word and nonword reading fluency although, presumably, the formation of orthographic representations is more important to word reading than to nonword reading. In a study by Moll, Fussenegger, Willburger, and Landerl (2009), RAN (digits and objects) only accounted for a modest amount of variance in word reading fluency (between 0.5 and 1.7%) among German speaking children in Grades 3 and 4 after differences in nonword reading fluency were controlled. A similar result was found by de Jong (2011) with a sample of Dutch speaking children in Grades 1, 2 and 4. RAN (digits and letters) accounted for similar amounts of variance in standard tests of word and nonword reading fluency. A further challenge comes from studies showing that RAN is more closely related to reading than to spelling, although the formation of orthographic representations is likely as important for spelling as for reading. In a sample of Dutch speaking children from Grades 1 to 6, Vaessen and Blomert (2013) found that RAN (digit and letters) did not contribute to concurrent spelling performance in any of the grades. This contrasted to the strong contribution of RAN to performance in reading fluency. Finally, Moll et al. (2009) found that PA explained more variance in spelling than RAN, even though most spelling errors in German reflect a lack of orthographic rather than phonological knowledge.

As an alternative account of the relation between RAN and literacy, Moll et al. (2009) suggest that it has to do with the automaticity of orthography to phonology associations at the letter and letter cluster level. This account seems more compatible with the studies summarized above, but it is not quite clear whether one should expect RAN to be a predictor of

spelling development beyond the early phases where basic association between sounds and letters are being formed. Thus, it was of special interest to observe whether RAN would emerge as a strong long-term predictor in the present study.

Since learning to spell is about learning associations between written and spoken language elements, one might expect measures of **paired associate learning (PAL)** to be predictive of spelling development. PAL involves establishing associations between stimulus items and response items in memory. These can be unimodal (e.g., visual–visual, verbal–verbal) or crossmodal (e.g., visual–verbal) in nature. Importantly, performance on a PAL task depends on successful learning of three separate components: the stimulus item, the response item, and the association between the two. Individual differences in performance may originate from processes operating at any of these three levels (Litt, de Jong, van Bergen, & Nation, 2013).

For reading ability, visual-verbal PAL with nonwords has been shown to be a unique concurrent predictor among English speaking children (e.g., Hulme, Goetz, Gooch, Adams, & Snowling, 2007; Warmington & Hulme, 2012). Moreover, Vellutino, Scanlon, Sipay, Small, Pratt, and colleagues (1996) showed that early variations in PAL ability (matching ideographs with common words) during kindergarten were predictive of variations in later reading skills among English speaking children in Grades 1 and 2. However, a limitation to this study was that phoneme awareness was not controlled for (Hulme et al., 2007). To our knowledge, only one longitudinal study of spelling development has included a measure of visual-verbal PAL, namely Lervåg and Hulme's (2010) study of Norwegian children. Participants in this study had to associate three nonword names with pictures of either unfamiliar children, fantasy animals, or letters. These nonword PAL tasks did *not* predict later word spelling when LK, PA, VSTM, and RAN were controlled for. Norwegian is closely related to Danish (the two languages are mutually intelligible), but, unlike Danish, Norwegian is a relatively transparent orthography (Hagtvet, Helland, & Lyster, 2006). Hence, it was of special interest to observe whether the weak predictive pattern found by Lervåg and Hulme (2010) would be replicated in the current study of the more opaque Danish orthography.

One theoretical account of the PAL–reading relationship is that visual–verbal PAL taps a *crossmodal associative learning mechanism* involved in establishing orthography–phonology mappings (Hulme et al., 2007; Warmington & Hulme, 2012). The orthographic units involved in this mapping process may involve either lexical units (arrays of letters that identify words) or sublexical units (letters or letter clusters). In this view, visual-verbal PAL taps the efficiency with which novel associations can be created in memory between visual stimuli and their names (the verbal response). According to many theorists, reading and spelling are closely linked during development and rely on the same store of knowledge (Ehri, 2000; Perfetti, 1997), and studies of the interplay between reading and spelling indicate that orthographic representations of words acquired during exposure to print are used for both reading and spelling (Moll & Landerl, 2009). Hence, if PAL is tapping variations in establishing orthography–phonology mappings at both the lexical and sublexical level, one would expect

PAL to be predictive of both spelling and reading skills from the earliest stages of literacy development.

Another theoretical account termed *the verbal account* by Robin Litt and colleagues (2013) is based on studies of children with dyslexia. Findings from these studies suggest that deficits in visual–verbal PAL are explained by the verbal nature of the task rather than by its crossmodal demands (e.g., Mayringer & Wimmer, 2000; Messbauer & de Jong, 2003). More specifically, researchers have proposed that *verbal learning* is the crucial component of visual–verbal PAL because the strongest deficits are observed when response stimuli are nonwords, i.e., phonological forms that have not been learned prior to the test (Elbro & Jensen, 2005; Mayringer & Wimmer, 2000). This has recently been supported by the study by Litt and colleagues (2013) who found that only PAL tasks requiring verbal output correlated significantly with reading. It has been suggested that difficulties in learning new phonological forms, tapped by visual-verbal PAL with nonwords, may affect both reading and spelling acquisition via impaired storage of new phonological forms. These phonological forms are thought to serve as underpinnings of the letter patterns of words or parts of words (Mayringer & Wimmer, 2000). Hence, orthographic learning may be negatively affected by under-specified phonological representations, and this may be a particular problem in opaque orthographies, where writers often need to establish word-specific associations between (strings of) phonemes and their conventional spellings (Shahar-Yames & Share, 2008). The present study addressed whether visual-verbal PAL with nonwords would turn out as a long-term predictor of spelling among Danish children who are faced with multiple instances of inconsistent mappings between sounds and letters.

Spelling in Danish

As previously mentioned, Danish has an opaque orthography with many inconsistent mappings between phonemes and graphemes and with many complex graphemes (Elbro, 2006; Juul & Sigurðsson, 2005). This sets it apart from the orthographies of the other Nordic languages (e.g., Norwegian and Finnish) and makes it similar to English (Seymour, Aro, & Erskine, 2003). Computing phoneme-grapheme consistencies along the same lines as Kessler and Treiman (2001), Juul (2008) reported consistencies (on a scale from 0 to 1) of .672 for Danish vowels and .750 for consonants. These coefficients indicate that the correct spelling of a Danish phoneme is generally quite hard to predict. For English, Kessler and Treiman (2001) found an even lower vowel consistency of .529; they did not report consistencies for individual consonant phonemes.

Two longitudinal studies have found Kindergarten PA and/or LK to be predictive of spelling in Danish beginners (Frost, 2001; Juul, 2007). However, both studies terminated in Grade 2 when variance in spelling mainly reflected phonological rather than orthographic spelling skills. Measures of spelling were also included in two Danish intervention studies (Elbro & Petersen 2004; Lundberg, Frost, & Petersen, 1988), but, unfortunately, these did not report correlations between Kindergarten measures and later spelling skills. Thus, although

Danish is of theoretical interest as an orthography akin to English, relatively little is known about predictors of spelling skills in Danish students.

The present study

In the present study we asked whether the findings from other orthographies with respect to longitudinal predictors of early spelling development could be replicated for Danish. Specifically, we asked, whether PA, LK, RAN, and PSTM measured in Grade 0 (= Kindergarten) would predict spelling skills at the beginning of Grade 2. Furthermore, we asked two questions, which few previous studies have addressed, namely whether the predictors would also predict later phases of spelling development (from Grade 2 to Grade 5), and whether the addition of Kindergarten measures of PAL (both words and nonwords) would enable us to predict additional variance in spelling skills.

With respect to early spelling development (Grade 2 spelling), findings from other orthographies suggested that PA and LK would be the most salient predictors. For PAL (included mainly on the basis of studies of *reading* development), we expected that both PAL-words and PAL-nonwords would be positively correlated with early spelling skills. However, whether PAL would be a unique predictor of spelling above and beyond PA, LK, RAN, and PSTM was an open question.

With respect to later spelling development (Grade 5 spelling) we expected that, given the greater time span, all predictors would tend to lose power. However, we suspected that this tendency would be less strong for measures associated with the acquisition of orthographic spelling knowledge than for measures associated with phonological spelling knowledge. If measures were predictive *specifically* of the acquisition of orthographic spelling knowledge, we expected that they would remain significant even with controls for Grade 2 spelling levels.

Method

Participants and design

The present study was part of a longitudinal study conducted in Copenhagen, Denmark (cf. Elbro, de Jong, Houter, & Nielsen, 2012). The main focus of the study was the development of word reading accuracy and speed in Grades 1 and 2, but measures of spelling (the focus of this report) were included at the beginning of Grade 2 and in a follow-up at the beginning of Grade 5. Predictor measures were taken at the end of Grade 0 (the Kindergarten grade). Results from the study have previously been reported in three articles (Elbro, de Jong, Houter & Nielsen, 2012; Poulsen, Juul, & Elbro, 2012; Juul, Poulsen & Elbro, 2014), none of which shared the present focus on development of spelling skills.

In this article we report results from 140 students who participated at all three assessment points (Grade 0, Grade 2 and Grade 5). The students came from eight classes from four schools in Copenhagen. Nine students (6%) were bilingual, but all but one listed Danish as their preferred language. Sixty-seven (48%) were girls. Mean ages were 6;10 years (*SD* = 4 months) at the end of kindergarten; 8;3 years at the beginning of Grade 2; and 11;3 years at the beginning of Grade 5.

The original sample was somewhat larger (187 students in Grade 0, and 174 in Grade 2), but not all participants could be re-tested in Grade 5, either because of moving, absence on the day of testing, or because no signed consent from the parents was handed in. On the spelling test administered at the beginning of Grade 2, no significant difference was found between the 140 students who remained in the study, and the 34 students who only participated in Grade 2.

Spelling skills were not assessed in Grade 0, but results on a test of word reading accuracy indicated that initial literacy skills were quite limited; on a list of 32 items, 73% of the 140 participants were unable to name more than two words correctly, at most. This came as no surprise, as Danish students do not receive formal reading instruction in Grade 0. However, games and activities designed to stimulate phonological awareness and letter knowledge are common at this grade level.

Scores on the spelling tests in Grades 2 and 5 were found to be close to the reported norms for the tests (Juul, 2012). Thus, the sample appears to be typical for Danish students, at least with respect to spelling levels.

Procedure

All testing was done by trained assistants and took place in a quiet room at the participants' school or, for the group-administered tests, in the participants' own classrooms.

Measures

Preschool-measures

Phoneme deletion In this test (adapted from Elbro, Borstrøm, & Petersen, 1998), the participants were presented with a word spoken by the examiner and asked to say what was left when a given phoneme was deleted, for example, What is left if you remove [m] from *mand* ('man')? Expected answer: *and* ('duck'). The phonemes to be deleted were initial (9 words), medial (5 words), or final (4 words). Up to six practice trials were given to each participant. Testing was stopped if the participant made four incorrect responses in a row. The score was the number correct. Cronbach's alpha was .91 in the full sample.

Phoneme matching In this group-administered test (from Borstrøm & Petersen, 2006) participants were asked to select one of four pictures that had the same initial phoneme as a target picture. The test has two parts with 10 items each; one part with vowels and one part

with consonants as target phonemes. Two practice items were given for each part of the test. The score was the number correct. Cronbach's alpha was .80 in the full sample.

Phonological short term memory In this test participants were asked to repeat 19 nonsense words consisting of one to five syllables (e.g., *skug, ki-bra-di-ka-se*). The score was the number correct. Cronbach's alpha was .72 in the full sample.

Letter naming In this test (from Elbro et al., 1998), the participants were asked to name each of the 29 uppercase letters in the Danish alphabet presented in a random order on a sheet of paper. The score was the number correct. Cronbach's alpha was .92 in the full sample.

Rapid automatized naming with digits and objects Previous studies have used a range of different RAN tasks (cf. the introduction). In the present study both an alphanumeric task (digits) and a non-alphanumeric (objects) were used. Digits were preferred over letters for the alphanumeric task, both because it was unclear whether all Grade 0 students would have sufficient letter knowledge, and also to avoid letter knowledge as a confound when interpreting correlations between RAN and literacy skills. In the digit section of the test, the participants named five rows of 10 digits (digits 1–5) presented in a fixed random order. In the objects section, the participants named four rows of eight objects (*sol* 'sun'; *saks* 'scissors'; *hjerte* 'heart'; and *blomst* 'flower'). The score was the number of correctly named items per second. The correlation between RAN-digits and RAN-objects in the present sample was .67.

Paired associate learning with nonwords The participants had to learn non-familiar names of three non-familiar cartoon animals (*sput*, *laf* and *ky*). Initially, two of the animals were introduced along with a small story. Their names were repeated numerous times. The participants repeated the names and answered simple questions about the story. The purpose of these questions was to get the participants to repeat the names. The participants were then presented with the two animals in varying orders in separate trials, until the animals were named correctly on three successive trials If the participants made mistakes they were corrected and asked to repeat the names. When the criterion was reached, a new animal was presented in the same way as the first two. Naming trials with three animals then continued until they were named correctly three times in a row. The task was terminated if the criterion was not reached within 15 trials. If testing terminated because the criterion was reached, the remaining trials were scored as correct. The score for the task was the number of correctly named animals in the 15 trials. The task was modeled after Elbro and Jensen, 2005, but differed in some parts; in the task used in the present study, the participants had several opportunities to repeat the names before the first trial, whereas in the study by Elbro and Jensen, participants only repeated each name once before the first trial. Moreover, in the study by Elbro and Jensen, human faces were used rather than animals, and participants were introduced to all names in the first trial. Additionally, compared to the tasks used in the study by Lervåg and Hulme

(2010), the task included more separate trials (15 versus 10); also, the nonwords to be learned in the Lervåg and Hulme study were generally more complex, e.g., CCVCV.

Paired associate learning with words The participants had to learn four real names (*Nina, Lone, Jeppe* and *Lasse*). These names are all frequent in Danish; however it is unlikely that their spellings were known to the participants who had very limited literacy skills (cf. the participants section above). The procedure was similar to the nonword task except that three cartoon animals were introduced to start with and this time without a story. The task was terminated if the criterion was not reached within 15 trials. If testing terminated because the criterion was reached, the remaining trials were scored as correct. The score for the task was the number of correctly named animals in the 15 trials. The task was modeled after Elbro and Jensen (2005), but differed it some respects, as described above. The correlation between the two PAL-tasks in the present sample was .38 (cf. the comments on Table 1).

Table 1 Descriptive statistics for predictor measures (Grade 0)

Measures	*Min*	*Max*	*M*	*SD*	*Skewness*
PD (max = 18)	0	17	6.2	5.0	0.5
PM (max = 20)	9	20	17.0	2.9	-1.0
LK (max = 29)	5	29	24.8	5.1	-1.7
PSTM (max = 19)	4	19	12.2	3.2	-0.3
RAN-digits (correct per sec.)	0.4	1.9	1.0	0.2	0.0
RAN-objects (correct per sec.)	0.5	1.3	0.9	0.2	0.6
PAL-words (max = 56)	17	56	45.9	9.7	-1.2
PAL-nonwords (max = 42)	10	42	32.2	7.0	-0.9

PD phoneme deletion, *PM* phoneme matching, *LK* letter knowledge, PSTM phonological short term memory, *RAN-digits/objects* rapid automatized naming with digits/objects, *PAL-words/PAL-nonwords* paired associate learning with words/nonwords

Spelling (Grade 2 and Grade 5)

Spelling skills were assessed with age-appropriate standardized group-administered tests of word spelling. *Staveprøve 2* ('Spelling Test 2', recommended for students from Grade 2 to 4; Juul, 2012) was used in Grade 2, and *Staveprøve 3* ('Spelling Test 3', recommended for students from Grade 4 to 6; Juul, 2012) was used in Grade 5. Strong correlations between the two tests have been found for fourth-graders who took both tests either in September (r = .84; N = 298) or February (r = .83; N = 528; standardization sample data owned by the publishers). Responses were scored both for correctness and for phonological plausibility.

Staveprøve 2 has 17 items which target phonological spelling skills (e.g., several items feature two-consonant onsets, and some sounds have to be written with a complex grapheme in order to be phonologically plausible, such as [ŋ] = *ng*). For correct spelling some

orthographic knowledge is required, too (e.g., knowledge that the onset [sb] is spelled *sp* rather than *sb*; that certain vowels spellings depend on the length of the vowel; and that certain consonants are doubled after short vowels). Cronbach's alpha in the standardization sample was .91 (Juul, 2012).

Staveprøve 3 has 36 items which target orthographic spelling skills (e.g., many items feature vowel spellings that are not predictable from phonology, silent letters, or suffixes that need to be identified as such in order to be spelled correctly such as the notoriously difficult present tense marker *-er*; Juul & Elbro, 2004). Cronbach's alpha in the standardization sample was .94 (Juul, 2012).

Results

Predictor measures

Descriptive statistics for the predictor measures are given in Table 1. The results indicate that phoneme deletion was a challenging task for the participants, while phoneme matching was fairly easy. In the subsequent analyses, these two measures are combined (mean z-scores) into a single measure of phonological awareness (PA). The correlation between the two was only moderate (r = .36), but, presumably, this was due to the different distributions (a floor tendency in the deletion task and a ceiling tendency in the matching task). Likewise, the two RAN measures (r = .67) were combined, in order to simplify analyses and maximize reliability. The remaining measures were entered separately in the subsequent analyses. Note, however, that many participants scored near ceiling on the test of LK and on PAL-words; contributions to the prediction of spelling skills may be underestimated because of the limited sensitivity of these measures.

The correlations among the measures are given in Table 2. The correlation between the two PAL measures was only low to moderate (r = .38), but it is comparable in size to the correlations between the PAL measures reported in the study by Lervåg and Hulme (2010). The correlations between RAN and PAL measures were weak and non-significant, suggesting that distinct constructs were tapped. All measures correlated significantly with PA, and, as one might expect, both PAL measures correlated significantly with PSTM.

Table 2 Correlations among predictor measures (Grade 0)

	1	2	3	4	5
1. PA	-				
2. LK	.47**	-			
3. PSTM	.39**	.12	-		
4. RAN	.29**	.27**	-.07	-	
5. PAL-words	.23**	.16	.31**	.05	-
6. PAL-nonwords	.43**	.22*	.30**	.13	.38**

PA phonological awareness, *LK* letter knowledge, *PSTM* phonological short term memory, *RAN* rapid automatized naming, *PAL-words/PAL-nonwords* paired associate learning with words/nonwords
* $p < .05$, ** $p < .01$

Spelling measures

On the Grade 2 spelling test, the students spelled 4.1 of the 17 items correctly (*SD* = 3.2) on average. This rather low score is typical of the age group (as mentioned in the participants section above); the test is intended for students all the way up to Grade 4, and therefore features relatively difficult words. As one would expect at this level, students did not always spell the words in a phonologically plausible way either (*M* = 11.6; *SD* = 4.9). Hence, low scores can be due to limitations in either phonological or orthographic spelling skills, or both.

On the Grade 5 spelling test, the students spelled 22.3 of the 36 items correctly (*SD* = 7.9). Here, the participants' spellings were nearly always phonologically plausible (*M* = 32.0; *SD* = 5.4). Hence, individual differences in the Grade 5 spelling test were primarily reflections of differences in orthographic spelling skills.

In the relatively few cases where spellings were not phonologically plausible, the erroneous spelling often reflected a common reduced pronunciation, e.g., leaving out the unstressed middle syllable of the present participle *synge<u>n</u>de* 'singing' ['søŋənə > 'søŋnə]. At this level, it seems likely that spelling knowledge is an important source of knowledge of distinct pronunciations, rather than vice versa; students may not be aware that the distinct pronunciation of *syngende* has three syllables, *because* they are poor spellers. In other words, phonologically implausible spellings may not reflect a lack of phonological spelling ability *per se*.

Predicting early vs. later spelling

The correlation coefficients between the predictor measures and the spelling measures appear in Table 3. All predictors were significantly associated with spelling in both grades and the two spelling measures correlated moderately with each other.

Table 3 Correlations among predictor measures (Grade 0) and spelling measures (Grades 2 and 5)

	PA	LK	PSTM	RAN	PAL-words	PAL-nonwords	Spell G2 correct
Spell G2 correct	.55**	.27**	.33**	.40**	.26**	.27**	-
Spell G5 correct	.40**	.32**	.21**	.34**	.26**	.45**	.56**

PA phonological awareness, *LK* letter knowledge, *PSTM* phonological short term memory, *RAN* rapid automatized naming, *PAL-words/PAL-nonwords* paired associate learning with words/nonwords, *Spell G2 correct* the number of words correctly spelled, Grade 2, *Spell G5 correct* the number of words correctly spelled, Grade 5
* $p < .05$, ** $p < .01$

We ran a series of *z*-tests of dependent correlations (Meng, Rosenthal, & Rubin, 1992) to investigate whether any of the correlations between each of the predictor measures and spelling in Grade 2 and Grade 5, respectively, changed significantly. The correlation between PA and spelling weakened significantly from Grade 2 to Grade 5 ($Z = 2.19$, $p < .05$) while the correlation between PAL-nonwords and spelling got significantly stronger from Grade 2 to Grade 5 ($Z = 2.43$, $p < .05$). For the other measures, the differences between Grade 2 and Grade 5 coefficients were not significant, and the expected weakening tendency was found only for PSTM and RAN. Furthermore, when compared to PAL-words, PAL-nonwords was significantly more strongly correlated with spelling in Grade 5 ($Z = 2.17$, $p < .05$) However, the two PAL measures were equally correlated with spelling in Grade 2 (cf. Table 3).

Next, we conducted two multiple regression analyses to test whether the Grade 0 measures would contribute uniquely to the prediction of early spelling in Grade 2 and later spelling in Grade 5, respectively. In both analyses the six predictors were entered simultaneously as independent variables. For each predictor the squared semipartial correlation was calculated. This correlation expresses the unique contribution of each predictor to the total variance of the dependent variable (Tabachnick & Fidell, 2014, p. 208). These regression analyses allowed investigating the predictive patterns for early and later spelling.

Table 4 shows the results of the two multiple regression analyses with early spelling in Grade 2 and later spelling in Grade 5 as the dependent variables. The table displays the standardized regression coefficients (β), the squared semipartial correlations (sr^2) and the total amount of variance explained (R^2). In total, the six predictors explained 43% of the variance in early spelling in Grade 2. Only PA, PSTM, and RAN explained unique variance above and beyond the other variables.

For Grade 5 spelling, the six predictors explained 33% of the variance. In this model, only RAN and PAL-nonwords explained unique variance beyond the other variables. The two models are evidently distinct, and only RAN made a unique contribution to both.

Finally, we examined whether RAN and PAL-nonwords remained significant predictors of Grade 5 spelling if Grade 2 spelling was taken into account. In other words, we asked whether RAN and PAL-nonwords could be viewed as predictors of developments in spelling that took place between Grades 2 and 5. The correlation between Grade 2 and Grade 5 spelling was fairly strong ($r = .56$, cf. Table 3), but as can be seen in Figure 1 (a plot of the spelling scores in Grades

2 and 5, with vertical and horizontal lines representing the means), some students obtained higher scores in Grade 5 than one would expect from their relatively low scores in Grade 2 (the circles appearing in the upper left corner of the scatterplot). Thus, not all variance in Grade 5 spelling was explained by Grade 2 spelling. On the other hand, students who started out with relatively high scores in Grade 2 seem to have continued their course of development, and nearly all obtain scores above average again in Grade 5.

To shed light on this question, a hierarchical multiple regression analysis with spelling in Grade 5 as the dependent variable was conducted (cf. Table 5). At step one early spelling in Grade 2 was entered to control for the effect of early spelling skills. Then, RAN and PAL-nonwords were entered as predictor variables at the second and third step; the remaining predictor variables were left out because they did not explain unique variance in the previous model. The analysis showed that PAL-nonwords did survive as a unique predictor when Grade 2 spelling was controlled. RAN, however, did not. In total, 42% of the variance in Grade 5 spelling was explained.

Table 4 Summary of Multiple Regression Analyses for Variables Predicting Early Spelling in Grade 2 and Later Spelling in Grade 5

	Grade 2		*Grade 5*	
Variable	*sr^2 (unique)*	*β*	*sr^2 (unique)*	*β*
PA	.09	.40***	.00	.06
LK	.00	-.05	.02	.14
PSTM	.03	.21**	.01	.10
RAN	.09	.32***	.05	.24**
PAL-words	.01	.11	.00	.06
PAL-nonwords	.00	-.05	.07	.31***
	R^2 = .43		R^2 = .33	

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

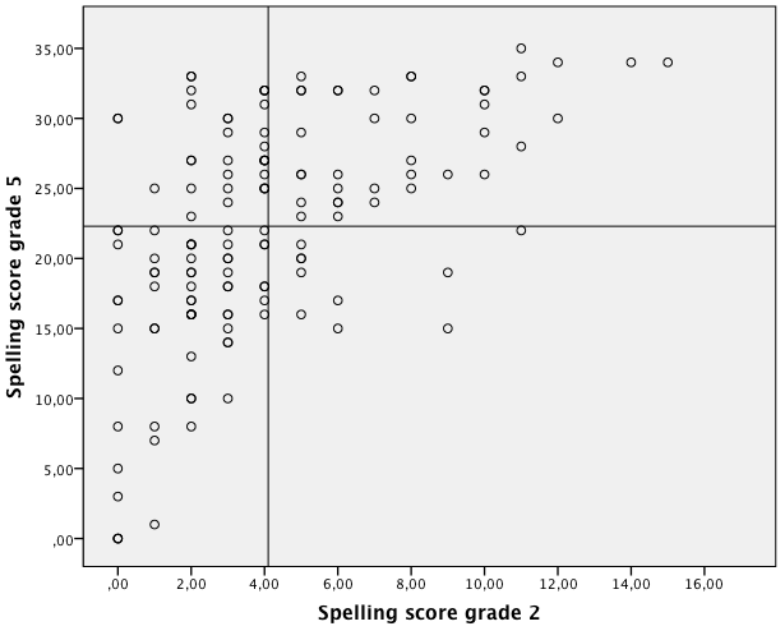

Figure 1 Scatterplot of spelling scores in Grade 2 and Grade 5

Table 5 Hierarchical multiple regression analysis for variables predicting later spelling in Grade 5 controlling for early spelling in Grade 2

Step	*Variable*	R^2	ΔR^2	*Final β*
1	Spell G2 correct	.31	.31	.42***
2	RAN	.33	.02	.12
3	PAL-nonwords	.42	.09	.32***

*** $p < .001$

Discussion

In the present study we investigated to what extent a range of measures taken at the end of Kindergarten predicted spelling skills in Danish children in an early phase (beginning of Grade 2) and in a later phase (beginning of Grade 5) of development. For the early phase, we found that PA, RAN and PSTM were unique predictors, whereas LK and PAL with words and nonwords were not. For the later phase, the pattern of prediction was clearly different, with RAN and PAL-nonwords being the only significant predictors. When controlling for Grade 2 spelling levels, PAL-nonwords still explained a significant and relatively large share of the variance (R^2 = .09), suggesting a specific link between this measure and the acquisition of spelling skills beyond Grade 2. Overall, the results suggest that the acquisition of orthographic spelling knowledge (occurring mainly in the later phases of spelling development) is partly based on skills different from those necessary for phonological spelling development (in the earlier phases).

The contributions of PA and RAN to early spelling replicated findings from previous studies of other orthographies (e.g., Caravolas et al., 2001 & 2002; Georgiou et al., 2012; Lervåg & Hulme, 2010). The significant contribution from RAN seems to be in accordance with the suggestion put forward by Moll et al. (2009) that RAN is related to the automaticity of orthography to phonology associations at the letter and letter cluster level rather than to the acquisition of orthographic spelling knowledge.

The finding that RAN was not a predictor of later growth in spelling is in accordance with earlier findings (e.g., Furnes & Samuelsson, 2011; Lervåg and Hulme, 2010). Lervåg and Hulme suggested that RAN's power as a concurrent predictor of spelling skills above Grade 2, as found in some correlational studies (e.g., Moll et al., 2014; Savage et al., 2008), reflects the link between RAN and individual differences in earlier stages of spelling development. This interpretation is also in accordance with the assertion by Moll et al. (2009) that RAN reflects the automaticity of orthography to phonology associations at the letter and letter cluster level. By contrast, if RAN taps into the ability to form word-specific orthographic representations (e.g., Conrad & Levy, 2007; Manis, Seidenberg, & Doi, 1999; Wolf & Bowers, 1999), one would expect RAN to be specifically related to the later phase of spelling development. The findings of the current study did not show such pattern.

The unique contribution of PSTM to the prediction of early spelling may simply reflect the fact that relatively heavy demands are placed on PSTM when children still struggle to analyze the sound structure of words during a dictation task. Still, the finding suggests that measures of short term memory are important as controls in studies of early spelling skills.

The relevance of LK as a spelling predictor was not confirmed in the present study. Note, however, that LK shared substantial variance with PA (r = .47), and that the LK measure lacked sensitivity in the upper range; many participants already knew most of the alphabet when we tested them at the end of Kindergarten.

The inclusion of PAL in the present study did not improve the prediction model for early spelling development although, as expected, both PAL-words and PAL-nonwords correlated significantly with spelling skills. For later spelling however, PAL-nonwords (but not PAL-words) was a unique predictor. The fact that PAL-nonwords gained predictive power from the early to the later phase of spelling development is, perhaps, the most remarkable finding of our study and seems to contrast with the finding of Lervåg and Hulme (2010) that PAL-nonwords did not predict growth in spelling skills from Grade 2 and onwards to Grades 3 and 4. The contrast may be due to differences in the transparency of the Norwegian and Danish orthographies; the opaque Danish orthography requires orthographic learning to a much higher degree than the more transparent Norwegian orthography, especially in the later phases of spelling development. The contrast may also be due to differences in task demands. The three PAL-nonwords tasks used in the Norwegian study were clearly more difficult than the task used in the present study; across tasks the participants correctly named 40% of the items in the Norwegian study which is much lower than the 77% correctly named items found in the present study. Compared to the participants in the Norwegian study, the participants in the present study had more opportunities to repeat the nonwords before the first trial, i.e., they

had better opportunities to establish representations of the new phonological forms before associating them with the visual stimuli. Moreover, they completed more trials (15 versus 10). Together, these differences suggest that our PAL-nonwords task was more sensitive to differences in verbal learning of new phonological forms among children who performed in the lower range. This interpretation seems to fit with the theoretical position that verbal learning is the critical factor behind the relationship between PAL-nonwords and literacy skills (e.g., Litt et al., 2013) – a position which also accommodates the finding that PAL-nonwords, but not PAL-words, was a unique predictor of later spelling.

To explain why verbal learning abilities (as tapped by PAL-nonwords in Kindergarten) should be specifically related to the development of *orthographic* spelling skills, we speculate that children who have difficulties learning new phonological forms also have difficulties extracting the phonological forms that correspond to conditional or word-specific spelling patterns. When spelling words akin to the items from the Grade 5 spelling test, children cannot rely on simple phoneme-grapheme correspondences but have to draw on knowledge of recurring orthographic patterns. In order to remember such spelling patterns, children must link them to phonological forms below the word level. Well-specified representations of these forms may play an important supportive role as underpinnings for the crucial letter patterns.

This interpretation however, rests on the reliability of the PAL-nonword task used in the current study. As discussed below, the PAL-measures may have had limited reliability.

Limitations

Since different tests of spelling skills were used in Grade 2 and Grade 5, we were evidently not predicting variation on the exact same measure at the two time points. The differences in the predictive patterns for the early and later phases of spelling development may reflect differences between the two tests. As the same word material would not be equally sensitive to differences in spelling skills for children in Grade 2 and Grade 5, it may be more accurate to say that the present study investigated the achievement of spelling knowledge children are *expected* to have acquired at different phases in their spelling development. However, as mentioned in the method section, strong correlations have been found for fourth-graders taking both tests, indicating that the two tests do, to a large extent, measure the same, or strongly related, skills.

Because many students obtained relatively low scores on the Grade 2 spelling test, the predictive patterns observed could reflect the limited sensitivity of this measure in the lower range. For participants with low scores, a measure based on the number of phonologically plausible (rather than correct) spellings was more sensitive. However, when we repeated the regression analyses above with this alternative Grade 2 spelling measure, the predictive patterns found were essentially the same.

A major limitation of our study was that measures of morphological awareness were not included among the predictors despite the relevance of morphological knowledge for spelling

(e.g., Boulware-Gooden, Joshi, & Grigorenko, 2015; Bourassa & Treiman, 2014). This was due to the fact that the study was part of a larger study focusing primarily on the development of accuracy and speed in reading, and, again, a concern that a too demanding test battery in Grade 0 would cause participants to withdraw from the study. It seems likely that such measures would have contributed to the prediction of spelling development, especially in the later phases where awareness of inflectional morphemes have been found to correlate with spelling skills (e.g., Juul, 2005). Also, it is possible that such measures would have shared variance with our PAL-measures.

Among the predictor measures included, some had somewhat limited sensitivity. First, there was some degree of ceiling effect on LK, PAL-words and phoneme matching and a degree of floor effect on phoneme deletion. For phoneme awareness, using a combined measure of the phoneme matching and phoneme deletion scores solved this problem. However, for LK and PAL-words, the ceiling tendencies may indeed have reduced their predictive power. Especially in light of the high level of LK observed, it would have been useful to include a test of initial spelling skills in the Grade 0 battery. In fact, such a test was considered, but not included; we were concerned that the test battery could be too time consuming and demanding for children who were not used to being tested, and lead to negative attitudes towards continued participation in the longitudinal study.

A final possible limitation to be considered is the reliability of the PAL tasks. Measures of internal consistency are probably not informative reliability measures for PAL tasks since they really consist of only one item (a fixed set of words to be learned; Poulsen et al., 2012). However, the correlations with other measures suggest that our measures were at least comparable to those used in previous studies. The correlation between PAL and PA was in the same range as found in some studies (Hulme et al., 2007; Litt et al., 2013; Windfuhr & Snowling, 2001), but lower than in other studies (de Jong, Seveke, & van Veen, 2000; Lervåg, Bråten, & Hulme, 2009). Likewise, the correlation between PAL and RAN was in the same range as found in some studies (Lervåg & Hulme, 2010; Litt et al., 2013) but lower than in other studies (Lervåg et al., 2009; Warmington & Hulme, 2012).

Conclusions

The ambition of the present study was to contribute to the understanding of the cognitive foundations of both the early and later phases of spelling development. Ultimately, we hope that such studies can pave the way for improved spelling instruction. The present study raises particular questions about how children can be helped to acquire orthographic spelling knowledge more easily. Factors other than basic PA and LK seem to be of importance, and especially students with poor verbal learning abilities may be in need of explicit instruction. In the present study, general measures of spelling skills were used. To further test the hypothesis that PAL is specifically related to the acquisition of orthographic spelling knowledge, it would be useful to include measures of specific types of orthographic knowledge (e.g., word-specific knowledge; knowledge of graphotactic patterns; knowledge of conditional spelling patterns).

Moreover, it would be useful to include multiple tasks to assess PAL, both to ensure reliability and to tease apart the role of different task demands. In particular, it may be of importance to distinguish between the verbal learning and the association part of the task.

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Rapport om udvikling af danske gruppetest af ortografisk viden

På dansk vil det ofte være tilfældet, at der ikke findes standardiserede sproglige test, der egner sig til at indgå i planlagte undersøgelsesdesigns. Og det vil derfor ofte være nødvendigt at oversætte, videreudvikle eller nyudvikle egnede test til danske forskningsstudier. Da styrken af forskningsresultater bl.a. afhænger af kvaliteten af de anvendte test, er det afgørende, at der går en grundig afprøvning af nye test forud for, at de medtages i endelige forskningsstudier. I denne rapport beskrives udvikling og afprøvning af tre gruppetest af henholdsvis ordspecifik ortografisk viden, grafotaktisk viden og viden om fonologisk betingede stavemønstre. Mens testene af ordspecifik ortografisk viden og grafotaktisk viden bygger på udenlandske forlæg, er testen af viden om fonologisk betingede stavemønstre nyudviklet i forbindelse med denne afhandling. De tre gruppetest af ortografisk viden var helt centrale for her og nu-undersøgelsen i studie 2, der undersøgte, hvorvidt kendskab til betingede stavemønstre kan forklare unik variation i samtidig stavefærdighed ud over fonologisk afkodning, grafotaktisk viden og ordspecifik viden blandt danske elever i 5. klasse. De tre test indgik også i træningsundersøgelsen i studie 3, men her spillede de en mindre central rolle. Testene indgik i et testbatteri, som deltagerne gennemførte før iværksættelsen af træningen. Formålet var at vise, at eksperiment- og kontrolgruppen ikke adskilte sig signifikant fra hinanden på mål for ortografisk viden. Da træningen var målrettet betingede stavemønstre, var det særligt afgørende at vise, at de to grupper ikke adskilte sig fra hinanden på deres kendskab til netop denne type ortografiske viden.

Formålet med testen af *ordspecifik ortografisk viden* var at få et mål for børns kendskab ordspecifikke stavemåder på dansk. En sådan test kan designes på flere måder, men en hyppig anvendt version er at lade deltageren se to bogstavfølger, der udtales ens, men som ortografisk repræsenterer to forskellige ord (fx *finde* eller *finne*). Når deltageren bliver stillet et spørgsmål (fx *hvilket ord er en person*?) skal deltageren vælge, hvilken stavemåde der er den rigtige. Formålet med testen af *grafotaktisk viden* var at få et mål for børns viden om de bogstaver og bogstavkombinationer, der optræder i skrevne ord på dansk. Endelig var formålet med testen af *viden om fonologisk betingede stavemønstre* at få et mål for børns kendskab til stavemønstre med en uregelmæssig udtale, der optræder på tværs af danske ord.

Gruppetestene blev i første omgang udviklet med henblik på at blive anvendt til elever i 3. klasse (studie 3). Under udviklingen af testene blev der dog mulighed for at afprøve og anvende dem i forbindelse med Center for Læseforsknings langtidsundersøgelse *Development of speed in reading* med deltagelse af elever fra 4. og 5. klasse. De endelige versioner af testene blev anvendt i studie 3 afviklet i foråret 2014 med elever fra 3. klasse. Tabel 2 viser en oversigt over de forskellige versioner af testene med angivelse af, i hvilke undersøgelser de har været anvendt. Analyser af resultaterne fra henholdsvis pilotundersøgelse 2 samt studie 3 gennemgås i denne rapport. Da rapportens fokus er en sammenligning af testudgaverne i version 2 og 3, gennemgås resultaterne fra pilotundersøgelse 1 ikke. Ligeledes gennemgås resultaterne fra studie 2 ikke i denne rapport, da de beskrives indgående i artiklen om studiet. I

pilotundersøgelse 2 og studie 3 er deltagerne elever fra 3. klasse, hvilket giver et godt grundlag for at sammenligne testenes kvalitet i version 2 og i deres endelige udgave.

Tabel 2 Oversigt over anvendelsen af tre gruppetest af ortografisk viden i forskellige versioner

Undersøgelse	*Version 1*	*Version 2*	*Version 3*
Pilotundersøgelse 1 ▪ marts 2013 ▪ 22 elever fra to 4. klasser	x		
Studie 2 ▪ september 2013 ▪ 133 elever fra ni 5. klasser		x	
Pilotundersøgelse 2 ▪ oktober 2013 ▪ 40 elever fra to 3. klasser		x	
Studie 3 ▪ marts 2014 ▪ 72 elever fra fire 3. klasser			x

Redskaber til vurdering af testenes kvalitet

Der anvendes en række redskaber til at vurdere testene på forskellige parametre. For det første ønskes svar på, hvorvidt testene skaber en fornuftig spredning i deltagernes scorer. Til det vurderes *distributionen* af scorer opnået i testene. For det andet ønskes svar på, i hvor høj grad de enkelte items i testene kan siges at måle den samme færdighed. Til det formål vurderes testenes *interne reliabilitet* vha. Chronbach's alfa. For det tredje ønskes svar på, hvorvidt de enkelte items i testene er i stand til at skelne mellem deltagere, der opnår enten en høj eller en lav score på den samlede test. Til det formål beregnes *item-diskriminationen*. Endelig ønskes svar på, hvorvidt testene kan siges at måle det, de har til hensigt at måle. Til det formål vurderes testenes *samtidige validitet*. Nedenfor gennemgås de nævnte redskaber kort.

Distribution af scorer

For at en test kan betragtes som tilstrækkelig følsom for variation blandt deltagerne, er det nødvendigt, at den kan producere en fornuftig spredning i de scorer, deltagerne opnår i testen (Kline, 2000). En ideel spredning er den såkaldte normalfordeling, hvor data er distribueret symmetrisk omkring de centrale scorer på skalaen for en given test. En sådan fordeling betyder, at størstedelen af deltagerne har opnået en score inden for den centrale del af testens skala. Jo længere væk fra den centrale del af skalaen en score befinder sig, jo færre deltagere vil have opnået scoren. Er en test samlet set for let eller for svær for en given gruppe deltagere, vil fordelingen af deres scorer blive skæv, idet de fleste scorer i så fald vil være centreret enten i den lave ende af skalaen (gulveffekt) eller i den høje ende af skalaen (lofteffekt). Distributionen

kan bl.a. vurderes visuelt ved at betragte fordelingen af deltagernes scorer i et histogram (Field, 2013).

Reliabilitet

I forbindelse med testning kan man skelne mellem to betydninger af reliabilitet; den ene relaterer sig til en tests pålidelighed over tid i form af *test-retest-reliabilitet*, og den anden relaterer sig til en tests interne konsistens dvs. sammenhængen mellem de enkelte items i en test kaldet *item-homogenitet*. Man måler test-retest-reliabilitet ved at korrelere scorerne fra den samme gruppe deltagere, der har taget den præcis samme test på to forskellige testpunkter. Hvis testen er pålidelig, må det forventes, at deltagerne klarer testen meget ensartet ved begge lejligheder, hvorved korrelationen mellem scorerne ved de to testpunkter bliver høj (Kline, 2000). I forbindelse med afprøvningerne af gruppetestene er hver test kun afprøvet én gang med den samme gruppe deltagere, hvorfor det ikke er muligt at beregne test-retest-reliabilitet.

For at en tests interne konsistens kan være høj, skal de individuelle items producere resultater, der er i overensstemmelse med resultatet af den overordnede test. Chronbach's alfa er det mest udbredte mål for en tests interne reliabilitet (Field, 2013). Hvis en test skal være valid, dvs. teste det, den har til formål at teste, skal den interne konsistens være høj. En meget høj intern konsistens kan dog også være tegn på, at testen er for specifik. Det vil være i tilfælde, hvor de enkelte items i for høj grad er afspejlinger af hinanden og dermed i praksis overflødiggør hinanden. Det vil betyde, at testen har en meget høj reliabilitet, men en lav validitet, fordi den ikke er tilstrækkelig følsom for den færdighed, den skal måle. Ideelt bør alfa-koefficienten ligge inden for ,7-,9 afhængig af testens formål (Kline, 2000). Til at vurdere det enkelte item anvendes målet *Corrected Item-Total Correlation*. Det er et mål for sammenhængen mellem hvert enkelt item og den totale score på testen. Lave værdier (< ,3) indikerer, at det pågældende item måler noget andet end testen som helhed (Field, 2013).

Samtidig validitet

En test kan betragtes som valid, hvis den måler det, den har til formål at måle. Der findes forskellige former for validitet, hvoraf én anvendes her. En test kan siges at have *samtidig validitet*, hvis det kan demonstreres, at den korrelerer stærkt med en etableret test, som antages at måle samme færdighed. Hvis den test, der sammenlignes med, kan betragtes som "en gylden standard" for færdigheden, bør korrelationen være så høj som mulig (Kline, 2000).

I undersøgelserne, der gennemgås i dette afsnit, har deltagerne gennemført den standardiserede staveprøve *Staveprøve 2* (Juul, 2012). For at få et mål for validiteten af de nye test, er elevernes præstationer på disse blevet korreleret med deres præstation på staveprøven. Her er det vigtigt at have for øje, at gruppetestene *ikke* har som formål at teste deltagernes stavefærdighed. Derimod forventes det, at det, de måler i større eller mindre grad,

er beslægtet med elevernes stavefærdighed. Har testene kun en meget begrænset sammenhæng med staveprøven, kan det derfor være et tegn på manglende validitet.

Item-diskrimination

Item-diskriminationen D er et mål for det enkelte items evne til at diskriminere mellem de deltagere, der samlet set har klaret testen bedst, og de deltagere, der samlet set har klaret testen dårligst. D beregnes som:

[D = (antal deltagere blandt de bedste 25% der har et specifikt item korrekt - antal deltagere blandt de dårligste 25% der har det samme item korrekt) / antal elever i den bedste gruppe] (Ebel & Frisbie, 1986).

D-værdien ligger inden for intervallet +1 til -1. Jo højere D-værdi, jo bedre er det pågældende item til at skelne mellem den bedste og den dårligste fjerdedel af deltagerne på den samlede test. Ebel og Frisbie (1986) har foreslået følgende guidelines for tolkning af D-værdier:

- D > ,40 (godt)
- D = ,30 - ,39 (fornuftigt)
- D = ,20 - ,29 (marginalt)
- D < ,19 (dårligt – evt. korriger eller fjern)

Test af ordspecifik ortografisk viden

Testforlæg

Forlægget, kaldet *Homophone knowledge task*, er en gruppetest udviklet og anvendt af Cunningham (2006). Forlægget til denne stammer fra en undersøgelse af Stanovich og West (1989) med deltagelse af en gruppe bachelorstuderende. I deres version er der tale om en individuel test, hvor deltageren stilles et spørgsmål af testtager (*which one is a fruit*), hvorefter to homofone stavemåder vises på en computerskærm (*pair/pear*). Deltageren svarer ved at trykke på en af to taster for at angive, hvilken stavemåde der matcher spørgsmålet. Testen består af 25 opgaver. Scoren bliver opgjort som et kompositmål af reaktionstid (median) og antal fejl. I gruppetesten fra undersøgelsen af Cunningham (2006) med deltagelse af elever fra 1. klasse, præsenteres deltagerne skriftligt for korte spørgsmål efterfulgt af to homofone stavemåder (*which is a flower? rows* or *rose*). I alt indgår 24 homofone par i testen. Hver stavemåde bliver præsenteret separat, hvorfor 48 items/spørgsmål indgår i testen. Deltagerne bliver bedt om at indcirkle den stavemåde, der bedst passer til spørgsmålet. Scoren bliver beregnet som antal korrekt besvarede items.

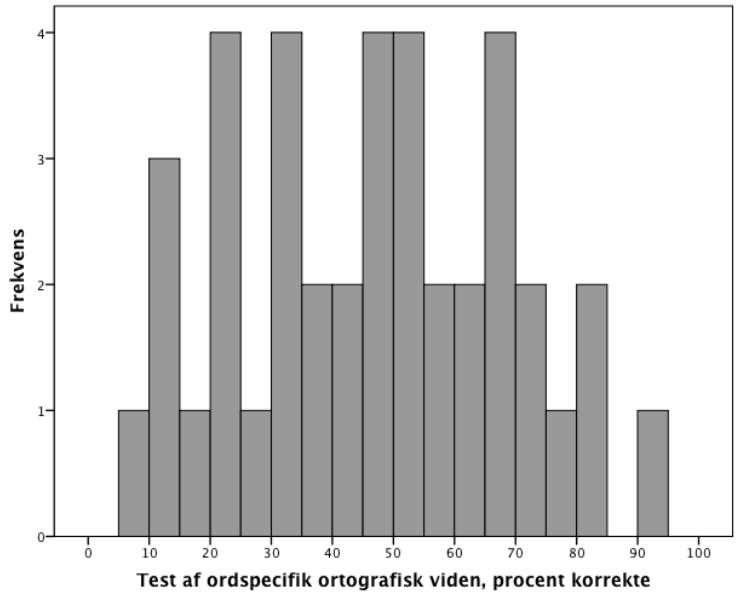
Testen

I version 2 af testen indgik i alt 20 homofonpar. Homofonparrene blev valgt ud fra det kriterium, at *betydningen* af hvert af de to ord kunne forventes at være kendt af elever i 3. klasse. Hver stavemåde blev præsenteret separat, hvorfor den samlede test bestod af i alt 40 items. Hvert item blev præsenteret i en sætning (fx *Der sidder en krave / krage i træet*). For at minimere betydningen af elevernes afkodningsfærdigheder for løsningen af testen, blev sætningerne læst op af testlederen, der gentog målordet (*krage*). Deltagerne blev bedt om at tegne en cirkel om den stavemåde, der passede til sætningen. Efter ca. 5 sekunder blev næste sætning læst højt. Testen blev delt op i en A og en B del bestående af hver 20 items. Først blev del A afviklet, hvorefter to andre gruppetest blev afviklet, før del B blev afviklet. For at reducere gættesandsynligheden blev scoren opgjort som antal korrekt identificerede homofonpar. Dvs. hvis en deltager satte ring om stavemåden *krage* i både sætningen (*Der sidder en krave / krage i træet*) og sætningen (*Min nye bluse har en stor krave / krage*), blev vedkommende tildelt scoren 0. Hvis en deltager satte ring om den korrekte stavemåde i begge sætninger, blev vedkommende tildelt scoren 1. Dermed blev gættesandsynligheden reduceret fra 50% til 25%, og den maksimale score blev 25.

Pilotundersøgelse 2

Deltagerne identificerede i gennemsnit 44,0% (*SD* = 22,2) af homofonparrene korrekt. Som det fremgår af figur 2, ses der en fornuftig spredning i scorerne. En fjerdedel af deltagerne scorede svarende til eller under chanceniveauet. De 20 homofonpar har gennemsnitligt et D på ,57 og fordeler sig således på de tidligere beskrevne kategorier: > ,40 (18); ,30 - ,39 (1); ,20 - ,29 (1). Testens interne homogenitet er god med Chronbach's alfa på ,81. Korrelationen mellem deltagernes præstation på testen af ordspecifik ortografisk viden og deres præstation på Staveprøve 2 er moderat til stærk (*r* = ,57). En stærk sammenhæng er forventet, da staveprøven i nogen grad må forventes at teste elevernes kendskab til ordspecifikke stavemåder.

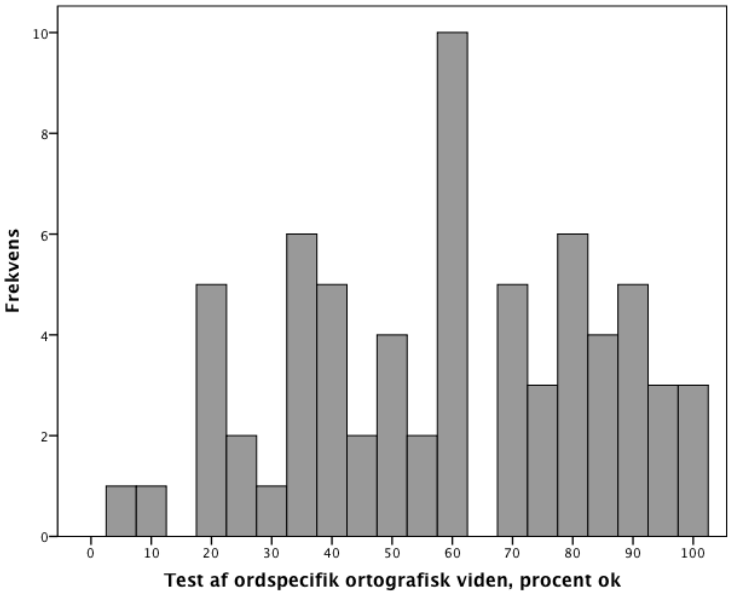
På baggrund af resultaterne blev testen ikke justeret yderligere.



Figur 2 Fordeling af deltagernes scorer på test af ordspecifik ortografisk viden (pilotundersøgelse 2)

Studie 3

68 af de 72 elever gennemførte testen. Deltagerne identificerede i gennemsnit 59,3% (*SD* = 25,2) af homofonparrene korrekt. Som det fremgår af figur 3, er spredningen af scorerne fornuftig. Kun 13% af deltagerne scorede svarende til eller under chanceniveauet. De 20 homofonpar har gennemsnitligt et D på ,63 og fordeler sig således: > ,40 (19); ,30 - ,39 (0); ,20 - ,29 (0); < ,19 (1). Korrelationen med Staveprøve 2 er meget stærk (*r* = ,81). Sammenlignet med deltagerne i pilotundersøgelse 2, scorer deltagerne i studie 3 gennemsnitligt højere på testen. Det skal sandsynligvis forklares med, at pilotundersøgelsen er afviklet i 1. halvår af 3. klasse, mens studie 3 er afviklet i 2. halvår af 3. klasse. Korrelationen med Staveprøve 2 er desuden stærkere for deltagergruppen i studie 3 end for deltagergruppen i pilotundersøgelsen. Dette skal sandsynligvis forklares med forskelle i spredningen af deltagernes scorer på testen af ordspecifik ortografisk viden og på stavetesten i de to undersøgelser; deltagerne i pilotundersøgelsen staver gennemsnitligt 38,3% (*SD* = 25,3) af ordene korrekt i stavetesten, mens den tilsvarende score er 52,7% (*SD* = 29,5) for deltagerne i studie 3.



Figur 3 Fordeling af deltagernes scorer på test af ordspecifik ortografisk viden (studie 3)

Test af grafotaktisk viden

Testforlæg

Der er to forskellige testforlæg. Det første forlæg kaldet *Orthographic knowledge letter string task* er en gruppetest udviklet og anvendt i undersøgelsen af Cunningham (2006) beskrevet ovenfor. Denne er videreudviklet fra testen *Orthographic nonword pairs* anvendt i en undersøgelse af Cassar og Treiman (1997) med deltagere fra 1., 2., 3., 6., og 9. klasse samt en gruppe bachelorstuderende. I deres test blev 20 nonordspar konstrueret med henblik på at måle deltagernes kendskab til dobbeltkonsonanter. Der var tale om to typer. Den første handlede om dobbeltkonsonanters position (fx *baff/bbaf*) den anden om såvel position som forekomst (fx *heniss/hhenis*). Deltagerne blev instrueret i at se på hvert nonordspar og tegne en cirkel om det nonord, der lignede et rigtigt ord mest. I Cunninghams videreudvikling af testen indgår 30 nonordspar bestående af homofone nonord af 4-5 bogstavers længde. Et af nonordene i hvert par består af bogstavfølger, der er hyppigt forekommende i engelsk ortografi, mens det andet nonord består af bogstavfølger, der ikke forekommer/forekommer sjældent (fx *fage/fayj*, *prant/prahnt*). Deltagerne bliver bedt om at se på hvert nonordspar og tegne en cirkel om det nonord, der ligner et rigtigt ord mest.

Det andet forlæg kaldet *General orthographic knowledge task* er en individuel computerbaseret test udviklet og anvendt af Conrad et al. (2013) i en undersøgelse med deltagelse af børn i alderen 7-9 år. Testen er videreudviklet fra *The nonlexical choice task* udviklet og anvendt af Siegel et al. (1995) i en undersøgelse, hvor deltagernes læsealder strakte sig fra 1. til 8. klasse. Her præsenteres deltagerne for to nonord og skal vælge, hvilket af de to der ligner et rigtigt ord mest. I det ene af de to alternativer optræder en bogstavfølge, der

forekommer i den pågældende position i engelske ord, mens det andet alternativ indeholder en bogstavfølge, der ikke optræder i den pågældende position [fx *filk/filv*]. Der indgår 17 items i testen. I den nye version udviklet af Conrad et al. (2013), består nonordsparrene af homofone nonord på fire bogstaver. I det ene nonord indgår en hyppigt forekommende bogstavfølge i engelske ord, mens der i det andet nonord indgår en bogstavfølge, der ikke forekommer i ord på fire bogstaver [fx *siff/siph, tays/tayz*]. Der indgår 29 items i testen. Hvert item præsenteres på en computerskærm. Deltagerne bliver instrueret i at vælge det ord, der ligner et rigtigt ord mest ved at trykke på en tast.

Testen

I version 2 af testen indgik i alt 30 items. Et item består af to homofone nonord - et målord og en distraktor. Følgende kriterier ligger bag valget af items:

- Et item består af to homofone nonord - et målord og en distraktor.
- Nonordene består af en eller to stavelser.
- Bogstavkombinationen i målordet skal findes i rigtige danske ord med tilsvarende struktur (fx ccvcv →<u>sk</u>abe →<u>sk</u>æle).
- Bogstavkombinationen i distraktoren findes ikke (<u>sd</u>yf)/forekommer sjældent (<u>sg</u>æle) i den pågældende position i rigtige danske ord.
- Der må ikke indgå rigtige ord i målordet (fx <u>ski</u>le/sgile) eller distraktoren (<u>si</u>uf/sjuf), der ikke indgår i det parrede nonord. Dette for at undgå at det ene af nonordene i et par vælges, fordi det indeholder et rigtigt ord.

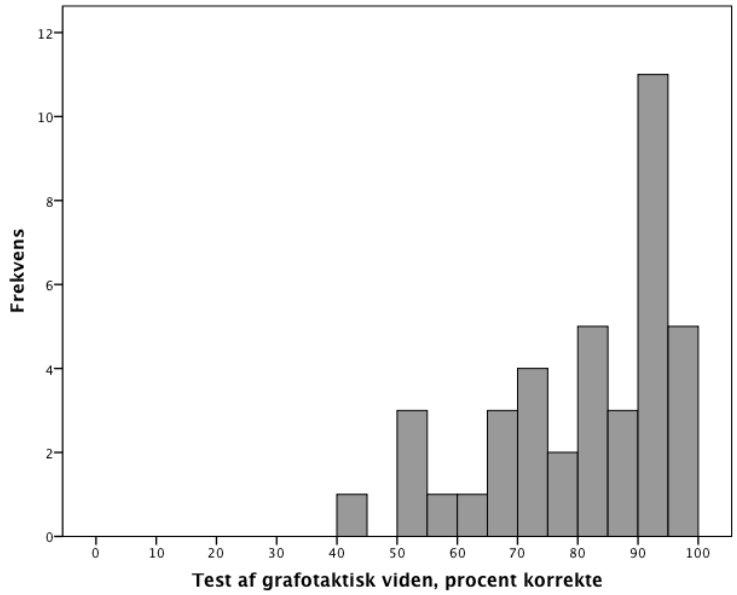
To ark med hver 15 items udleveres til deltagerne. Hvert item optræder på en selvstændig linje. Hvert nonordspar er adskilt med / (fx skæle / sgæle). Deltagernes opgave er at sætte en cirkel om det nonord, de synes ligner et rigtigt ord mest. De får så lang tid, de har behov for, til at løse opgaven. Scoren opgøres som antal korrekt indcirklede målord. Gættesandsynligheden er 50%.

Pilotundersøgelse 2

Deltagerne identificerede i gennemsnit 80,6% (*SD* = 15,2) af items korrekt. Kun en enkelt elev scorede under chanceniveau. Som det fremgår af figur 4, er der en tendens til lofteffekt på målet. Testens interne homogenitet kan betragtes som høj med Cronbach's alfa på ,83. De 30 items har gennemsnitligt et D på ,39 og fordeler sig således på kategorierne: > ,40 (12); ,30 - ,39 (4); ,20 - ,29 (6) og < ,19 (8). Syv af de otte items med D < ,19 blev alle identificeret korrekt af hovedparten af deltagerne (84,6 - 97,4%). Det sidste item korrelerede meget dårligt med de øvrige items (*Corrected Item-Total Correlation* = ,02). På den baggrund blev de otte items fjernet. Da testen giver anledning til lofteffekt blandt deltagere i 3. klasse, er det ønskværdigt, at den gøres sværere. På den baggrund blev yderligere tre af de letteste items fjernet. Fem nye items blev tilføjet. De matchede items, der i pilotundersøgelse 2 havde et D på > ,40, og som kan betragtes som et svært/moderat svært item (identificeret korrekt af 43,6 – 74,4% af

deltagerne). Korrelationen med Staveprøve 2 kan betragtes som en moderat til stærk sammenhæng (*r* = ,64).

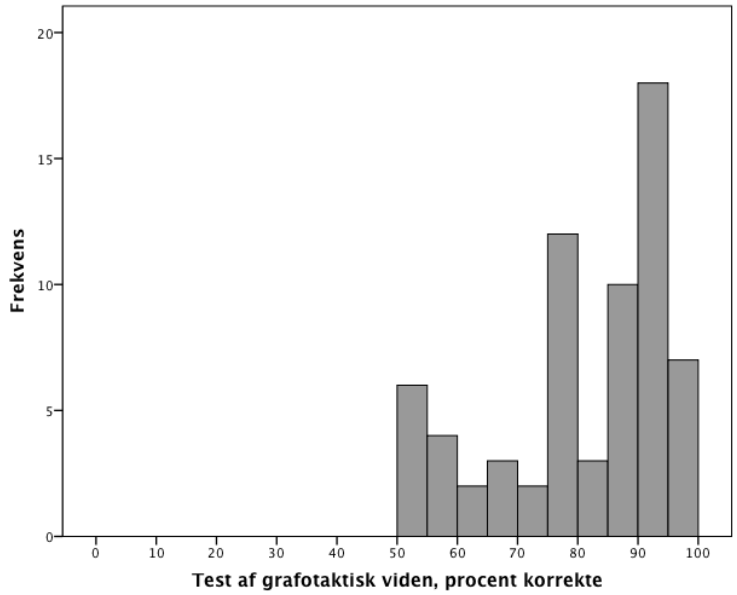
I den endelige version af testen indgår således 24 items.



Figur 4 Fordeling af deltagernes scorer på test af grafotaktisk viden (pilotundersøgelse 2)

Studie 3

67 af de 72 elever gennemførte testen. Deltagerne identificerede i gennemsnit 80,2% (*SD* = 13,9) af items korrekt. Ingen scorede under chanceniveau. Som det fremgår af figur 5, er fordelingen mellem chanceniveauet og maksscoren fornuftig, men den største koncentration af scorer er fortsat at finde i den høje ende af skalaen. Testens interne homogenitet kan også betragtes som høj i denne elevgruppe med Cronbach's alfa på ,86. De 24 items har gennemsnitligt et D på ,56 og fordeler sig således på kategorierne: > ,40 (22); ,30 - ,39 (2); ,20 - ,29 (0) og < ,19 (0). Der er dermed tale om en klar forbedring af item-diskriminationen sammenlignet med pilotundersøgelsen. Korrelationen med Staveprøve 2 kan betragtes som en moderat sammenhæng (*r* = ,55). Deltagerne i studie 3 scorer gennemsnitligt helt svarende til deltagerne i pilotundersøgelse 2. Det peger på, at det er lykkedes at gøre testen sværere, da man ud fra deltagernes præstationer på stavetesten og testen af ordspecifik ortografisk viden skulle forvente at se et højere gennemsnit hos deltagerne i studie 3.



Figur 5 Fordeling af deltagernes scorer på test af grafotaktisk viden (studie 3)

Test af viden om betingede stavemønstre

Testforlæg

Der eksisterer ikke et egentligt testforlæg. Men i dens opbygning kan testen betragtes som en parallel til testen af grafotaktisk viden. Der er fortsat tale om items bestående af homofone nonord, hvoraf deltagerne skal vælge det ene baseret på deres viden om skriftsprogets indretning. Men modsat testen af grafotaktisk viden, hvor deltagerne skal vælge, hvilket ord der *ligner* et rigtigt ord mest, skal deltagerne i denne test forholde sig til, hvilket stavemønster der bedst matcher *udtalen* af et nonord.

Testen

I den anden version af testen indgik i alt 30 items. Et item består af to homofone nonord - et målord og en distraktor. Følgende kriterier ligger bag valget af items:

- Et item består af to homofone nonord - et målord og en distraktor.
- Nonordene består af en eller to stavelser.
- Målordet indeholder et stavemønster med en uregelmæssig udtale af vokalen. Stavemønstret indgår i flere rigtige, danske ord.
- Stavemønstret i distraktoren 1) indgår ikke i rigtige danske ord (fx *øng* udtalt [øŋˀ][1]), 2) har en anden udtale i rigtige ord (fx *eng* udtalt [eŋˀ]), 3) er en sjælden repræsentant for udtalen (fx *ond* udtalt [ɔnˀ]).

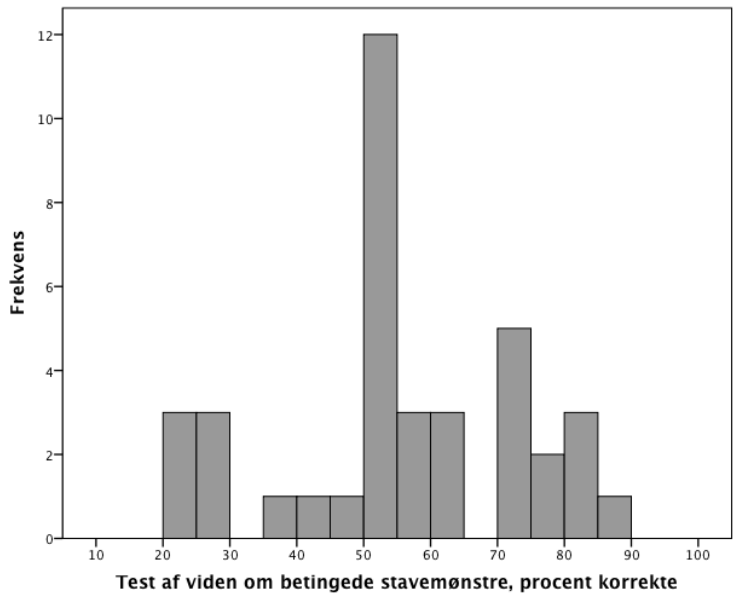
[1] Undtaget egenavnet Høng

To ark med hver 15 items udleveres til deltagerne. Hvert item optræder på en selvstændig linje. Hvert nonordspar er adskilt med / (fx pøng / pyng). Testleder udtaler et nonord fx [pøŋˀ] og gentager det. Deltagernes opgave er at sætte en cirkel om den stavemåde, de synes er den rigtige. Scoren opgøres som antal korrekt indcirklede målord. Gættesandsynligheden er 50%.

Pilotundersøgelse 2

38 af de 40 elever gennemførte testen. I gennemsnit identificerede de 54,3% (*SD* = 18,1) af items korrekt. 24% af deltagerne scorede under gættesandsynligheden, mens 32 % scorede svarende til gættesandsynligheden. Dette mønster må forventes at afspejle, at elever, der i stor udstrækning benytter sig af deres viden om simple fonem-grafem forbindelser i løsningen af testen, i mange tilfælde har en præference for distraktorerne, hvorved de scorer under/svarende til chanceniveauet. Item-homogeniteten kan betragtes som god med Chronbach's alfa på ,78. De 30 items har gennemsnitligt et D på ,50 og fordeler sig således på kategorierne: > ,40 (24); ,30 - ,39 (2); ,20 - ,29 (3) og < ,19 (1). Seks items med D =< ,30 blev fjernet. Heraf korrelerede tre items meget dårligt med de øvrige (*Corrected Item-Total Correlation* < ,07). Yderligere tre items blev fjernet, mens fire nye blev tilføjet. De matchede items der i pilotundersøgelse 2 havde et D på > ,70. og en *Corrected Item-Total Correlation* på > ,48. Korrelationen mellem testen af viden om betingede stavemønstre og Staveprøve 2 kan betragtes som en moderat sammenhæng (*r* = ,39).

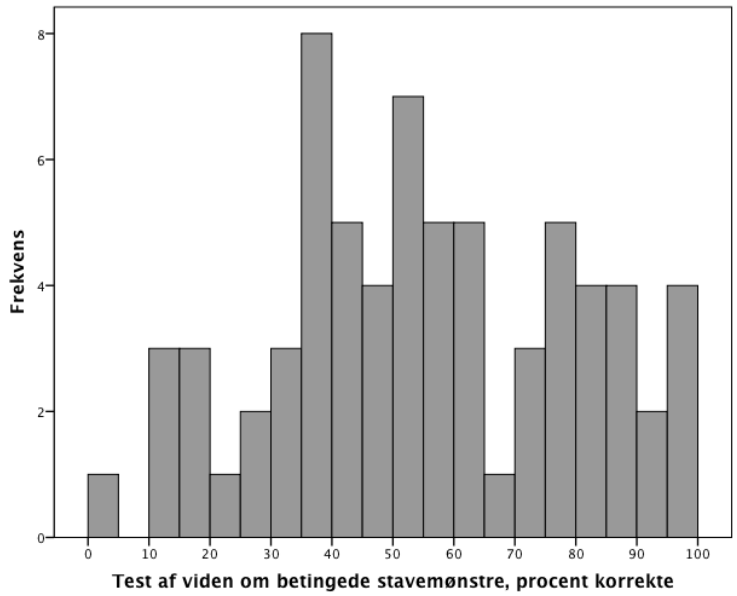
I den endelige version af testen indgår således 28 items.



Figur 6 Fordeling af deltagernes scorer på test af viden om betingede stavemønstre (pilotundersøgelse 2)

Studie 3

71 af de 72 elever gennemførte testen. I gennemsnit identificerede deltagerne 55,5% (*SD* = 24,8) af items korrekt. Lidt under halvdelen af deltagerne scorede under gættesandsynligheden, og der ses en fornuftig spredning af scorerne (figur 7). Item-homogeniteten kan betragtes som god med Chronbach's alfa på ,90. De 28 items har gennemsnitligt et D på ,59 og fordeler sig således på kategorierne: > ,40 (26); ,30 - ,39 (2); ,20 - ,29 (1) og < ,19 (1). Korrelationen med Staveprøve 2 er moderat til stærk (*r* = ,61). Sammenlignes med resultaterne i pilotundersøgelse 2 ses en forbedring af item-homogeniteten og item-diskriminationen samt en stærkere korrelation med staveprøven.



Figur 7 Fordeling af deltagernes scorer på test af viden om betingede stavemønstre (studie 3)

Intern korrelation mellem de tre test af ortografisk viden

Et væsentligt spørgsmål at få svar på i udviklingen af de tre test af ortografisk viden er, i hvor høj grad de korrelerer med hinanden. Formålet med de tre test er at måle beslægtede, men forskellige aspekter af ortografisk viden. Derfor er det forventeligt, at der vil være en positiv sammenhæng mellem deltagernes præstationer på de tre test, men samtidig er det ikke ønskværdigt, at disse sammenhænge er meget stærke. Der er i tidligere undersøgelser rapporteret sammenhænge mellem forskellige test af ordspecifik ortografisk viden og grafotaktisk viden på mellem *r* = ,27-,66 (Conners et al., 2011; Conrad et al., 2013; Cunningham, 2006; Cunningham et al., 2001; Deacon et al., 2012; Hagialiassis et al., 2006). Tabel 3 viser de parvise korrelationer mellem de tre test af ortografisk viden i pilotundersøgelse 2 og i studie 3.

Alle parvise sammenhænge er positive og spænder fra svage til moderate. Korrelationerne er dermed af en styrke, der synes at leve op til formålet om, at testene skal

måle beslægtede, men forskellige aspekter af ortografisk viden. De parvise korrelationer er stærkere i studie 3 end i pilotundersøgelse 2. Dette skal sandsynligvis forklares med en generelt større spredning af deltagernes scorer i studie 3 sammenlignet med pilotundersøgelsen. Forskellen i spredning af deltagernes scorer skal sandsynligvis både forklares med testtidspunkt (1. halvår vs. 2. halvår af 3. klasse) samt en øget kvalitet af testene efter de beskrevne korrektioner.

Tabel 3 Korrelationer mellem de tre test af ortografisk viden i henholdsvis pilotundersøgelse 2 og studie 3

Test	*Pilotundersøgelse 2*	*Studie 3*
Ordspecifik / grafotaktisk	,54	,68
Ordspecifik / stavemønstre	,19	,59
Grafotaktisk / stavemønstre	,26	,53

Studie 2

Knowledge of conditional spelling patterns supports word spelling among Danish fifth graders

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Abstract

Background
Graphotactic knowledge and word specific orthographic knowledge have been shown to account for unique variance in concurrent spelling skills beyond phonological skills in the early school years.
Methods
The study examined whether knowledge of spelling patterns conditioned by phonological context would add to the concurrent prediction of spelling among 133 Danish fifth graders.
Results
Findings from other orthographies (e.g., English and German) were replicated, in that measures of graphotactic knowledge and word specific orthographic knowledge accounted for unique variance in spelling beyond phonological decoding. However, the results went further by demonstrating that a measure of knowledge of conditional spelling patterns was an independent predictor of spelling.
Conclusions
The findings indicate that children learning to spell in Danish use multiple sources of knowledge to guide their choice of spellings and call for increased attention to conditional spelling patterns in literacy instruction.
Keywords
Spelling, Orthographic knowledge, Conditional spelling patterns, Danish orthography

Highlights

What is already known about this topic

- Earlier studies have demonstrated that measures of lexical and sublexical orthographic knowledge account for unique variance in concurrent spelling skills, beyond phonological skills, in the early school years.
- Earlier studies have demonstrated that children and adults take advantage of phonological context in order to spell ambiguous consonants and vowels, and that several spelling patterns are not acquired until fairly late in grade school (ages 6-18).

What this paper adds

- Great variance in an experimental measure of knowledge of spelling patterns conditioned by phonological context was found among Danish children in Grade 5 (ages 10-12).
- Differences in performance on the measure of knowledge of conditional spelling patterns explained unique variance in concurrent spelling skills over and above phonological decoding, graphotactic knowledge, and word specific orthographic knowledge.

Implications for practice

- The findings support suggestions from other researchers that increased attention to conditional spelling patterns in literacy instruction is relevant.
- Training studies are needed to explore the potential of enhancing knowledge of conditional spelling patterns among children struggling to become competent spellers.

Introduction

Part of becoming a competent speller is learning to deal with the complexities that many alphabetic writing systems possess (Treiman & Kessler, 2013). One of the most challenging orthographies is English, due to the many complex graphemes and inconsistent mappings between phonemes and graphemes that characterize English orthography (Caravolas, 2004). Like English, Danish is considered a deep or inconsistent orthography (Elbro, 2006; Seymour, Aro, & Erskine, 2003) posing challenges for mastering the spelling of numerous Danish words.

When a child is asked to spell a word featuring a complex spelling pattern, it might be the case that the target word is already stored as an orthographic representation in the child's mental lexicon. The child could also use an analogous spelling strategy by assessing another familiar word. In both cases, the child will draw on his *word specific orthographic knowledge* when spelling the target word (Ehri, 2014). If the child does not know the spelling of the target word or an analogous word, the most basic strategy would be to spell the word phoneme by phoneme, using *knowledge of regular phoneme-grapheme correspondences*. The child's spelling attempt might also reflect conventional *graphotactic knowledge*, i.e., knowledge of how letters are legally and frequently combined in an orthography (Bourassa & Treiman, 2014). Graphotactic knowledge constrains the possible combination of letters that could constitute a plausible phonological spelling of a word. Another source the child might draw on is knowledge of *conditional spelling patterns*, i.e., knowledge of *phonologically* or *morphologically* based regularities that constrain the number of alternative spellings for ambiguous phonemes (Deacon, Conrad, & Pacton, 2008; Treiman & Kessler, 2006).

Spelling knowledge that goes beyond knowledge of regular phoneme-grapheme correspondences has been referred to as "orthographic" (e.g., Notenboom & Reitsma, 2003; Varnhagen, Boechler, & Steffler, 2009). Orthographic knowledge and skills have often been further separated with a lexical part referred to as *word specific* and a sublexical part referred to as *general* (e.g., Conrad, Harris, & Williams, 2013; Hagialiassis, Pratt, & Johnston, 2006; Loveall, Channell, Phillips, & Conners, 2013). Studies have demonstrated that both English and Danish spellers appear to make use of spelling knowledge beyond knowledge of regular phoneme-grapheme correspondences (Juul, 2005; Treiman & Kessler, 2006). Hence, it is relevant, from both a theoretical and an educational perspective, to investigate the specific types of spelling knowledge children may be using to become competent spellers.

The focus of the present study was to determine the significance of both lexical and sublexical orthographic knowledge for spelling skills among Danish fifth graders. Sublexical orthographic knowledge was further divided into two types of knowledge, termed *graphotactic knowledge* and *knowledge of conditional spelling patterns* (specifically, knowledge of spelling patterns that are conditioned by phonologically-based regularities). Thus, it was possible to address a question that has not been addressed by previous studies: to what extent does knowledge of conditional spelling patterns account for unique variance in spelling skills over

and above phonological decoding skills, word specific orthographic knowledge, and graphotactic knowledge?

Word specific orthographic knowledge, graphotactic knowledge, and knowledge of conditional spelling patterns are discussed separately in the following sections. Important to note, measures of spelling patterns conditioned by morphological context (e.g., the spelling of /e/ in h*ea*lth driven by the root h*ea*l) were not included in this study, despite the relevance of morphological knowledge for spelling (e.g., Bourassa & Treiman, 2008; Deacon & Bryant, 2005; Sangster & Deacon, 2011).

Word specific orthographic knowledge

Word specific orthographic knowledge has been defined as ''memory for specific visual/spelling patterns that identify individual words'' (Barker, Torgesen, & Wagner, 1992, p. 335). The self-teaching hypothesis (Share, 1995) describes the acquisition of word specific orthographic representations. According to this theory, phonological decoding is the central mechanism behind the self-teaching of written words, and well-specified orthographic representations are primarily acquired through independent reading. Repeatedly decoding new words successfully can lead to the formation of well-specified orthographic representations. As children gain more experience with the orthography through reading and writing, their grapheme-phoneme connections are strengthened and they gradually build up orthographic knowledge. Thus, the decoding of words is progressively adapted to the orthography in an interaction between phonological decoding skills and orthographic knowledge (Share 1995, 2008).

Different types of tasks have been used to assess word specific orthographic knowledge. Often, the participant has to select the spelling pattern that matches a specific word. The distractors are either real words, known as the *homophone verification test/homophone choice test*, or phonologically plausible spelling patterns, known as the *orthographic verification test/orthographic choice test*. The common feature for these tests is that they are designed to reflect the participant's ability to recognize written spellings of target words, without using phonological cues (Cunningham, Nathan, & Raher, 2011; Hagialiassis et al., 2006).

Moderate to strong correlations (ranging from r = .49 to .74) have been reported between measures of word specific orthographic knowledge and measures of word spelling among children in the early school years (Conrad et al., 2013; Cunningham, Perry, & Stanovich, 2001; Hagialiassis et al., 2006).

Graphotactic knowledge

Graphotactic knowledge has been described as knowledge of "the legal combinations of letters" (Deacon, Conrad, & Pacton, 2008, p. 118), and "letters and letter combinations that occur in the printed words" (Bourassa & Treiman, 2014, p. 572). It has been suggested that children gain knowledge of graphotactic features of orthography through *statistical learning* (e.g., Deacon et

al., 2008; Pollo, Treiman & Kessler, 2007; Treiman & Kessler, 2013), an implicit process in which children observe and internalize the relative frequency with which letters or letter combinations occur and co-occur when exposed to print (Savara & Caravolas, 2014).

Recent studies have shown that children as young as four, who have not begun to spell words phonologically, produce letter strings that conform to graphotactic patterns in their respective orthographies (Kessler, Pollo, Treiman, & Cardoso-Martins, 2013; Pollo, Kessler, & Treiman, 2009). Thus, even young children seem to be influenced by written language in their environment (Treiman & Kessler, 2013). Sensitivity to graphotactic patterns has also been found among children beginning to spell words phonologically. Treiman (1993) showed that children in Grade 1 were more likely to use frequent letter doublets compared to letter doublets that rarely occur in English orthography. Additionally, Wright and Ehri (2007) found that children in Kindergarten and Grade 1 used fewer trials to learn to read legally spelled words with single or doubled consonants than illegally spelled words containing initial doublets. Moreover, on a spelling posttest, the children remembered single consonants better than final doublets, and final doublets better than initial illegal doublets. These results indicate that the children's memory for new orthographic patterns were constrained by their existing graphotactic knowledge.

Different versions of the *nonword choice task* (e.g., Siegel, Share, & Geva, 1995; Treiman, 1993) have been used to measure graphotactic knowledge. In a nonword choice task the participant is presented with pairs of pronounceable nonwords and asked to select the nonword that looks more like a real word. If children are sensitive to graphotactic patterns they should choose the target nonword at above-chance levels (Bourassa & Treiman, 2014). The target nonword conforms to a specific graphotactic pattern of the orthography while the distractor does not. The nonword pairs from different versions of the test have been constructed to reflect sensitivity to the legal position of bigrams (e.g., *filv / filk*; Siegel et al., 1995), the legal position of doublets (e.g., *nnus / nuss*; Cassar & Treiman, 1997), the frequency of doublets (e.g., *yill / yihh*; ibid.), and the frequency of trigrams (e.g., *vage / vayj*; Conrad et al., 2013). Several studies across languages have shown that children in Grade 1 score above chance-levels in nonword choice tasks and that performance improves with age (e.g., Cassar & Treiman, 1997; Lehtonen & Bryant, 2005; Pacton & Fayol, 2004; Rothe, Schulte-Körne, & Ise, 2014).

Generally, moderate correlations (ranging from r = .47 to .62) have been reported between measures of graphotactic knowledge and word spelling among children in the early school years (Conrad et al., 2013; Cunningham et al., 2001; Hagialiassis et al., 2006; Rothe et al., 2014). However, one study (Ise, Arnoldi, & Schulte-Körne, 2014) found very low correlations (r = .05 - .16) between spelling and graphotactic knowledge in a sample of German children tested in Grade 1 and Grade 2. Rothe et al. (2014) have suggested that this finding might reflect a low reliability and validity of the nonword choice test used in the study.

Knowledge of conditional spelling patterns

In the current paper, knowledge of conditional spelling patterns refers to knowledge of spelling patterns that are inconsistent at the level of the single phoneme, but (more) consistent if *the phonological context* is considered (Juul, 2005). As for graphotactic knowledge, it has been suggested that children apply their statistical learning skills to the links between phonemes and letters as they gain more experience with the written language (Treiman & Kessler, 2013). The learning is conceived as statistical since it goes beyond all-or-none patterns to encompass probabilistic patterns (Treiman & Kessler, 2006). Through repeated exposures to text children gradually pick up both unconditional and conditional sound-spelling correspondences even though many of them are not explicitly taught. Following this, knowledge of conditional spelling patterns is essentially based on observations that particular sound–spelling correspondences are more frequent than others in a particular context (Kessler, 2009).

Several studies in English have demonstrated that children and adults take advantage of phonological context in order to spell ambiguous consonants and vowels (Hayes, Treiman, & Kessler, 2006; Treiman & Kessler, 2006; Treiman et al., 2002; Varnhagen et al., 1999). Moreover, knowledge of contextually conditioned spelling patterns seems to develop gradually, with some contexts being learned more quickly than others (Kessler, 2009). The same pattern has been found with Danish children from Grades 4 to 6 (Juul, 2005).

Some studies have used nonword spelling tasks to test performance on phonetically based context sensitive spellings (e.g., Dich, 2010; Treiman & Kessler, 2006; Treiman et al., 2002; Varnhagen, 1999). Nonword pairs are constructed in which the pronunciations of the experimental and control nonwords have the same onsets and vowels but different codas. The experimental nonwords are designed so that the coda conditions the spelling of the vowel, whereas the coda of the control nonword does not. For example, in the nonword spelling task used in the study by Dich (2010), the experimental nonwords were constructed so each contained one spelling that was the most typical spelling of the target vowel across all contexts, whereas the other was the most typical spelling of the vowel within the context of the particular rhyme. For the experimental nonword /deθ/, the default spelling of the rhyme would yield (daith), whereas the default spelling of the vowel would yield (dathe). For the control nonword /dek/, the default spelling of the vowel would yield (dake). Thus, if individuals take the rhyme context into account when spelling vowels, they should prefer the default rhyme spellings over default vowel spellings for the experimental nonwords but not for the control nonwords (Dich, 2010).

Cassar & Treiman (1997) used a version of the nonword choice task to test knowledge of phonological context on the use of single consonants versus doublets. Participants saw two letter strings while hearing a pronunciation of a nonword. Their task was to choose the best spelling for the word they heard. One nonword (e.g., *tebif*) contained a single medial consonant and the other contained a double medial consonant (e.g., *tebbif*). The pronunciation contained either a short or a long vowel before the medial consonant.

None of the above-mentioned studies report correlation coefficients between measures of knowledge of context sensitive spellings and word spelling measures. However, studies have found that good spellers are more sensitive to phonological context than poorer spellers; e.g., Treiman & Kessler (2006) found that children (ranging from Grade 1 to 9) with higher levels of spelling skill took more advantage of context. Similarly, Juul (2005) reported that good spellers (children from Grade 4 to 6) performed better on context sensitive vowels than on word specific vowels, compared to poor spellers. Dich (2010) found the same pattern with adults. The participants who were good at spelling challenging words were also good at using context information in nonword spelling.

Orthographic knowledge as predictor of spelling skills

Several studies have included measures of orthographic knowledge as predictors of word reading skills (e.g., Bekebrede, van der Leij, & Share, 2009; Deacon, 2011; Deacon, Benere, & Castles, 2012; Cunningham, Perry, & Stanovich, 2001; Cunningham & Stanowich, 1990; Georgiou, Parrila, & Papadopoulos, 2008; Roman, Kirby, Parrila, Wade-Woolley, & Deacon, 2009). However, fewer studies have included measures of orthographic knowledge as predictors of spelling abilities (e.g., Arab-moghaddam & Sénéchal, 2001; Conrad et al., 2012; Ise et al., 2014; Rothe et al; 2014).

Two recent studies with German-speaking children have investigated the longitudinal and concurrent prediction of *graphotactic knowledge* for spelling skills in the early school years. In the study by Ise et al. (2014) children were followed from Kindergarten to Grade 2. No systematic relationship between performances on a nonword choice task and a standardized spelling test were found at any grade level. Contrary to this result, Rothe et al. (2014) found that children's performances on two nonword choice tasks (targeting sensitivity to frequent double consonants and sensitivity to legal positions of double consonants) at the end of Grade 1 accounted for a significant amount of unique variance (7%) in their concurrent spelling performance after controlling for phonological awareness, rapid automatized naming, verbal short-term memory, letter knowledge, and nonverbal IQ. However, no correlations were found between children's graphotactic knowledge in Kindergarten and their subsequent spelling performance. This result might well be explained by the children's low performance on the nonword choice task in Kindergarten (ibid.)

Arab-Moghaddam and Sénéchal (2001) examined the concurrent role of phonological and orthographic skills in spelling among bilingual Persian-English children (Grade 2 and Grade 3). *Word specific orthographic knowledge* was measured using an orthographic choice test. For English spelling, word specific orthographic knowledge explained a significant 5% of the variance after controlling for grade, vocabulary, reading experience, and phonological skills. For Persian spelling, word specific orthographic knowledge explained a significant 22% of the variance.

Conrad et al. (2013) investigated the concurrent prediction of spelling among 7-9 year old English-speaking children. They included *graphotactic knowledge* (a nonword choice task) and

word specific orthographic knowledge (an orthographic choice task) as predictor measures. A composite measure of the children's performances on the two tests was calculated. The composite measure of orthographic knowledge explained a significant amount of unique variance in children's word spelling skills (29%) after controlling for age and phonological awareness.

The present study

As described above, sensitivity to phonological context seems to be important in the acquisition of competent spelling skills in inconsistent orthographies like English and Danish (e.g., Juul, 2005; Kessler, 2009). However, measures targeting knowledge of phonetically based context sensitive spellings have not been included in previous studies concerning the contribution of lexical and sublexical orthographic knowledge to spelling abilities. Moreover, these previous studies have only focused on the significance of orthographic knowledge for spelling during the early school-age years. Based on this, the main question addressed in the present study was to what extent knowledge of conditional spelling patterns would account for unique variance in concurrent spelling skills over and above phonological decoding skills, graphotactic knowledge, and word specific orthographic knowledge among Danish children in Grade 5. Previous studies with English-speaking children have shown that various spelling patterns (e.g., the most common spelling of /i/ in medial position is *ea*, as in *dream*, but in words that end with /p/, *ee*, as in *creep*, outnumbers *ea* (Treiman, Kessler, & Bick, 2002)) are not acquired until fairly late in grade school, and in many cases, the patterns that are acquired are not applied nearly as often as they ought to be (Kessler, 2009). Hence, Grade 5 should be a relevant time to explore the significance of different types of orthographic knowledge for more advanced spelling skills in the opaque Danish orthography.

It was anticipated that both phonological decoding and word specific orthographic knowledge would be strongly correlated with word spelling. This is based on the notion that phonological decoding is central for the acquisition of orthographic representations (e.g., Share, 1995, 2008), and that skilled word spelling draws on fully specified orthographic representations, to which tasks of word specific orthographic knowledge are thought to be sensitive (e.g., Burt, 2006; Castles & Nation, 2006; Vellutino, Scanlon & Tanzman, 1994). However, when words are not yet stored as fully specified word specific orthographic representations in the mental lexicon, other sources of orthographic knowledge may be important for correct word spelling (e.g., Bourassa & Treiman, 2014).

It was hypothesized that both measures of graphotactic knowledge and knowledge of conditional spelling patterns would be independent predictors of word spelling over and above phonological decoding and word specific orthographic knowledge. However, since participants (mean age = 11;3) were students with at least five years of formal reading instruction, it was anticipated that the majority would perform near ceiling on the test of graphotactic knowledge, which would weaken its predictive power.

Method

Participants

The present study was conducted in Copenhagen, Denmark. 133 students from nine classes, in five schools, in mixed socioeconomic status neighbourhoods completed a battery of tests at the beginning of Grade 5. Only participants who completed the whole test battery were included, otherwise no specific inclusion or exclusion criteria were used. Mean ages were 11 years three months (*SD* = 4 months), and participants were equally distributed on gender. Nine students (7%) were bilingual, with all but one listing Danish as their preferred language. Informed consent was obtained from all individual participants included in the study.

Analyses of the same sample have previously been reported in four articles (Elbro, de Jong, Houter & Nielsen, 2012; Juul, Poulsen & Elbro, 2014; Poulsen, Juul & Elbro, 2012; Nielsen & Juul, 2015).

Procedure

All testing was done by trained assistants and took place in a quiet room at the participants' school or, for the group-administered tests, in the participants' own classroom.

Measures

The four predictive measures presented below were devised and piloted for the present study, as no existing tests applicable for the purpose of the study were available in Danish.

Phonological decoding In this individually administered test the participants read aloud two nonword lists (see Appendix A). The nonwords were constructed of five to eight letters and included one to three syllables. Several nonwords contained two and/or three consonant clusters (e.g., *skvemp*). Each list consisted of eight nonwords plus an easy starter (a VC nonword which was not scored). Thus, the total number of items was 16. Participants were asked to read the lists as accurately and fast as they could. The final score represented the number of nonwords correctly decoded. Cronbach's alpha was .85 and the correlation between the two nonword lists was r = .64.

Word specific orthographic knowledge In this group-administered homophone choice test, short written sentences were presented with two homophonic real words displayed side by side (e.g., *Der sidder en krave / krage i træet* 'A crow (*krage*) is sitting in the tree'). A total of 20 pairs were included (see Appendix A), with each member of the pair presented separately, resulting in 40 sentences. Each sentence was read aloud, and the children were asked to circle the word spelling that best fit the sentence. Two examples were presented on the classroom board to ensure that the children understood the task. They were instructed to guess if they did

not know the answer. The test was divided in two parts, and each member of the homophone pairs was presented in either the first (A) or the second (B) part. Part A was completed first and part B was completed last, out of a total of three group tests completed during one test session. To reduce the effect of guessing, the score was calculated as the number of homophone pairs correct, i.e., to get a correct score, the participants had to choose the correct spelling of *each* member of a homophone pair. Thus, the final score represented the number of the 20 homophone pairs correctly identified. Cronbach's alpha was .75.

Graphotactic knowledge This group-administered nonword choice task consisted of 30 pairs of four- to seven-letter nonwords (see Appendix A). The nonword pairs had similar pronunciations and parallel structure. In each pair the target nonword contained a letter pattern found regularly in Danish words (e.g., *pryldt*). The distractor nonword contained a letter pattern never or rarely found in Danish words (e.g., *pryllt*). The participants were asked to look at the nonword pairs and circle the nonword that looked most like a real word. Two examples were presented on the classroom board to ensure that the children understood the task. They were instructed to guess if they did not know the answer. The final score represented the number of correct answers. Cronbach's alpha was .72.

Knowledge of conditional spelling patterns This group-administered nonword choice task consisted of 30 pairs of four- to seven-letter nonwords (see Appendix A). The test leader pronounced a nonword (e.g., [sbɑjnə]), and the participants were asked to look at the nonword pair and to circle the best spelling for the pronunciation they heard. In each pair the target nonword contained a letter pattern in which the vowel is irregularly spelled in Danish words (e.g., [ɑjnə] spelled -*egne*). However, the spelling of the vowel is more predictable if the phonological context is taken into account. The letter-sound patterns used for the target nonwords are found in several Danish words. The distractor nonword contained a letter pattern which was a phonologically plausible spelling of the nonword pronounced (e.g., -*ajne*). Moreover, the letter pattern in the distractor nonword was characterized by one of the following features: 1) the letter pattern is never found in Danish words with the same structure, but it represents a regular spelling of the target pronunciation (e.g., -*ajne*), 2) the letter pattern is a rare representative for the target pronunciation in Danish words (e.g., [ɑjlə] spelled -*ajle*), or 3) the letter pattern is consistently pronounced differently in Danish words (e.g., the pronunciation of the target letter pattern -*ippe* is [ebə], while the distractor letter pattern -*eppe* is pronounced [ɛbə]). Two examples were presented on the classroom board to ensure that the children understood the task. They were instructed to guess if they did not know the answer. The final score represented the number of correct answers. Cronbach's alpha was .85.

Word spelling Spelling abilities were assessed with an age-appropriate standardized group-administered test of word spelling named *Staveprøve 3* ('Spelling Test 3', recommended for students from Grade 4 to 6; Juul, 2012). The test consists of 36 items which target advanced

spelling abilities (e.g., many items feature vowel spellings that are not predictable from phonology, silent letters, or suffixes that need to be identified as such in order to be spelled correctly). The final score represented the number of correct word spellings. Cronbach's alpha in the standardization sample was .94 (Juul, 2012).

Results

Table 1 displays descriptive statistics for all variables. Participants scored within the average range for their age group on the standardized spelling task. When decoding fairly complex nonwords, many of the participants struggled to decode them accurately (Table 1). This may seem surprising given the presumed amount of print experience of Grade 5 students. However, the accuracy score might, to some extent, reflect decoding efficiency, since the participants were asked to decode the nonwords as fast as possible. Thus, for some of the participants, the speed demand might have influenced the decoding accuracy negatively.

To investigate whether the participants performed above chance level on the measures of word specific orthographic knowledge, graphotactic knowledge, and knowledge of conditional spelling patterns, the mean number of correct responses on the tasks was compared with chance performance using one-sample t-tests. The participants performed significantly above chance level on the word specific orthographic knowledge task ($t(131) = 41.5$, $p < .001$); on the graphotactic knowledge task ($t(131) = 60.8$, $p < .001$), and on the task of knowledge of conditional spelling patterns ($t(131) = 2.2$, $p = .03$). The majority of the children performed near ceiling on the graphotactic knowledge task, causing limited sensitivity. Nevertheless, 19% of the participants scored between 50 and 90% correct on this task, illustrating that, even in Grade 5, variability in graphotactic knowledge can be identified. In contrast, and somewhat surprisingly, 42% of the children scored at or below chance level on the task of knowledge of conditional spelling patterns. The broad range in scores (Table 1) indicates that this type of sublexical orthographic knowledge is still developing among Danish children in Grade 5.

The distributions of scores were examined for normality. The graphotactic knowledge task was severely negatively skewed and was consequently transformed following Tabachnick & Fidell (2014, p. 120-122) before conducting analyses. One participant was excluded from analyses as a univariate outlier.

Table 1 Descriptive statistics for all variables

Measure	*Range*	*M*	*SD*	*Skewness*
PD (*max = 16*)	1.0 - 16.0	11.4	3.7	-0.8
WSOK (*max = 20*)	6.0 - 20.0	16.4	3.1	-1.1
GK (*max = 30*)	16.0 - 30.0	27.8	2.4	-2.1
KCSP (*max = 30*)	2.0 - 28.0	16.2	6.3	-0.1
WS (*max = 36*)	1.0 - 35.0	22.7	7.4	-0.5

Note. PD = phonological decoding; WSOK = word specific orthographic knowledge; GK = graphotactic knowledge; KCSP = knowledge of conditional spelling patterns; WS = word spelling

Pearson correlations among all variables are shown in Table 2. The four predictor variables were all significantly correlated with word spelling. Word specific orthographic knowledge was moderately correlated with graphotactic knowledge and knowledge of conditional spelling patterns, whereas the two measures of sublexical orthographic knowledge did not correlate with each other. Phonological decoding was strongly correlated with word spelling skills. As mentioned above, this might reflect that the nonword decoding task was sensitive to *efficiency* in grapheme-phoneme translation skills. Both accuracy and speed in phonological decoding is thought to be related to success in orthographic learning (e.g., Share, 2011). In line with expectations, word specific orthographic knowledge correlated strongly with word spelling. This was expected since measures of word specific orthographic knowledge are presumably drawing on fully specified orthographic representations just as skilled word spelling is (e.g., Burt, 2006; Castles & Nation, 2006).

Table 2 Correlations between variables

	1	2	3	4	5
1. PD	-				
2. WSOK	.40**	-			
3. GK	.13	.40**	-		
4. KCSP	.40**	.26**	.10	-	
5. WS	.62**	.71**	.39**	.47**	-

Note. PD = phonological decoding; WSOK = word specific orthographic knowledge; GK = graphotactic knowledge; KCSP = knowledge of conditional spelling patterns; WS = word spelling
* $p < .05$. ** $p < .01$.

The result of a hierarchical regression analysis is presented in Table 3. The analysis was conducted to determine whether knowledge of conditional spelling patterns would be a unique concurrent predictor of word spelling skills. Phonological decoding was entered first to control

for the contribution of knowledge of regular grapheme-phoneme connections. Following this, word specific orthographic knowledge was entered at the second step. At the third step, graphotactic knowledge was entered, followed by knowledge of conditional spelling patterns at the fourth and final step.

Knowledge of conditional spelling patterns predicted a significant 3% of the variance in word spelling, after controlling for phonological decoding, word specific orthographic knowledge, and graphotactic knowledge. The independent contributions of both measures of sublexical orthographic knowledge were modest indeed (Table 3). However, the magnitude of the contribution from sublexical orthographic knowledge to word spelling skills should be viewed in light of the strong control. In total, phonological decoding and word specific orthographic knowledge explained 65% of the variance in word spelling skills. Since the predictor measures are all moderately correlated with each other, it is notable that both measures of sublexical orthographic knowledge survived the strong control.

Due to the nested structure of the data (children nested in classes), an alternative hierarchical multiple regression analysis with group-centred variables was conducted. By centring the variables on classroom means, the between group variance was removed. The predictive patterns found with this alternative analysis were essentially the same as depicted in Table 3.

Table 3 Hierarchical Multiple Regression Analysis for Variables Predicting Concurrent Spelling in Grade 5

Step	*Predictor*	R^2	ΔR^2	*Final β*
1	PD	.39	.39	.33***
2	WSOK	.65	.26	.47***
3	GK	.67	.02	.14*
4	KCSP	.70	.03	.20***

Note. PD = phonological decoding; WSOK = word specific orthographic knowledge; GK = graphotactic knowledge; KCSP = knowledge of conditional spelling patterns; WS = word spelling
* $p < .05$. *** $p < .001$.

Discussion

The present study examined whether a measure of knowledge of spelling patterns conditioned by phonological context would add to the concurrent prediction of word spelling skills among Danish fifth graders over and above measures of phonological decoding skills, word specific orthographic knowledge, and graphotactic knowledge. As anticipated, both phonological decoding skills and word specific orthographic knowledge were strongly correlated with word spelling skills. Nonetheless, after accounting for phonological decoding skills and word specific orthographic knowledge, both graphotactic knowledge and knowledge of conditional spelling patterns explained additional variance in word spelling. Thus, the results support the notion that different types of knowledge sources are available for children when spelling words (e.g., Bourassa & Treiman, 2014).

The majority of the participants scored near ceiling on the test of graphotactic knowledge. It may not be surprising since the children participating in this study have had at least five years of formal reading and writing instruction and a fairly great amount of reading experience. In line with studies with younger children (Conrad et al., 2013; Rothe et al., 2014), the variation found in graphotactic knowledge in the present study did explain unique variance in word spelling skills in Grade 5. Most importantly, this study further clarified that knowledge of conditional spelling patterns was an independent concurrent predictor of word spelling. The great variability in performance suggests that most Danish children in Grade 5 are still acquiring knowledge of spelling patterns conditioned by phonological context.

In line with earlier studies, a moderate correlation between measures of graphotactic knowledge and word specific orthographic knowledge was found in the present study (e.g., Conrad et al., 2013; Cunningham, 2006; Hagialiassis et al., 2006). However, contrary to expectations, the two measures of sublexical orthographic knowledge did not correlate with each other. This result might be explained by several factors: first of all, the sensitivity of the measure of graphotactic knowledge was limited, restricting correlations with other measures. Further, both measures of sublexical orthographic knowledge were based on forced choice tasks with a chance level of 50%, making them subject to a considerable amount of measurement error. Finally, the two measures were designed to measure different aspects of orthographic knowledge. The correlational pattern between phonological decoding and the three measures of orthographic knowledge supports that this was indeed accomplished. While phonological decoding correlated moderately with word specific orthographic knowledge and knowledge of conditional spelling patterns, it only correlated weakly with graphotactic knowledge. One likely interpretation is that the measure of graphotactic knowledge is primarily sensitive to *visual* recognition of letter patterns, while the measure of knowledge of conditional spelling patterns is primarily sensitive to recognition of *sound-spelling* patterns.

Direction of causality

Following a statistical learning perspective, the rate of acquisition of knowledge of conditional spelling patterns should depend heavily on amount of print exposure (e.g., Kessler, 2009). However, the correlational nature of the present study does not shed light on the direction of causality. That is, whether variation in sub-types of orthographic knowledge is predictive of progress in spelling, or if positive correlations between word spelling and sub-types of orthographic knowledge can be entirely explained by a common underlying factor. Studies have found that measures of print exposure contributes unique variance to orthographic knowledge suggesting that reading and spelling experience boosts the development of orthographic knowledge (Chateau & Jared, 2000; Cunningham et al., 2001; Cunningham & Stanovich, 1993; Mesman & Kibby, 2011; Stanovich & West, 1989). However, Barker et al. (1992) found that variation in orthographic knowledge existed independently from amount of reading exposure among children in Grade 3. Yet, they also stressed that measures of print experience are not sensitive enough to rule out the possibility that variation in orthographic knowledge can be fully explained by amount of print exposure (ibid.).

The issue of directionality between orthographic knowledge and *word reading skills* has been tested in a three-year longitudinal study of children from Grades 1 to 3 (Deacon et al., 2012). The study included measures of lexical orthographic knowledge (an orthographic choice test), sublexical orthographic knowledge (a nonword choice task), word reading accuracy, and controls of vocabulary, non-verbal reasoning, and phonological awareness. In all analyses, word reading predicted progress in the acquisition of orthographic knowledge. In contrast, measures of orthographic knowledge did not predict progress in word reading, suggesting that children in the early school years acquire orthographic knowledge through their reading, and that variability in orthographic knowledge does not play an independent role in supporting reading acquisition (ibid).

The issue of directionality between sublexical orthographic knowledge and *word spelling skills* were tested in two studies with German-speaking children from Kindergarten, Grade 1, and Grade 2. As mentioned in the introduction, Ise et al. (2014) did not find any systematic relationship between performances on a nonword choice task and a standardized spelling test at any grade level. Rothe et al. (2014) found that children's graphotactic knowledge at the end of Grade 1 accounted for a significant amount of unique variance in their *concurrent* spelling performance after controlling for known predictors. However, since no correlations were found between the children's graphotactic knowledge in Kindergarten and their subsequent spelling performance, the results do not support that differences in orthographic knowledge play an independent role in spelling acquisition.

Since existing measures of lexical and sublexical knowledge appear to be sensitive to the outcome of literacy acquisition rather than a process that is underpinning this development (e.g., Burt, 2006; Castles & Nation, 2006; Deacon et al., 2012), researchers call for the development of new measures that capture the ability to form and store orthographic representations, akin to orthographic learning tasks (Burt, 2006; Deacon et al., 2012). Deacon

et al. (2012) stress that such measures should build on findings that differences in sublexical orthographic knowledge explain variance in reading and spelling beyond lexical orthographic knowledge. This notion is supported by the findings of the present study, indicating that at least some Danish children in Grade 5 are drawing on both graphotactic knowledge and knowledge of conditional spelling patterns when spelling rather advanced words. A central question to address in future studies is whether differences in such sub-types of orthographic knowledge are a contributing factor to the acquisition of fully specified orthographic representations critical for the development of competent spelling skills.

Measurement issues

A limitation of the test measuring knowledge of conditional spelling patterns is that the participants might not be responding to the target pronunciation when choosing between the items in a nonword pair even though they are instructed to do so. Instead, they might guess by chance or draw on graphotactic knowledge choosing the letter combinations that are most frequently found across Danish words *regardless* of pronunciation. As described in the method section, the items could be separated in three groups based on the spelling patterns found in the distractor nonwords: 1) the letter pattern is never found in Danish words with the same structure, but represents a regular spelling of the target pronunciation, 2) the letter pattern is a rare representative for the target pronunciation in Danish words, or 3) the letter pattern is consistently pronounced differently in Danish words. Drawing solely on graphotactic knowledge when solving the items of group 1 would most likely result in a correct answer, since the letter combinations in the distractor words can be viewed as *illegal* in the specific context. In contrast, using a phonological strategy, but not taking into account the phonological context, would most likely result in a wrong answer, since the letter strings of the distractors represent regular spellings of the target pronunciations. The spelling patterns found in the distractor and target nonwords from group 2 and 3 are not matched on frequency when it comes to how often they appear in Danish words *regardless* of pronunciation. Therefore, the participants might draw on graphotactic knowledge and choose the nonwords with the most frequent spelling pattern not taking pronunciation into account. Hence, the present design does not rule out the possibility that participants use graphotactic knowledge to some extent to solve the task. However, some results speak against this. First, the high internal consistency found in the test indicates that the participants were drawing on the same type of knowledge/using the same strategy when choosing nonwords regardless of which of the three groups the nonword pairs belong to. Further, if the participants were mainly drawing on graphotactic knowledge, one would expect that the items of group 1 would predominantly produce correct answers. However, the mean score of group 1 items is just above chance level (55%). Moreover, the correlation between the participants' performance on knowledge of conditional spelling patterns and their performance on the task specifically designed to test graphotactic knowledge is very weak, and the two measures explain different variance in word spelling. Finally, phonological decoding correlates moderately with knowledge of conditional

spelling patterns, unlike graphotactic knowledge. This suggests that the measure of graphotactic knowledge is primarily sensitive to *visual* recognition of letter patterns, while the measure of knowledge of conditional spelling patterns is primarily sensitive to recognition of *sound-spelling* patterns.

Limitations

A weakness of the design in the current study is that it only included one task to measure each type of orthographic knowledge. Estimates of different types of orthographic knowledge based on a single measure could be subject to a considerable amount of measurement error, not least when using forced choice tasks. Hence, including multiple measures of each type of orthographic knowledge would have been a substantial improvement of the study.

A measure of nonword decoding was included as a control for the participants' knowledge of regular grapheme-phoneme connections. However, since the study was concerned with the concurrent prediction of word spelling abilities rather than word reading abilities, it might have been more appropriate to control for the participants' knowledge of phoneme-grapheme connections using a nonword spelling task (Savage, Pillay, & Melidona, 2008). However, phonological decoding has been used to control for phonological skills in earlier studies investigating the prediction of spelling abilities from measures of orthographic knowledge making the results from the current study comparable to earlier results (Arab-Moghaddam & Sénéchal, 2001; Conrad et al., 2013).

Finally, the predictor measures included in the present study explained a substantial part of the variation in word spelling skills. However, the role of knowledge of spelling patterns conditioned by *morphological* regularities is a missing piece in the predictive pattern found in the present study. As described in the introduction, several studies have demonstrated the significance of morphological knowledge for spelling (e.g., Bourassa & Treiman, 2006; Deacon & Bryant, 2005).

Implications for practice

Poor spellers have been found to write fewer words and produce lower quality compositions than good spellers, making correct word spelling an important part of successful written communication (Abbott, Berninger, & Fayol, 2010; Moats, Foorman, & Taylor, 2006). The present study demonstrated great variability in spelling abilities among fifth graders learning to spell in the opaque Danish orthography. Notably, great variance in different types of orthographic knowledge supporting word spelling was also found. This highlights the need for direct and systematic spelling instruction in later phases of literacy development.

The benefits of spelling instruction were attested in a recent meta-analysis with studies including participants from kindergarten through 12th Grade. Positive effects on spelling, writing, and even on reading comprehension were found (Graham & Santangelo, 2014). The results of the review indicated that systematic spelling instruction had a positive impact with

both younger and older students. As a result, the authors recommend that teachers in the upper elementary grades should place more emphasis on such instruction (ibid.). Since knowledge of conditional spelling patterns was found to be a unique predictor of spelling skills in the present study, it seems useful to make this type of knowledge subject to direct spelling instruction in irregular orthographies.

Conclusion

The most striking finding in the present study was that great variance in an experimental measure of knowledge of conditional spelling patterns was found among Danish children in Grade 5. Importantly, differences in performance on this task correlated moderately with word spelling and explained unique variance in concurrent spelling abilities over and above phonological decoding, word specific orthographic knowledge, and graphotactic knowledge. Based on earlier studies demonstrating that children and adults take advantage of phonological context in order to spell ambiguous consonants and vowels, and that several useful spelling patterns are not acquired until fairly late in grade school, researchers have suggested that increased attention to conditional spelling patterns in literacy instruction would be relevant (Juul, 2005; Kessler, 2009; Treiman & Kessler, 2013). This suggestion is supported by the present study. However, training studies aiming at measuring the effect of direct instruction targeting conditional spelling patterns are needed to further explore this.

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Appendix A

Words and nonwords used in the tests of phonological decoding, word specific orthographic knowledge, graphotactic knowledge, and knowledge of conditional spelling patterns

Test of phonological decoding (16 items)

spalk	klast
panke	hænke
grumle	flurme
skvemp	sprøng
trønser	klommet
kværler	snæffes
prifling	pjølerne
skylerne	kaligyne

Test of word specific orthographic knowledge (20 items)

gælle / gælde	bunde / bonde
toge / tåge	viske / hviske
krage / krave	borde / bore
vær / værd	bække / begge
skrald / skræl	lege / leje
love / låge	gård / går
held / hæld	hvide / vide
svær / sværd	rat / ret
lægger / lækker	skin / skind
vejr / hver	ryk / ryg

Test of graphotactic knowledge (30 items)
Target nonwords in italics

sgæb / *skæb*
semp / semb
gønns / *gønds*
qvøse / *kvøse*
sdyf / *styf*
skrik / sgrik
cråne / *kråne*
spøk / sbøk
vrutt / *vrudt*
rys / ryz
cleg / *kleg*
palds / palls
sprolle / sbrolle
plosg / *plosk*
dax / *daks*
strum / sdrum
sveze / *svese*
spruk / sbruk
støsk / støsg
haks / hax
vømp / vømb
sdynne / *stynne*
sgæne / *skæne*
skrale / sgrale
pryz / *prys*
spaj / sbaj
fått / *fådt*
krøse / crøse
klåk / clåk
pryllt / *pryldt*

Test of knowledge of conditional spelling patterns (30 items)
Target nonwords in italics

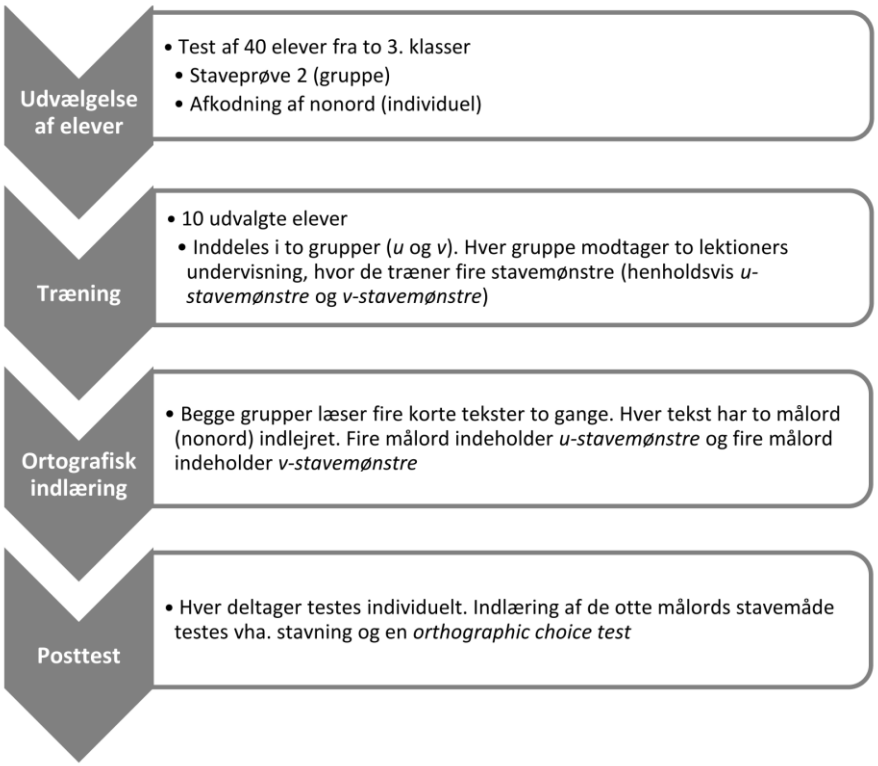
pøng / *pyng*
kånd / kon
mippe / meppe
fjårt / *fjort*
trajle / *trejle*
bingsle / bengsle
nense / *ninse*
nufle / nåfle
jynde / jønne
pleske / *pliske*
jumle / jåmle
plajne / *plegne*
gåndle / *gundle*
goppe / gåppe
sponds / *spunds*
tuft / tåft
klind / klend
nunds / nonds
lånd / lon
spajne / *spegne*
jenk / *jink*
kvop / kvåp
kåms / *kums*
tåndsk / *tundsk*
jisk / jesk
tøngs / *tyngs*
tjort / tjårt
drejle / drajle
bleppe / *blippe*
vynder / vønner

Rapport om pilotering af træningsundersøgelsen i studie 3

Før iværksættelsen af den endelige træningsundersøgelse i studie 3 var det vigtigt at få en ide om, hvorvidt den planlagte træning var mulig at gennemføre som tiltænkt, og hvorvidt den gav anledning til positiv overføringseffekt til indlæring af ordspecifikke stavemåder under selvstændig læsning. Hvis en overføringseffekt kunne identificeres i pilotundersøgelsen, kunne effektstyrken vha. en power-analyse anvendes til at beregne, hvor mange deltagere der som minimum burde indgå i den endelige træningsundersøgelse, hvis man med en given sandsynlighed skulle finde en signifikant forskel på mål for indlæring af ordspecifikke stavemåder mellem eksperiment- og kontrolgruppen.

Design af pilotafprøvningen

I piloteringen af træningsundersøgelsen fungerer hver elev som sin egen kontrol, idet det undersøges, hvorvidt der hos den enkelte deltager er signifikant forskel i indlæring af ordspecifikke stavemåder betinget af, hvorvidt stavemåderne indeholder trænede stavemønstre eller ej. Dette design adskiller sig fra den endelige træningsundersøgelse, hvor det undersøges, hvorvidt der mellem en matchet eksperiment- og kontrolgruppe er signifikant forskel i indlæring af ordspecifikke stavemåder betinget af, hvorvidt *gruppen* har modtaget træning eller ej. Valget af design til pilotafprøvningen blev truffet på baggrund af, at det kun var muligt at gennemføre piloteringen med et meget begrænset deltagerantal, pga. de ressourcer det kræver at gennemføre hele træningsundersøgelsen samt at opgøre og efterfølgende analysere data. Vurderingen var, at der ville være en større chance for at opdage en signifikant effekt af træningen, hvis hver deltager fungerede som sin egen kontrol frem for at operere med matchede grupper. Det skyldes, at den usystematiske variation (ofte kaldet fejlvariationen) reduceres kraftigt ved at sammenligne de samme deltagere frem for forskellige deltagere under to forskellige betingelser. Det gør det lettere at opdage systematisk variation betinget af den eksperimentelle manipulation (Field, 2013). Figur 8 viser de overordnede elementer i pilotafprøvningen. Hvert element uddybes i de følgende afsnit.



Figur 8 Overordnede elementer i piloteringen af træningsundersøgelsen i studie 3

Udvælgelse af elever

I forbindelse med piloteringen af de nyudviklede gruppetest (se tabel 2 s. 59) blev 40 elever fra to 3. klasser gruppetestet med den standardiserede stavetest *Staveprøve 2* (Juul, 2012). Ligeledes blev elevernes afkodning af nonord testet individuelt. Hver elev blev bedt om at læse to lister med hver ti nonord så præcist og så hurtigt, som de kunne. På baggrund af staveprøven og nonordtesten samt lærernes vurdering af, hvilke elever der var egnede til at indgå i gruppeundervisningen, blev fem elever fra hver af de to 3. klasser udvalgt til at indgå i piloteringen af træningsundersøgelsen. Pga. sygdom var det ikke muligt at gennemføre hele træningsforløbet med en af de fem elever fra u-gruppen. Derfor er de efterfølgende resultater baseret på ni elever. Som det fremgår af tabel 4, opnår de fem udvalgte elever fra v-gruppen gennemsnitligt højere score end de fire udvalgte elever fra u-gruppen på stavning og på afkodning af nonord.

Tabel 4 Deskriptiv statistik for afkodning af nonord og stavning

Gruppe	*N*	*Nonord, ok pr. minut* *M(SD)*	*Stavning, ok (max 17)* *M(SD)*
u	4	41,3(8,8)	8,7(4,0)
v	5	44,1(9,9)	10,0(4,1)

Træning

I alt indgik otte forskellige stavemønstre i træningen. Mens u-gruppen deltog i to lektioners undervisning, hvor de arbejdede med fire stavemønstre (kaldet *u-stavemønstre*), deltog de fem elever fra v-klassen i to tilsvarende lektioners undervisning med fire andre stavemønstre (kaldet *v-stavemønstre*). Stavemønstrene fremgår af tabel 5. I undervisningen af de to grupper indgik forskellige stavemønstre, da det gjorde det muligt at pilotere træningen med otte bogstavfølger frem for kun fire.

Tabel 5 Stavemønstre trænet af henholdsvis gruppe u og gruppe v

Gruppe	*Trænede stavemønstre*
u	rymme [ʁœmə] - osse [ʌsə] - igl [iˀl] [i:l] - ygl [yˀl] [y:l]
v	ods [ʌs] - eds [ɛs] - algt [alˀd] [ald] - ølgt [ølˀd] [øld]

Som introduktion til undervisningen fik eleverne at vide, at de skulle lære at stave navnene på seks kæmper. For at kunne det skulle de først lære om nogle bestemte bogstavfølger, der indgik i kæmpernes navne. Derefter fik de at vide, at alle de ord, de kom til at arbejde med i undervisningen, var vrøvleord, så de ikke kendte ordenes stavemåde i forvejen. Dernæst blev eleverne introduceret til, hvad en bogstavfølge er (fx *-ette* i Anne-M*ette*, udtales altid [ɛdə]). Første lektion var bygget op som følger:

- *Introduktion* af stavemønstrene (fx *–eds* [ɛs] og *–ods* [∧s]). Her fokus på stumt d og den betingede udtale af vokalen.
- *Afkodning* af seks nonord indeholdende stavemønstrene. Først afkodede eleverne ordene for sig selv, derefter læste de hver ét af ordene højt. Underviseren gav feedback og mindede om udtalen af stavemønstrene efter behov.
- *Stavning* med seks nonord indeholdende stavemønstrene. Eleverne fik at vide, at de nu skulle stave seks ord, der indeholdt ét af stavemønstrene. Underviseren dikterede ordene, og eleverne skrev dem på et kopiark. Derefter blev ordenes stavemåde gennemgået i plenum.
- *Diktat* i form af højtlæsning af en kort tekst om de seks kæmper, eleverne skulle lære at stave navnene på. I teksten blev hver kæmpe præsenteret med en række unikke egenskaber. Eleverne havde forinden fået udleveret et kopiark med illustrationer af

de seks kæmper. Deres opgave var at matche hver illustration med navnet på en af kæmperne ud fra de egenskaber, de fik fra højtlæsningsteksten. Når de havde fundet et match, skulle de skrive navnet på kæmpen ved siden af den rigtige illustration. Navnene blev efterfølgende gennemgået på tavlen. Hver elev fik lov at diktere, hvordan de havde stavet ét af navnene, og underviseren skrev det på tavlen. Hvis stavemåden var forkert, blev den rettet og kommenteret, og eleverne blev bedt om at skrive den rigtige stavemåde på kopiarket, hvis de havde stavet det forkert i første omgang.

- Alle kopiark blev samlet ind og eleverne fik en kort pause inden anden lektion.

I anden lektion blev eleverne introduceret til to nye stavemønstre, de skulle kende for at kunne stave navnene på seks hekse. Lektionen fulgte ovenstående skabelon.

Ortografisk indlæring

To til tre dage efter træningen deltog de ni elever i et individuelt træningspas, hvor de blev præsenteret for otte målord (nonord) indlejret i fire korte tekster. Fire af de otte målord indeholdt u-stavemønstre [*trymme, vrygle, gosse, frigle*], mens de øvrige fire målord indeholdt v-stavemønstre [*medsk, hølgte, gjods, balgt*]. Hvert målord blev præsenteret som navnet på en opfindelse. Først så eleven en illustration af opfindelsen og fik at vide, hvad den hed. Derefter blev eleven bedt om at højtlæse en kort tekst om opfindelsen to gange. Under første højtlæsning fik eleverne hjælp til fejllæsninger, anden gang læste de teksten uden hjælp. Hvert målord optrådte to gange i teksten, hvorfor eleverne læste hvert målord fire gange.

Posttest

Elevernes indlæring af de otte målord blev målt 3-4 dage efter træningspasset vha. en *stavetest* og en *orthographic choice test*. I stavetesten blev eleverne blev bedt om at stave til navnene på de opfindelser, de tidligere havde læst om. Eleverne fik udleveret et kopiark med illustrationer af opfindelserne. Testtageren udtalte navnet på en opfindelse og bad eleven stave det så godt han/hun kunne. Testen blev opgjort som antal korrekt stavede målord. I den efterfølgende *orthographic choice test* blev eleverne præsenteret for en illustration af hver af de otte opfindelser. Under illustrationen var der fire forskellige stavemåder, eleverne skulle vælge imellem: den korrekte stavemåde, to homofone stavemåder og en stavemåde, hvor ét bogstav var ændret i forhold til den korrekte stavemåde. Testen blev opgjort som antal korrekt identificerede stavemåder.

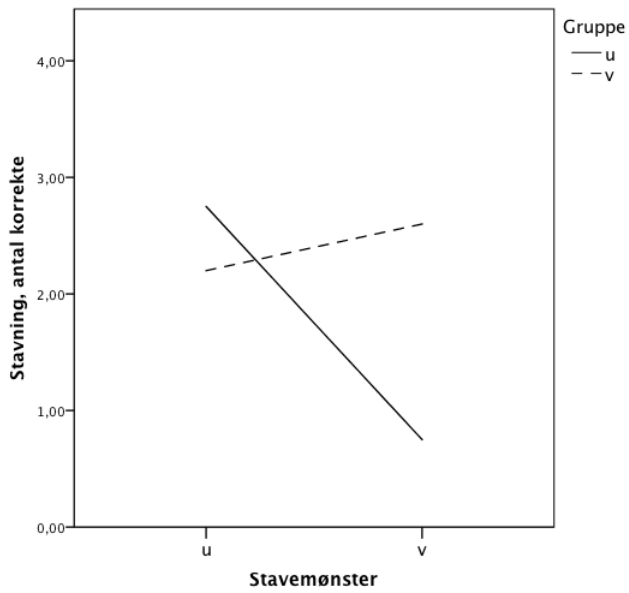
Resultater

Tabel 6 viser gruppernes gennemsnitlige scorer på posttest stavning samt effektstørrelsen Cohen's *d* for forskellen mellem gruppernes stavning af ord med og uden trænede stavemønstre.

Tabel 6 Posttestscorer på stavetesten for gruppe u og v

Gruppe	*u-stavemønstre M(SD)*	*v-stavemønstre M(SD)*	*Effektstørrelse d*
u	2,8(1,0)	0,8(1,0)	2,00
v	2,2(1,3)	2,6(0,9)	0,36

En variansanalyse (*mixed between-within subjects*) blev gennemført for at undersøge, hvorvidt eleverne var signifikant bedre til at stave målord, der indeholdt stavemønstre, de var blevet undervist i. Der var en signifikant interaktion mellem trænede bogstavfølger og typen af målord, Wilks Lambda = ,418, F (1,7) = 9,74, p = ,017. Interaktionen er illustreret i figur 9.



Figur 9 Interaktion mellem stavemønster og gruppe på posttest stavning

Elever fra u-gruppen (fuldt optrukken linje), er gennemsnitligt bedre til at stave målord med trænede bogstavfølger (u-stavemønstre) end målord med stavemønstre, de ikke har trænet (v-stavemønstre), hvilket resulterer i en stærk effekt (d = 2,00). Det modsatte mønster ses hos elever fra v-gruppen (stiplet linje), der gennemsnitligt er bedre til at stave målord med trænede bogstavfølger (v-stavemønstre) end målord med stavemønstre, de ikke har trænet

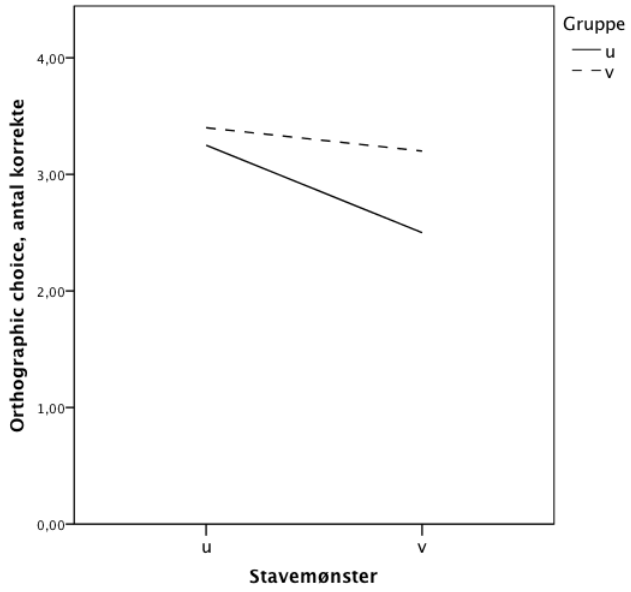
(u-stavemønstre). Her er forskellen dog markant mindre end for u-gruppen, hvilket resulterer i en moderat effekt (*d* = 0,36).

Tabel 7 viser gruppernes gennemsnitlige scorer på *orthographic choice testen* ved posttest samt effektstørrelsen Cohen's *d* for forskellen mellem gruppernes genkendelse af ord med og uden trænede stavemønstre.

Tabel 7 Posttestscorer på *orthographic choice testen* for gruppe u og v

Gruppe	*u-stavemønstre M(SD)*	*v-stavemønstre M(SD)*	*Effektstørrelse d*
u	3,3(1,0)	2,5(0,6)	0,97
v	3,4(0,6)	3,2(0,8)	-0,28

En variansanalyse (*mixed between-within subjects*) blev gennemført for at undersøge, hvorvidt eleverne var signifikant bedre til at identificere den korrekte stavemåde af målord, der indeholdt stavemønstre, de var blevet undervist i. Der var ikke en signifikant interaktion mellem trænede bogstavfølger og typen af målord, Wilks Lambda = ,945, *F* (1, 7) = ,41, *p* = ,544. Interaktionen er illustreret i figur 10.



Figur 10 Interaktion mellem stavemønster og gruppe på posttest *orthographic choice*

Elever fra u-gruppen (fuldt optrukken linje) er bedre til at identificere den korrekte stavemåde af målordene med trænede stavemønstre (u-stavemønstre) end målord med ikke-trænede stavemønstre (v-stavemønstre), hvilket resulterer i en stærk effekt (*d* = 0,97). Det samme mønster ses hos v-gruppen (stiplet linje). Mod forventning er denne gruppe

gennemsnitligt bedre til at identificere målord med ikke-trænede stavemønstre. Forskellen er dog meget begrænset.

Genkendelse af ordspecifikke stavemåder målt med *orthographic choice testen* må forventes at være en lettere opgave end genkaldelse af ordspecifikke stavemåder målt med stavetesten, hvilket kan være en af forklaringerne på forskellen mellem resultaterne på de to test illustreret i figur 9 og 10. At eleverne fra v-gruppen gennemsnitligt er lige så gode til at genkende ordspecifikke stavemåder, uanset om de indeholder trænede stavemønstre eller ej, mens der hos eleverne fra u-gruppen ses en forskel, kan både hænge sammen med forskellen mellem grupperne på stave- og afkodningsfærdighed beskrevet i tabel 4, og at de to grupper trænede forskellige stavemønstre.

Der er naturligvis stor statistisk usikkerhed forbundet med analyser, der baserer sig på resultater fra så få deltagere. Det er dog opmuntrende, at træningen synes at give anledning til en stærk effekt på indlæring af ordspecifikke stavemåder målt med stavetesten. Dermed peger resultaterne på, at træningen kan indgå med sin nuværende form og med sit nuværende omfang i den endelige træningsundersøgelse. Yderligere kan resultaterne anvendes til at få et kvalificeret bud på, hvor mange deltagere der bør indgå i den endelige træningsundersøgelse.

Statistisk power

En tests evne til at finde en effekt kaldes dens *statistiske power*. En tests power er sandsynligheden for, at den vil finde en effekt under forudsætning af, at effekten eksisterer i populationen. Dette er det modsatte af sandsynligheden for, at testen *ikke* vil finde en effekt, der eksisterer i populationen, kaldet *β-niveauet.* En tests power kan derfor udtrykkes som 1 – *β*. Cohen (1988) anbefaler en sandsynlighed på 0,2 (20%) for *ikke* at opdage en ægte effekt. Det korresponderende *power-niveau* er derfor 1 - 0,2 = 0,8. Det er med andre ord almindeligt at tilstræbe, at man med en given test har 80% sandsynlighed for at opdage en ægte effekt. En statistisk tests power afhænger af følgende:

- Effektstørrelsen. Jo større effekt, jo lettere vil den være at opdage.
- Hvor man sætter *α-niveauet*. Dvs. sandsynligheden for at finde en effekt, der *ikke* eksisterer i populationen. Jo højere alfa, jo sværere vil det være at opdage en effekt. Det er konventionelt at accepterer en sandsynlighed på 0,05 (5%).
- Antal deltagere. Jo større deltagerantal man opererer med, jo bedre stikprøve af populationen er der tale om, og jo mindre stikprøveusikkerhed vil der være (Field, 2013).

Power-analyse

Da det er muligt at sætte α- og power-niveauet til den værdi, man ønsker, kan man ved at kende den sandsynlige effektstørrelse, baseret på tidligere forskningsstudier eller pilotering

af eksperimenter, beregne, hvor mange deltagere det er nødvendigt at medtage i en given undersøgelse for at opdage effekten. *G*Power* er et frit tilgængeligt program, der kan anvendes til at beregne det nødvendige deltagerantal baseret på oplysningerne beskrevet ovenfor. G*Power version 3.1 (Faul, Erdfelder, Lang, & Buchner, 2007) blev anvendt til at beregne deltagerantallet til den endelige træningsundersøgelse baseret på resultaterne fra pilotafprøvningen.

Valg af statistisk test

For at kunne beregne deltagerantallet til træningsundersøgelsen er det nødvendigt at vide, hvilken type statistisk test, der skal anvendes til at analyserer resultaterne. Til analysen af resultaterne fra træningsundersøgelsen er der behov for en test, der kan svare på, hvorvidt der er signifikante forskelle mellem eksperimentgruppens og kontrolgruppens scorer på posttestene. I undersøgelsen indgår to grupper, der er én afhængig variabel (fx stavning af målordene) og én uafhængig variabel (+/- træning). En egnet analyse at anvende til et sådant design er en *variansanalyse* (*one-way between groups*). Men ved at udvide analysen til en *ko-variansanalyse* muliggøres en mere effektiv test af træningseffekten. I en sådan analyse kontrolleres først for individuel variation på før-træningsmål, der har sammenhæng med den afhængige variabel, før den sædvanlige variansanalyse gennemføres med de korrigerede scorer. Dermed øges F-testens power og sandsynligheden for at finde en signifikant træningseffekt (Field, 2013). I eksperimentelle træningsundersøgelser, hvor tilskrivningen til eksperiment- og kontrolgrupper er randomiseret, er der tale om en legitim teknik til at reducere individuel variation i grupperne (Miller & Chapman, 2001).

Det er vigtigt, at kovariable vælges med omhu. Der skal for det første være tale om kontinuerte og pålidelige variable. For det andet skal de korrelere signifikant med den afhængige variabel. Og er der tale om flere kovariable, skal de ideelt set kun korrelere moderat med hinanden, så hver variabel bidrager unikt til at forklare variation i den afhængige variabel. Endelig er det afgørende, at kovariablene er målt, før den eksperimentelle manipulation gennemføres (Field, 2013; Pallant, 2007). I forbindelse med træningsundersøgelsen testes deltagerne med en række mål, inden træningen iværksættes. Bl.a. testes deltagernes ordlæsning, stavning og nonordsafkodning. Dermed indgår en række mål, der må formodes at have sammenhæng med indlæringen af ordspecifikke stavemåder under tekstlæsning. Der er ligeledes tale om mål, der må formodes at korrelere stærkt indbyrdes. Hvilke variable, der skal fungere som kovariable i variansanalyserne, afgøres derfor først, når resultaterne af træningsundersøgelsen i studie 3 foreligger. Men til beregningen i G*Power sættes kovariablene til at korrelere moderat til stærkt (r = ,50) med den afhængige variabel.

Beregning af det nødvendige deltagerantal

Til beregninger, hvor variansanalyser er involveret, anvender G*Power effektstørrelsen Cohen's *f*. Til beregningen i G*Power sættes den forventede effektstørrelse til f = 0,40, hvilket svarer til en stærk sammenhæng (svarende til Cohen's *d* = 0,80, Cohen, 1988). Baseret på resultaterne fra pilotundersøgelsen bør det være en realistisk effekt at finde målt på elevernes stavning af målordene, mens det er mere usikkert, når det gælder elevernes genkendelse af målordene i en *orthographic choice test*.

Til at estimere det nødvendige deltagerantal til træningsundersøgelsen blev følgende oplysninger indtastet i G*Power:

- Testfamilie: F-test
- Statistisk test: Variansanalyse (*repeated measures, between factors*)
- Effektstørrelse, Cohen's *f*: 0,40
- α-niveau: 0,05
- Power (1 – β): 0,80
- Antal grupper: 2
- Antal målinger: 2
- Korrelation mellem afhængig variabel og kovariable: *r* = ,50

Med de ovenstående oplysninger beregner G*Power, at der som minimum bør deltage 40 elever i træningsundersøgelsen i studie 3, hvis der skal opnås en signifikant træningseffekt.

På baggrund af de beskrevne resultater blev den endelige træningsundersøgelse planlagt. Fremgangsmåden for undervisningen i betingede stavemønstre blev fastholdt med den undtagelse, at omfanget blev udvidet, så i alt seks stavemønstre blev gennemgået. Ligeledes blev den ortografiske indlæringsfase udvidet til seks tekster med i alt 12 målord. Fire 3. klasser blev screenet med henblik på at udvælge minimum 40 deltagere til træningsfasen.

Studie 3

Boosting orthographic learning during independent reading

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Abstract

Research has shown that phonological decoding is critical for orthographic learning of new words during independent reading. Moreover, correlational studies have demonstrated that the strength of orthographic learning is related to the orthographic knowledge with which readers approach a text. The present training study was conducted to assess experimentally whether this relation between prior orthographic knowledge and orthographic learning while reading is causal by assessing whether instruction designed to increase sublexical orthographic knowledge would facilitate orthographic learning during independent reading. A group of Danish-speaking third graders (n = 21) was taught conditional spelling patterns conforming to the opaque Danish writing system, with emphasis on how to map the spellings onto their pronunciations. A matched control group (n = 21) received no treatment. Both groups were exposed to 12 novel words containing trained spelling patterns in an orthographic learning task. Posttests revealed a moderate transfer effect from training to orthographic learning, measured as the students' ability to identify target word spellings in an orthographic choice task, and a strong transfer effect when measured as their ability to reproduce target word spellings in a spelling task. However, no advantage of explicit training over reading only could be detected when orthographic learning was measured as target word naming. The findings support the view that larger sound spelling units are used to form connections between spellings and pronunciations of words. Additionally, the findings support the view that preexisting orthographic knowledge is causally related to the degree and quality of orthographic learning during independent reading.

Keywords
Orthographic learning, Orthographic knowledge, Conditional spelling patterns, Independent reading, Training study

Introduction

Young students face a great challenge in learning to read and spell words from memory, because they need to acquire an immense number of well-specified orthographic representations of words, morphemes, and sublexical units. As a first step in learning to read and spell words in alphabetic orthographies, students must become familiar with the basic alphabetic principle and learn to connect phonemes in spoken words with graphemes in written words. Using their emerging knowledge of the writing system, students learn to decode words by sounding out letters and blending the sounds to form recognizable words. Students learn to spell by segmenting spoken words into single phonemes and mapping them to single letters (Ehri, 2005). Students learn to read words from memory as they practice decoding and spelling words.

Beyond these early phases of development, spelling patterns are progressively refined and consolidated in memory through a process that has been termed *orthographic learning* (Castles & Nation, 2006). Issues that are central in the research on orthographic learning involve (a) describing the process by which orthographic representations are established in memory (e.g., Ehri, 2005; Share, 1995), (b) identifying central predictors of orthographic learning (e.g., Cunningham, Perry, Stanovich, & Share, 2002; Share, 1999; Wang, Nickels, Nation, & Castles, 2013), and (c) determining forms of instruction and practice that facilitate orthographic learning (e.g., Berends & Reitsma, 2007; Bhattacharya & Ehri, 2004; Conrad, 2008). One purpose of the present study was to provide evidence bearing on these issues.

Establishing well-specified orthographic representations while reading

A highly recognized theory describing the process of orthographic learning is the self-teaching hypothesis (Share, 1995). According to this theory, phonological decoding is the central mechanism that supports the acquisition of orthographic representations. When sounding out a written word, young readers have the opportunity to observe the order and the identity of letters and how they map onto phonemes in the word. Accordingly, phonological decoding during independent reading serves as a self-teaching mechanism that facilitates the establishment of well-specified orthographic representations in memory. With increased exposure to print, students' decoding of words becomes modified and refined because of a growing body of orthographic knowledge. Young readers learn regularities beyond the level of simple grapheme–phoneme correspondences, whereby their decoding of words becomes increasingly attuned to the given orthography (Share, 2008). Hence, the relationship between phonological decoding and orthographic knowledge is reciprocal; beginning readers are taught grapheme–phoneme connections, which, as used to decode during reading, become contextualized to specific words and phonological units as they are bound in memory.

As students learn regularities beyond the level of simple grapheme–phoneme correspondences, their alphabetic working knowledge expands and accelerates the development of both reading and spelling skills (Ehri, 2014). Such regularities are composed

of larger spelling units, such as rime spellings, spellings of syllables, and spellings of morphemes (Ehri, 2014). Moreover, students learn graphotactic features (i.e., knowledge of how letters are legally and frequently combined in the orthography; Bourassa & Treiman, 2014) and conditional spelling patterns (i.e., knowledge of phonologically or morphologically based regularities; Deacon, Conrad, & Pacton, 2008; Treiman & Kessler, 2006).

Researchers have proposed that young readers gain knowledge of graphotactic features of the orthography and knowledge of conditional spelling patterns during independent reading through a statistical learning process (e.g., Deacon et al., 2008; Pollo, Treiman, & Kessler, 2007; Treiman & Kessler, 2013). This is an implicit process in which beginning readers notice and internalize the frequency with which letters or letter combinations occur and co-occur in print (Samara & Caravolas, 2014). The learning is considered statistical because it goes beyond all-or-none patterns to include probabilistic patterns (Treiman & Kessler, 2006).

Studies have demonstrated that children and adults take advantage of phonological context to decode and spell ambiguous consonants and vowels and that knowledge of some spelling patterns are not acquired until fairly late in grade school (Juul, 2005; Kessler, 2009; Treiman & Kessler, 2013). These findings have led researchers to call for more explicit attention to conditional spelling patterns in literacy instruction.

Central predictors of orthographic learning during independent reading

In an orthographic learning task, participants read aloud short texts typically containing novel, pronounceable letter strings (target spellings) representing fictitious names. A few days later, students' orthographic memory for the words they saw is tested. Findings show that target spellings are identified more often, named more quickly, and spelled more accurately than alternative, homophonic spellings (e.g., Cunningham et al., 2002; Share, 1999, 2004).

Research has consistently demonstrated that phonological decoding is a key factor in orthographic learning while reading, which supports the self-teaching hypothesis. For instance, correlational studies have shown that phonological decoding is positively correlated with levels of orthographic learning of new words during orthographic learning tasks (e.g., Bowey & Miller, 2007; Cunningham et al., 2002). Studies have also shown that phonological decoding is critical for orthographic learning of new words (e.g., de Jong, Bitter, van Setten, & Marinus, 2009; Share, 1999).

Preexisting orthographic knowledge has been shown to account for additional variance in orthographic learning of new words during independent reading after controlling for phonological decoding ability (Cunningham, 2006; Cunningham et al., 2002; Wang et al., 2013). Wang and colleagues conducted a study with 45 English-speaking students in grades 2 and 3. In the orthographic learning task, students were exposed to regular and irregular word spellings. Preexisting orthographic knowledge was measured by students' accuracy in reading irregular words. Phonological decoding was measured by nonword decoding accuracy.

Results showed that orthographic knowledge made a unique contribution to orthographic learning above and beyond phonological decoding for both regular and irregular words.

However, the tasks used to assess orthographic knowledge have been criticized for evaluating the ability to access existing orthographic representations, thereby tracking the outcome of reading acquisition rather than the process that underpins orthographic learning (Burt, 2006; Castles & Nation, 2006; Deacon, Benere, & Castles, 2012). To clarify whether orthographic knowledge is causally related to orthographic learning, Burt called for training studies that assess the skills and processes involved in the effective learning of unfamiliar letter strings.

Instruction to facilitate orthographic learning during independent reading

Training studies have been conducted in which children and adolescents are implicitly or explicitly trained to recognize sublexical letter patterns across words to improve their reading accuracy and their reading speed of both trained words and new words containing trained letter patterns (e.g., Berends & Reitsma, 2006, 2007; Bhattacharya & Ehri, 2004; Conrad, 2008; Conrad & Levy, 2011; Marinus, de Jong, & van der Leij, 2012). The training is often composed of repeated readings of words sharing letter patterns such as rime units (e.g., Conrad, 2008), digraphs (e.g., Marinus, de Jong, & van der Leij, 2012), or syllables (e.g., Bhattacharya & Ehri, 2004). This type of training has been shown to improve recognition of trained words, with respect to both accuracy (Berends & Reitsma, 2006, 2007; Conrad, 2008) and speed (Berends & Reitsma, 2006, 2007; Conrad & Levy, 2011; Marinus, de Jong, & van der Leij, 2012). However, transfer to new words containing trained letter patterns seldom occurs or is marginal (e.g., Berends & Reitsma, 2006; Conrad & Levy, 2011; Marinus, de Jong, & van der Leij, 2012).

At least three studies using repeated readings (Berends & Reitsma, 2007; Bhattacharya & Ehri, 2004) or repeated readings/spellings of words (Conrad, 2008) have succeeded in obtaining transfer to reading and spelling of new words. Bhattacharya and Ehri conducted a study with adolescents in grades 6–10 identified as having below-average word-reading skills. Two groups practiced reading 100 multisyllabic words, either by analyzing graphosyllabic units or by reading the words as whole units. A third group did not participate in any training. During the graphosyllabic training, the participants analyzed four sets of 25 words in four steps: pronouncing words, dividing words into syllables, matching spoken and written syllables, and blending syllables to read whole words. Each word was analyzed four times. When compared with controls, posttests revealed that the group trained in graphosyllabic analysis did better in novel word and nonword decoding and had superior memory for spellings of words learned through a word-learning task. The transfer effect to decoding of new words and memory for word spellings suggests that students trained in graphosyllabic analysis had linked syllable spellings to pronunciations in memory and that these syllabic sound–spelling units facilitated orthographic learning of new multisyllabic words (Bhattacharya & Ehri, 2004; Ehri, 2014).

Conrad (2008) conducted a study with typically developing readers in grade 2. Practice consisted of either repeated reading or repeated spelling of words sharing orthographic rime patterns. Eight groups of five words sharing rime patterns were taught. One group of students repeatedly read a list with the 40 target words, and the other group repeatedly spelled the same words. Each target word was repeated 16 times (four trials per day over four days). Training effects were seen on both reading and spelling under both conditions. Conrad suggested that students were able to abstract out trained orthographic patterns, which facilitated both reading and spelling of new words with similar patterns. Thus, in addition to building word-specific orthographic representations, students also expanded their sublexical orthographic knowledge during training (Conrad, 2008).

The present study

The present training study was conducted to assess experimentally whether enhancing knowledge of conditional spelling patterns in a group of young students would lead to enhanced orthographic learning of unfamiliar letter strings during independent reading compared with a no-training control group. The study was conducted with Danish students in third grade. Danish has an irregular orthography with some similarities to English (Elbro, 2006; Juul & Sigurðsson, 2005). Computing phoneme–grapheme consistencies in accordance with Kessler and Treiman (2001), Juul (2008) reported consistencies (on a scale from 0 to 1) of .672 for Danish vowels and .750 for consonants. These coefficients imply that the correct spelling of a Danish phoneme is often relatively difficult to predict. Kessler and Treiman found a lower vowel consistency of .529 for English. They did not report consistencies for individual consonant phonemes.

The conditional sound–spelling patterns in focus were letter patterns that included irregular grapheme–phoneme connections (e.g., *igl*, pronounced /i:l/). However, the larger letter patterns were regular. Each spelling pattern included a complex letter unit containing a silent letter (e.g., *e* followed by the complex letter unit *ds*, pronounced /s/). In Danish, when the letter *e* precedes the complex letter unit *ds* in words, the most frequent pronunciation is by far /ɛs/. However, because there are a few exceptions, it cannot be taught as a rule but rather as a highly probable pattern. During training, the pronunciations of the complex letter units were not presented as isolated, abstract rules but rather as parts of six larger sound–spelling patterns. These spelling patterns were selected based on the criteria that they either appear in Danish words, but infrequently, or that they conform to spelling patterns found in Danish words. This was to ensure, on the one hand, that the sound–spelling patterns were consistent with the participants' preexisting knowledge of the Danish writing system and, on the other hand, that the participants had not been frequently exposed to the sound–spelling patterns prior to the training study. The sound–spelling patterns selected for the study are described in Appendix A.

The purpose of the present study was to investigate whether brief, explicit training in mapping pronunciations and spellings of conditional spelling patterns would be effective and

transfer to students' orthographic learning of new words that contained the taught patterns while reading. An orthographic learning task was used to examine transfer. Students in a control group participated in the orthographic learning task without any preceding training. Prior to training, several measures were taken to ensure that the two groups were well matched. Posttests involved reproducing, identifying, and decoding target word spellings from the orthographic learning task. Moreover, to assess whether differences in orthographic learning would generalize to decoding of new words, the participants' ability to decode nonwords closely matched to the target word spellings and presented on a word list was tested.

It was hypothesized that stronger orthographic learning of new words containing taught spelling patterns would occur for the experimental group during independent reading compared with the matched control group. The hypothesis was based on the assumption that students receiving training would form letter–sound connections of the spelling patterns being trained. Knowledge of these larger spelling–sound units would facilitate the forming of connections between the spellings and the pronunciations of the target words during independent reading, whereby orthographic representations of higher lexical quality would be established.

It was further hypothesized that a stronger training effect would occur when orthographic learning was measured as the students' ability to reproduce target word spellings compared with their ability to identify and decode target word spellings. This hypothesis was based on the assumption that reproducing complex word spellings requires complete spellings that are fully connected to their pronunciations in memory. By contrast, identifying or decoding word spellings may be accurate despite underspecified orthographic representations.

Method

Participants

Seventy-two students (35 girls and 37 boys) from four third-grade classes in the same school in the Greater Copenhagen Area of Denmark participated in the study. Informed consent was obtained from the parents of all participants included in the study. The students' mean age was 9 years 9 months (standard deviation = 4 months). Twenty-two students (30.6%) had Danish as their second language. Participants scored within the average range for their age group on the standardized spelling task and the standardized word-reading task subsequently described.

Procedure

All test and training sessions were conducted in the spring of third grade. The test sessions covered both group-administered tests conducted with whole classes and individually

administered tests conducted with selected students. All testing and training was conducted by me or by two trained student assistants. Figure 1 lays out the data collection design.

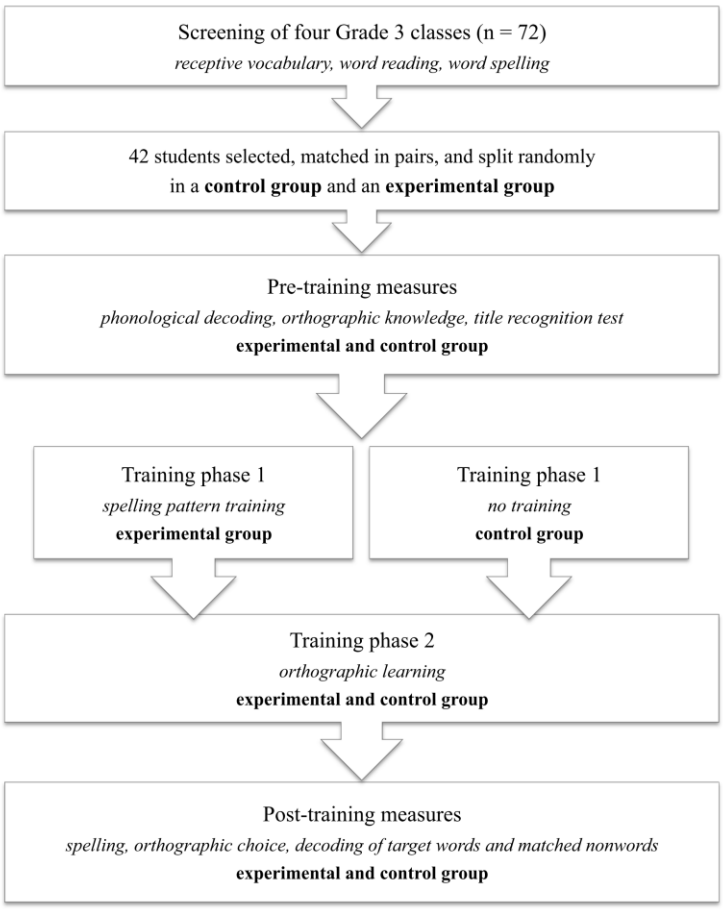

Figure 1 Data collection design

Screening measures, pre-training measures and group assignment

Screening tests

Staveprøve 2 (Spelling Test 2) The test has 17 items and is recommended for students in grades 2–4 (Juul, 2012). Each target word was orally presented in a meaningful sentence and repeated. The participants were asked to write the dictated words. The score was the number of correct spellings. Cronbach's alpha in the standardization sample was .91.

Ordlæseprøve 2 (Word Reading Test 2) This multiple-choice test, recommended for students in grades 2–5 (Juul & Møller, 2012), with 147 items increasing in level of complexity was administered. The participants were required to choose the drawing out of four options that matched a written word. The participants were given four minutes to solve as many items as possible. The score was the number of correct responses per minute. Cronbach's alpha in the standardization sample ranged from .80 to .93 for selected subsets of the items.

Find et foto! (Find a Photo!) This multiple-choice test of receptive vocabulary, developed for students in grade 3 (Rønberg & Petersen, 2016), with 30 items was administered. It consisted of a broad selection of both high- and low-frequency everyday words and content area words, including nouns, adjectives, and verbs, with nouns being the most frequent. All words were orally presented to the participants, and their task was to select one photo from among five options that corresponded to that word. The score was the number of correct responses. Cronbach's alpha was .84 for the full sample.

Group administered pre-training tests

Title recognition test A measure of individual differences in print exposure was developed for the present study. The test was adapted from the title recognition test developed by Cunningham and Stanovich (1990) and consisted of a total of 32 items: 18 actual children's book titles and 14 foils for book names. Librarians from the main libraries of the 10 largest cities in Denmark were asked to make a list of 20 popular children's books. Nine librarians returned a list. How frequently each book title appeared on a list was recorded. There were 26 titles mentioned between three and nine times. These titles were the basis for the final checklist. The foils were generated by me and were randomly interspersed among the actual book titles.

The students were told that the test contained the titles of books children their age commonly read and many foils—names of books that did not exist. Each title was orally presented. The participants were instructed either to put a mark in a green square on the response sheet if they recognized the title as the name of an actual book or to put a mark in a red square on the response sheet if they did not recognize the title. They were instructed not to guess and were reminded that guessing could be easily detected. That is, they should only put a mark in the green square if they felt certain that the title was the name of an actual book. For each participant, the number of targets correctly marked as the names of actual books was recorded, as well as the number of foils incorrectly marked as the names of actual books. Cronbach's alpha for the number of targets correctly marked was .73 for the full sample. To take into account possible differential thresholds for guessing, a derived score was calculated for each participant by subtracting the number of foils incorrectly marked from the number of actual titles correctly marked.

Word specific orthographic knowledge A homophone choice test was developed for the present study. Short written sentences were presented with two homophonic real words displayed side by side (e.g., "*Der sidder en krave/krage i træet*" ("A crow [*krage*] is sitting in the tree"). A total of 20 pairs were included, with each member of the pair presented separately, resulting in 40 sentences. Each sentence was read aloud, and the students were asked to circle the word spelling that best fit the sentence. Two examples were presented on the classroom board to ensure that the students understood the task. To reduce the effect of guessing, the score was calculated as the number of correct choices between each homophone

pair. To get a correct score, the participants had to choose the correct spelling of each member of a homophone pair. Thus, the score was the number of the 20 homophone pairs correct. Cronbach's alpha was .87 for the full sample.

Graphotactic knowledge A group-administered nonword choice task was devised for the present study. It consisted of 24 pairs of four- to seven-letter nonwords. The nonword pairs had similar pronunciations. In each pair, the target nonword contained a letter pattern found regularly in Danish words with a parallel structure (e.g., *pryldt*). The distractor nonword contained a letter pattern never or rarely found in Danish words with a parallel structure (e.g., *pryllt*). The participants were asked to look at the nonword pairs and circle the nonword that looked most like a real word. Two examples were presented on the classroom board to ensure that the students understood the task. They were instructed to guess if they did not know the answer. The score was the number correct. Cronbach's alpha was .86 for the full sample.

Knowledge of conditional spelling patterns A group-administered nonword choice task was devised for the present study. It consisted of 28 pairs of four- to seven-letter nonwords. The nonwords did not include any of the spelling patterns covered in the training described later. The examiner pronounced a nonword (e.g., /sbɑjnə/), and the participants were asked to look at the nonword pair and circle the best spelling for the pronunciation they heard. In each pair, the target nonword contained a letter pattern in which the vowel is irregularly spelled in Danish words (e.g., /ɑjnə/, spelled *egne*). However, the spelling of the vowel is more predictable if the phonological context is taken into account. The letter–sound patterns used for the target nonwords are found in several Danish words. The distractor nonword contained a letter pattern that was a phonologically plausible spelling of the nonword pronounced (e.g., *ajne*). Moreover, the letter pattern in the distractor nonword was characterized by one of the following features: (a) The letter pattern is never found in Danish words with the same structure, but it represents a regular spelling of the target pronunciation (e.g., *ajne*); (b) the letter pattern occurs rarely in Danish words (e.g., /ɑjlə/, spelled *ajle*); and (c) the letter pattern is consistently pronounced differently in Danish words (e.g., the pronunciation of the target letter pattern *ippe* is /ebə/, whereas the distractor letter pattern *eppe* is pronounced /ɛbə/). Two examples were presented on the classroom board to ensure that the students understood the task. They were instructed to guess if they did not know the answer. The score was the number correct. Cronbach's alpha was .90 for the full sample.

Individually administered pre-training test

Phonological decoding This nonword decoding task was developed for the present study. The nonwords consisted of three to five letters with CVC (consonant–vowel–consonant), CVCV, CVCC, CCVC, and CCVCC structures. To reduce the influence of knowledge of larger sound spelling units, the nonwords were constructed so they did not contain rime patterns frequently found in Danish words. The participants read aloud two nonword lists. Each list

consisted of 10 nonwords plus an easy starter (i.e., a VC nonword, which was not scored). Thus, the total number of items was 20. Participants were asked to read the lists as accurately and fast as they could. The score was the number of words read correctly per minute. The correlation between the two nonword lists was .83.

Criteria for selecting participants for the training phase

To prevent vocabulary from being a major contributor to learning during the orthographic learning task, students with a score that was more than one standard deviation below the mean on the receptive vocabulary test were excluded (n = 12). Also, students who produced phonologically implausible spellings for more than half of the words on the spelling test were excluded (n = 8). Moreover, students who spelled all words correctly on the spelling test were excluded (n = 6). This was done on the assumptions that participants had to possess basic alphabetic spelling knowledge to benefit from the training described later and that those participants who were very proficient spellers were likely to have already mastered some of the spelling patterns being trained.

Of the remaining participants, 23 pairs were formed. Each pair was matched on their spelling and reading performance in a stepwise way: As the first step, the 46 participants were listed based on their performance on the spelling test, from the lowest to the highest score. Then, the participant with the lowest score was paired with the participant with the second-lowest score, and so forth. If more participants had the same score on spelling, they were paired based on their reading scores. That is, the participants who had the closest scores on reading were paired. Subsequently, the students in each pair were randomly assigned to an experimental or a control group. However, two pairs of participants had to be excluded from the study. One participant changed school during the data collection, and another participant was absent for a longer period during the data collection due to illness. Thus, 42 participants remained in the study. The characteristics of the two groups are reported in Table 1.

Table 1 Characteristics of the participants in the experimental and control groups

Characteristic	Experimental	Control	X^2	p
Age[a]	9;8	9;9		
Gender F/M	10/11	8/13	0.39	.533
Danish L1/L2	17/4	13/8	1.87	.172

Training phase

Spelling pattern training: Phase 1

The spelling pattern training was designed to be applicable for use in an everyday school setting. Therefore, the training had a fairly short duration and followed a simple structure, with teacher modeling succeeded by a few exercises with feedback. The participants were explicitly taught the sound–spelling mappings of the conditional spelling patterns, followed by learning instances of the patterns in nonwords. Because the spelling patterns in focus were highly infrequent, real words could not be used. The training focused mainly on how to map spelling patterns onto their pronunciations (i.e., spelling). This was based on previous research indicating that training focused on producing target word spellings leads to superior orthographic learning compared with training focused on decoding of target word spellings (Conrad, 2008; Ouellette, 2010; Shahar-Yames & Share, 2008).

The 21 students in the experimental group were trained in four small groups. Each group participated in three lessons lasting about 45 minutes each. Two trained student assistants managed the training, following scripts for each lesson prepared and piloted by me. I observed all lessons to check fidelity to the scripts. In each lesson, two spelling patterns were introduced. Thus, six spelling patterns were trained in total (see Appendix A). Each lesson followed the same procedure:

- Introduction to the spelling patterns (mapping pronunciation and spelling)
- Decoding of six nonwords (with corrective feedback)
- Spelling of six nonwords (with corrective feedback)
- Dictation: The students were given a sheet with drawings of six fantasy figures. A short story containing their names was read aloud by the student assistant. A few distinctive features were mentioned for each figure. The students' task was to write the names of the figures below the matching drawings. The students were encouraged to remember the sound–spelling patterns they had practiced. Afterward, the students came to the blackboard in turn and presented how they had spelled the names. The other students and the student assistant gave corrective feedback. The students were instructed to correct any misspellings on their sheet.

Orthographic learning: Phase 2

Students from both the experimental and the control groups participated in the second part of the training phase. For the experimental group, this phase was carried out two or three days after the students had completed the training. The orthographic learning phase was administered individually. Each student read aloud six short texts containing two target nonwords. Thus, in the orthographic learning phase, each student was exposed to 12 target

words (see Appendix A). The target words were presented twice in each text, and the students read each text twice. Hence, each student was exposed to the target spellings four times. The students had not been exposed to the two target nonwords assigned to each text during training, but the nonwords contained the sublexical spelling patterns that were taught.

The target nonwords were the names of new inventions described in the texts. This was inspired by the study described by Wang, Castles, and Nickels (2012). First, the students saw a drawing of two inventions and were told what they were called and asked to repeat the names. Next, the students were asked to read aloud a text describing the two inventions and were told that they would have to answer questions about the story afterward. This was to ensure that the students paid attention during the reading. If a student misread any of the words during the first reading of the text, he or she was corrected. Afterward, the student was told to read the story again. This time, no help was provided. The feedback during the first reading of the story and the rereading were to ensure that the students read each text as fluently as possible. Finally, the students answered two questions related to the story. The purpose of the questions was to make the students pay attention during the reading, and the questions did not necessarily target the participants' comprehension of the story (e.g., "Can you imagine yourself wishing for a *krygl*?"; "Do you think that it is a clever invention?"). Accordingly, the participants' answers to the questions were not transcribed and scored.

I had written and piloted each story. The texts consisted of 42–49 words and followed the same basic story structure: Professor Axel has a problem; he invents a solution; the invention is described. The inventions were solutions to everyday events, such as forgetting your keys or flies being attracted to your food, so only highly familiar concepts and words were introduced. An example of one of the texts and one of the drawings used is presented in Appendix B.

Because the target words contained trained spelling patterns, the four readings of the target words could be interpreted to reflect the effect of training - that is, the students' application of the spelling patterns they were taught in reading new words. Therefore, the number of words correctly decoded during each of the four readings was calculated.

Posttests to assess transfer to orthographic learning during independent reading

Four posttests were administered individually two or three days after thereading task. The tests were conducted in the following order.

Spelling The participants were asked to spell the names of the inventions they had read about a few days before. Each student saw the drawing of an invention and was told the name. No help or feedback was provided. Two different scores were calculated: (a) the number of correct whole-word spellings and (b) the percentage of correct letters represented in the spelling attempts. Moreover, the misspellings produced by the participants were recorded in an Excel chart and coded as either a phonological possible spelling or a phonological impossible spelling. Cronbach's alpha was .89 on the whole-word spelling measure.

Decoding of matched nonwords The participants were asked to decode 12 nonwords from a list. The nonwords were derived from the 12 target words, so only the first letter in each nonword differed from the target word (see Appendix A). Both decoding accuracy and decoding efficiency were calculated; accuracy was the number of words correctly decoded, and efficiency was the number of words correctly decoded per minute. The nonwords were scored as correct if they were pronounced by analogy to the target words, with all but the first sound matching the target word. Cronbach's alpha was .82 for the accuracy measure.

Orthographic choice The participants had to recall and choose the correct spelling of an invention among three foils. Two foils were homophone distractors, and one was a visual distractor. The participants were instructed to draw a circle around the spelling that matched the invention in the drawing. The names of the inventions were not pronounced, and no help or feedback was provided. The score was the number of correct spellings chosen. Cronbach's alpha was .64.

Decoding of target words The participants were asked to decode the 12 target words from the reading task from a list. No help or feedback was provided. Both decoding accuracy and decoding efficiency were calculated; accuracy was the number of target words correctly decoded, and efficiency was the number of target words correctly decoded per minute. Cronbach's alpha was .85 for the accuracy measure. The correlation between the target word and the matched nonword efficiency score was .82.

Results

Screening measures

Score distributions were approximately normal, with all absolute values of skewness and kurtosis within the range of ±1. The only exception was vocabulary, which was moderately positively skewed. The tests of word reading and spelling were used to form matched pairs of participants whose members were randomly assigned to the experimental and control groups. Chi-square tests verified that no significant differences were found between the groups when analyzed according to gender and Danish as the first or second language (see Table 1). Further, independent samples *t*-tests verified that mean scores across the three screening measures were not significantly different between the groups (see Table 2).

Pre-training measures

To further ensure that the groups were well matched on factors thought to be central to orthographic learning, independent samples *t*-tests were conducted to test whether the two groups differed significantly on print exposure (title recognition), phonological decoding, word-specific orthographic knowledge, graphotactic knowledge, and knowledge of

conditional spelling patterns. Score distributions were approximately normal, with all absolute values of skewness and kurtosis within the range of ±1. Performance on the pretraining measures from the experimental and control groups, along with test statistics, are presented in Table 2. The mean scores were not significantly different between the two groups on any of the pretraining measures.

Table 2 Performance on screening and pretraining measures by the experimental and control groups

Measure	Experimental *M(SD)*	Control *M(SD)*	*t*	*p*
Screening				
Spell (*max = 17*)	9.4(3.5)	10.1(3.7)	0.64	.528
Read[b]	17.1(3.9)	17.3(4.5)	0.13	.898
Vocab (*max = 30*)	17.7(4.2)	17,0(3.9)	1.03	.309
Pre-training				
Print (*max = 18, corrected score*)	7.0(2.1)	6.3.(2.1)	1.03	.310
WSOK (*max = 20*)	11.9(3.9)	12.9(4.5)	0.77	.444
GK (*max = 24*)	19.2(3.3)	19.5(3.4)	0.23	.817
KCSP (*max = 28*)	16.8(5.9)	16.2(6.7)	0.27	.789
PD (*correct per minute*)	33.7(18.1)	38.8(18.4)	0.90	.372

Note. [b]correct responses per minute; Spell = spelling; Read = word reading; Vocab = vocabulary; Print = print exposure; WSOK = word specific orthographic knowledge; GK = graphotactic knowledge; KCSP = knowledge of conditional spelling patterns; PD = phonological decoding

Analyses of training effects

The performance of the two groups was compared across several dependent variables drawn from the reading task and the posttest tasks using analyses of covariance (ANCOVAs). Pretraining scores in phonological decoding, word-specific orthographic knowledge, and spelling were used as covariates. These measures were expected to relate to individual variance in measures of orthographic learning based on theoretical and empirical grounds. Hence, individual variability that could be attributed to well-known sources was accounted for by controlling for these pretraining measures. This provided a robust assessment of the effect of training. In an experimental setting where participants have been randomly assigned to groups, ANCOVA serves as a legitimate noise-reduction technique (Miller & Chapman, 2001).

The correlations between all pre- and posttraining measures are presented in Table 3. These correlations were used to evaluate the utility of the pretraining measures as CVs in the ANCOVAs (see the next section). Before conducting the analyses, assumptions for ANCOVA were examined, including linearity, normality, homogeneity of variances, and regression slopes.

Table 3 Correlations between all variables for the 42 participants selected for the training phase

	1	2	3	4	5	6	7	8	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
1. Spell	-															
2. Read	.62**	-														
3. Vocab	.04	.27	-													
4. Print	-.03	.23	.42**	-												
5. WSOK	.61**	.53**	.29	.18	-											
6. GK	.30	.35*	.12	.18	.58**	-										
7. KCSP	.40**	.07	-.09	.05	.41**	.45**	-									
8. PD	.48**	.69**	.06	.12	.34*	.28	.11	-								
9. TWD-1	.53**	.50**	-.15	-.08	.34*	.44**	.28	.61**	-							
10. TWD-4	.16	.23	-.15	.03	.18	.26	.06	.38*	.71**	-						
11. OC	.36*	.38*	-.10	-.06	.44**	.38*	.40**	.34*	.59**	.50**	-					
12. Spell-w	.34*	.09	-.02	.05	.23	.20	.49**	.14	.39*	.30	.60**	-				
13. Spell-l	.40**	.25	-.06	.03	.35*	.26	.44**	.28	.46**	.36*	.64**	.89**	-			
14. TWD-a	.39*	.26	.00	-.09	.27	.46**	.13	.29	.65**	.64**	.38*.	.32*.	.38*	-		
15. TWD-e	.57**	.61**	-.06	.09	.41**	.41**	.14	.69**	.73**	.62**	.44**	.19	.30	.63**	-	
16. MND-a	.55**	.42**	-.14	-.03	.37*	.45**	.39**	.45**	.81**	.71**	.65**	.47**	.56**	.75**	.67**	-
17. MND-e	.67**	.64**	-.01	.17	.45**	.37*	.30	.77**	.76**	.60**	.56**	.37*	.48**	.50**	.82**	.79**

Note. Post-training measures are written in italics. Spell = spelling; Read = word reading; Vocab = vocabulary; Print = print exposure; WSOK = word specific orthographic knowledge; GK = graphotactic knowledge; KCSP = knowledge of conditional spelling patterns; PD = phonological decoding; *TWD-1* = target word decoding, first attempt; *TWD-4* = target word decoding, fourth attempt; *OC* = orthographic choice; *Spell-w* = spelling, words; *Spell-l* = spelling, letters; *TWD-a* = target word decoding, accuracy; *TWD-e* = target word decoding, efficiency; *MND-a* = matched nonword decoding, accuracy; *MND-e* = matched nonword decoding, efficiency

*$p < .05$. **$p < .01$.

Performance on target word decoding during text reading

An ANCOVA was conducted to test whether the experimental group outperformed the control group on the first attempt to decode the target words during the reading task. Performance on phonological decoding and spelling were used as covariates. Both measures correlated moderately and significantly with the first decoding attempt and only moderately with each other (see Table 3). Both phonological decoding, $F(1, 39) = 15.72$, $p < .001$, and spelling, $F(1, 39) = 6.33$, $p = .016$, were significantly related to the first decoding attempt of the target words. There was also a significant main effect of group after controlling for the effect of the covariates, $F(1, 39) = 6.77$, $p = .013$. This meant that the experimental group decoded more words accurately than the control group (see Table 4). Thus, a moderate training effect (Cohen's $d = 0.58$)[1] was detected a few days after spelling instruction ended, reflecting that students who received training applied the spelling patterns they were taught in decoding new words while they read.

To test whether the experimental group also outperformed the control group on the fourth and final decoding attempt of the target words, an ANCOVA was conducted with phonological decoding as the covariate. Spelling was not included as a covariate in this analysis because it did not correlate significantly with the fourth decoding attempt (see Table 3). Because the measure of target word decoding was moderately negatively skewed, it was reversed and square root transformed following Tabachnick and Fidell (2014) prior to further analysis. Using the transformed variable, all assumptions for ANCOVA were met. Phonological decoding was found to be significantly related to the fourth decoding attempt of the target words, $F(1, 39) = 12.21$, $p = .001$. There was also a significant main effect of group after controlling for the effect of phonological decoding, $F(1, 39) = 9.85$, $p = .003$. This meant that the experimental group decoded more words correctly compared with the control group (see Table 4). Thus, a strong training effect (Cohen's $d = 0.86$) was seen on the final decoding of the target words.

Even though students had practiced decoding the target words three times in the text, the impact of the spelling pattern training was still evident in the fourth decoding attempt, indicating a persistent transfer effect. In the fourth reading, it was found that one student in the control group and 11 students in the experimental group decoded all words correctly. Analysis of the error types made by students in the control group revealed that the most common error was a mispronunciation of the complex letter units containing silent letters (e.g., *ods* pronounced /ʌds/ rather than /ʌs/). The second most frequent error was a mispronunciation of the vowel letter (e.g., *eds* pronounced /es/ rather than /ɛs/). Additionally, in a few cases, a sound was added (e.g., *balgt* pronounced /baldə/ rather than /bal^{ʔ}d/), or the target word was pronounced as an actual Danish word.

Table 4 Performance on target word decoding during text reading by the experimental and control groups

Target word decoding	*Experimental M(SD)*[a]	*Control M(SD)*[a]	*F*[b]	*p*
First attempt (max = 12)	8.7(3.2)	7.6(2.8)	6.77	.013
Second attempt (max = 12)	10.4(1.7)	9.9(1.8)		
Third attempt (max = 12)	10.7(2.1)	9.3(2.4)		
Fourth attempt (max = 12)	10.5(2.0)	9.2(2.3)	9.85	.003

[a]The scores are unadjusted raw scores. [b]F-statistics resulting from the analyses of covariance

Performance on posttest to assess orthographic learning during independent reading

Students' ability to identify, reproduce, and decode the spellings of the 12 target words was tested two or three days following the reading task. Moreover, students' ability to decode 12 matched nonwords from a list was tested to investigate whether differences in orthographic learning would transfer to the decoding of new analogous nonwords. Posttest performance in the experimental and control groups are presented in Tables 5 and 6, along with effect sizes for the differences. Score distributions were approximately normal, with absolute values of skewness and kurtosis within acceptable limits. The exception was target word spelling, which was positively skewed, and target word decoding accuracy, which was negatively skewed.

Table 5 Posttest performance by the experimental and control groups on tests of spelling memory

Posttest measure	*Experimental M(SD)*[a]	*Control M(SD)*[a]	*Effect size*[bc]
Orthographic choice (max = 12)	7.8(2.6)	6.1(2.1)	0.85
Spelling; words correct (max = 12)	3.7(3.8)	0.9(1.5)	1.87
Spelling; letters correct (max = 64)	52.7(6.3)	48.6(3.9)	1.19

[a]The scores are unadjusted raw scores. [b]The adjusted means resulting from the analyses of covariance were used to calculate effect sizes. [c]Cohen's *d* was calculated for the difference between groups on the orthographic choice task. However, Glass's *Δ* was calculated for the difference between groups on spelling, since the groups' standard deviations were significantly unequal on the two spelling measures. It was assumed that the standard deviation of the no-training control group was unaffected by treatment and therefore more closely reflected the population standard deviation (Ellis, 2010)

To investigate whether orthographic learning had occurred in both groups, the mean number of correct responses on the orthographic choice task was compared with chance performance

(three correct responses) using one-sample *t*-tests. Both the control group, $t(20) = 6.55$, $p < .001$, and the experimental group, $t(20) = 8.57$, $p < .001$, performed significantly above chance. In addition, paired-sample *t*-tests were conducted to investigate whether both groups decoded the target words significantly more accurately than they decoded the analogous nonwords. Both the control group, $t(20) = 4.95$, $p < .001$, and the experimental group, $t(20) = 3.99$, $p = .001$, decoded the target words significantly more accurately than they decoded the matched nonwords. These results suggest that the orthographic representation of the target words were established in memory during independent reading irrespective of prior training.

An ANCOVA was conducted to compare mean scores on the orthographic choice task. Performance on the word-specific orthographic knowledge task was used as the covariate. Word-specific orthographic knowledge was significantly related to performance on the orthographic choice test, $F(1, 39) = 14.04$, $p = .001$. There was also a significant main effect for group after controlling for the effect of word-specific orthographic knowledge, $F(1, 39) = 9.97$, $p = .003$. Thus, when measuring orthographic learning as the ability to recognize the correct word spelling among three foils, students in the experimental group significantly outperformed students in the control group, resulting in a moderate to large effect (Cohen's $d = 0.85$).

To examine the similarity of the distribution of scores from the two groups, a Mann–Whitney U-test was conducted. This was particularly relevant because a floor effect was present in the performance of the control group on the measure of whole-word spelling (13 students had a score of 0). Students in the experimental group (median = 3.0) spelled significantly more words correctly than the control group (median = 0.0), $U = 333.50$, $z = 3.03$, $p = .002$, resulting in a large effect (Glass's $\Delta = 1.87$). This result was supported by an ANCOVA that compared the ability of students to represent letters from the target word spellings in their spelling attempts. Unlike whole-word spelling, no floor effect was found on this measure. Performance on the standardized spelling test prior to training was used as the covariate. Performance on the measure of knowledge of conditional spelling patterns was also considered as an additional covariate for the analysis because performance on this measure correlated moderately and significantly with the students' ability to represent letters from the target word spellings (see Table 3). However, when examining assumptions for the ANCOVA, a significant interaction effect between group and knowledge of conditional spelling patterns was found. (This finding is further commented on in the Discussion section.) Spelling performance was significantly related to the proportion of correct letters represented in the participants' spelling attempts, $F(1, 39) = 11.49$, $p = .002$. There was also a significant main effect of group after controlling for the effect of spelling performance prior to training, $F(1, 39) = 10.13$, $p = .003$. This meant that the experimental group produced a higher proportion of

correct letters in their spelling attempts compared with the control group, resulting in a large effect (Glass's Δ = 1.19).

Table 6 Posttest performance by the experimental and control groups on tests of decoding

Posttest measure	*Experimental M(SD)*	*Control M(SD)*	*Effect size*[a]
Target word decoding accuracy (max = 12)	10.2(2.9)	10.2(2.5)	-
Target word decoding efficiency (wpm)	66.0(36.6)	61.8(30.5)	0.26
Matched nonword decoding accuracy (max = 12)	8.6(3.4)	7.7(2.8)	0.42
Matched nonword decoding efficiency (wpm)	39.9(24.2)	36.1(20.7)	0.42

[a]Cohen's *d* was calculated using the adjusted means resulting from the analyses of covariance

As shown in Table 6, no difference in the mean performance on isolated target word decoding accuracy was seen between the groups. However, a small difference favoring the experimental group was seen on decoding efficiency. An ANCOVA was conducted to test whether this difference was significant when taking into account the effect of participants' performance on phonological decoding and spelling prior to training. One participant in the control group was identified as a bivariate outlier. This student performed surprisingly poorly on target word decoding compared with performance on phonological decoding, and the student's results were excluded from the analysis. Both phonological decoding, $F(1, 38) = 42.00$, $p < .001$, and spelling, $F(1, 38) = 7.91$, $p = .008$, had a significant effect on target word decoding efficiency. There was no significant effect of group after controlling for the effect of the covariates, $F(1, 38) = 2.12$, $p = .154$.

To investigate whether differences in orthographic learning would transfer to decoding of new, analogous nonwords, the participants decoded 12 matched nonwords from a list. When decoding the new, analogous nonwords, a modest difference in mean performance favoring the experimental group was seen on both decoding accuracy and decoding efficiency (see Table 6). The difference in decoding accuracy was examined with an ANCOVA that controlled for participants' performance on spelling. Phonological decoding was dropped as an additional covariate because it did not provide a significant adjustment of decoding efficiency over and above spelling. Spelling, $F(1, 39) = 19.64$, $p < .001$ had a significant effect on decoding accuracy. There was no significant effect of group after controlling for the effect of spelling, $F(1, 39) = 2.65$, $p = .112$. Furthermore, an ANCOVA was conducted to test whether the difference in decoding efficiency was significant when taking into account the effect of participants' performance on phonological decoding and spelling. Both phonological decoding, $F(1, 39) = 43.17$, $p < .001$, and spelling, $F(1, 39) = 19.63$, $p < .001$,

had a significant effect on decoding efficiency. There was also a significant effect of group after controlling for the effect of the covariates, $F(1, 39) = 6.86$, $p = .013$.

In summary, explicit training did not provide an advantage over reading only, as reflected in the measures of isolated target word decoding accuracy and efficiency. The experimental group performed somewhat better than the control group when decoding nonwords analogous to the target word spellings, but the effect sizes were small (see Table 6). Still, after controlling for the strong effect of phonological decoding and spelling, there was a significant group effect on matched nonword decoding efficiency.

As depicted in Table 4, a moderate to strong transfer effect from training to orthographic learning of new words during independent reading was found on posttest results from the orthographic choice and spelling tasks. To determine whether the effect seemed to hold at an item level, the students' performance on each of the 12 target words on the orthographic choice task and the spelling task was examined. On 10 of the 12 items from the orthographic choice test and on all items from the spelling test, a greater number of students in the experimental group correctly identified the target spelling compared with the control group. Hence, within the two tasks, the benefit of training was evident across most of the words.

Discussion

Summary of results

The purpose of the present study was to examine whether explicitly teaching students conditional sound–spelling patterns would be effective and facilitate the acquisition of new words containing taught spelling patterns during independent reading. The target words embedded in short texts were nonwords cast as the names of new inventions. Because the spelling patterns trained were highly infrequent, real words could not be used. When decoding 12 target words on the first attempt during reading, the experimental group significantly outperformed the control group on decoding accuracy. This indicates that the explicit teaching of spelling patterns enabled students to apply these patterns in decoding target words while reading meaningful text better than when receiving no training. A significant difference between groups was also evident on the fourth and final decoding attempt of the target words, indicating a persistent transfer effect.

Both groups performed above chance level on an orthographic choice task at posttest, demonstrating that orthographic learning had occurred in both groups. This was expected because previous research has shown that decoding an unknown word a few times is sufficient for an orthographic representation to be established in memory (Cunningham et al., 2002; Reitsma, 1983; Share, 1999). As hypothesized, students who had received training

showed stronger orthographic learning at posttest compared with students who did not receive training. The transfer effect from training to orthographic learning during independent reading was strong when measured as the students' ability to spell the target words and moderate when measured as their ability to select target word spellings among foils. However, no significant group differences were seen on target word decoding accuracy and target word decoding efficiency. Thus, the facilitating effect of training that was present during the reading task could no longer be detected. Different factors might explain this finding. First, the training that the control group received on the spelling patterns as they decoded the target words during the reading task might have improved their decoding skill to the level of the trained group, at least enough to eliminate differences on target word decoding at posttest although not on tests involving memory for target spellings. Second, the participants were corrected if they failed to pronounce the target words correctly on the first two decoding attempts during text reading. This might have eliminated differences between the groups that would have been present had no feedback been provided during reading. Third, as for naming speed of target words following orthographic learning tasks, previous studies have shown that this measure is the least reliable of all three measures of posttest orthographic learning and also the least sensitive (e.g., Share, 1999, 2004; Share & Shalev, 2004).

Taken together, the findings confirmed the hypothesis that a stronger transfer effect would occur when orthographic learning was measured as the students' ability to reproduce target word spellings compared with their ability to identify and decode target words.

It was further assessed whether group differences in orthographic learning would generalize to the decoding of nonwords analogous to the target words. A small but insignificant difference favoring the experimental group was seen on matched nonword decoding accuracy. When controlling for the strong effect of phonological decoding and spelling prior to training, a significant effect of group was seen on matched nonword decoding efficiency, although the effect was small. Thus, enhanced orthographic learning of the target words seemed to generalize to decoding of new nonwords; that is, students in the experimental group were somewhat superior in reading the nonwords in analogy to the target words.

Enhancing knowledge of sublexical spelling patterns: Effect on orthographic learning

The findings of the present study are in line with previous studies that have found a transfer effect from explicit or implicit training targeting sublexical letter patterns to decoding of new neighbor words (Berends & Reitsma, 2007; Bhattacharya & Ehri, 2004; Conrad, 2008). Moreover, the results are consistent with those of Bhattacharya and Ehri, who found that a group trained in graphosyllabic analysis showed superior memory for word spellings when

asked to spell words learned through a word-learning task compared with a no-training control group (Cohen's *d* = 1.09). Because the words presented in the word-learning task contained several graphosyllabic patterns that the participants were exposed to during training (e.g., *com*, *tion*), the researchers suggested that superior knowledge of these sublexical patterns likely contributed to stronger orthographic learning of the target words during the word-learning task (Bhattacharya & Ehri, 2004).

Overall, the present results extend findings from previous training studies on word learning in important respects. Students in the experimental group were explicitly taught a sample of conditional spelling patterns conforming to Danish orthography. This method was distinct from previous studies using repeated readings of words to train participants in recognizing spelling patterns across words (e.g., Berends & Reitsma, 2006, 2007; Conrad, 2008; Conrad & Levy, 2011; Marinus, de Jong, & van der Leij, 2012)**.** Because levels of orthographic knowledge were experimentally manipulated in the present study, the findings provide new and stronger evidence for the idea that enhanced knowledge of sublexical sound–letter patterns boosts memory for new word spellings. Further, word learning emerged from four encounters with target spellings embedded in text, parallel to orthographic learning tasks often used in studies on self-teaching (e.g., Cunningham et al., 2002; Share, 1999, 2004). The task was distinct from word-learning tasks used in previous training studies in which words were presented on printed flash cards and learned over repeated trials with corrective feedback (e.g., Bhattacharya & Ehri, 2004; Boyer & Ehri, 2011; Castiglioni-Spalten & Ehri, 2003).

Establishing well-specified orthographic representations during independent reading

Previous studies on orthographic learning during independent reading have mainly been conducted in English (e.g., Bowey & Miller, 2007; Cunningham, 2006; Nation, Angell, & Castles, 2007; Wang et al., 2013), although studies have been conducted in other writing systems as well (e.g., Hebrew: Share, 1999; Dutch: de Jong & Share, 2007). In the present study, orthographic learning of complex word spellings conforming to the Danish writing system was observed among third graders after four exposures during reading. This replicates findings from other orthographies and extends the empirical support for the self-teaching hypothesis to the irregular Danish orthography (Share, 2008).

Perfetti and Hart (2002) introduced the concept of lexical quality to describe variation in the representations of written words that are formed in memory. A word that is high in lexical quality can be viewed as a nexus of high-quality orthographic, phonological, and semantic information. It was evident from the spelling task at posttest that several students had not established orthographic representations of such a high quality that they were able to spell the target words correctly. Notably, most of the letters from the target words were

correctly represented in the participants' spelling attempts (see Table 5). An examination of the spelling errors made by students in the control group revealed that the majority of the errors made were conventional phonetic equivalents to the target spelling patterns. Of the spelling errors made, 77% were phonologically possible spellings. Moreover, for each target word, the most common spelling was the simplest possible (each sound represented by one letter; e.g., *vrygle* spelled *vryle*, *podsk* spelled *posk*). For the target words *medsk* (/mɛsg/) and *kleds* (/klɛs/), the vowel sound /ɛ/ was equally often represented by the letter *æ* as the letter *e*. Hence, for many students, four exposures to the target words were not sufficient to fully memorize complexities such as silent letters and irregular spellings of vowel sounds.

The finding that enhanced knowledge of conditional spelling patterns led to stronger orthographic learning of new words serves as empirical evidence for Ehri's (2005, 2014) connectionist theory of developmental phases of reading and spelling. In the most advanced developmental phase, called the consolidated alphabetic phase, connections linking spellings to pronunciations are formed out of grapheme–phoneme blends that have been consolidated into larger spelling–sound units. Prior to training, students' knowledge of conditional spelling patterns was tested using a nonword choice task. This measure indicates the extent to which multiletter spelling–sound units have accumulated in memory. As suggested by Ehri, the predominant type of orthographic representation in memory changes with development and differentiates the developmental phases in reading and spelling.

As evidenced by the substantial variance in performance on the measure of conditional spelling patterns (see Table 2), multiletter sound–spelling patterns seemed to be well established in memory among some participants, placing them in the consolidated alphabetic phase, whereas other participants seemed to draw primarily on their knowledge of grapheme–phoneme spellings, placing them closer to the full alphabetic phase. Interestingly, a strong correlation was observed between prior knowledge of conditional spelling patterns and spelling performance at posttest in the spelling-trained group (whole-word spelling: $r = .77$, $p < .001$; letter spelling: $r = .69$, $p = .001$). The correlations were markedly lower in the control group (whole-word spelling: $r = .21$, $p = .335$; letter spelling: $r = .20$, $p = .394$). Importantly, the test of knowledge of conditional spelling patterns did not include any of the spelling patterns covered in the training. A tentative explanation for these correlations might be that the transfer effect from training to orthographic learning during independent reading increased as a function of the amount of preexisting knowledge of conditional spelling patterns. That is, preexisting knowledge facilitated the acquisition of new sound–spelling patterns that were trained explicitly, and better knowledge of these patterns contributed to the acquisition of higher quality orthographic representations of the target words while reading. However, caution is needed in interpreting correlations involving the control group because the standard deviations were much smaller on the two spelling posttest measures, possibly suppressing control group correlations.

Limitations

The control group received no training prior to the orthographic learning phase, so the groups were not equated for time spent in the study. This raises concern about possible Hawthorne effects. However, because all students had the experience of working individually with the experimenter at least two times before the posttest, it seems unlikely that Hawthorne effects explain the strong differences in orthographic learning during independent reading found between the groups. Additionally, the study design does not rule out the possibility that the group differences seen at posttest could be attributed to a general training effect rather than a specific effect of enhanced knowledge of specific conditional spelling patterns as claimed. These possible confounds should be addressed when designing future studies. Ideally, both an alternative training control group and a no-training control group should be included.

As evident in Table 1, imbalances in gender and Danish as a first or second language distinguished the two groups, although the differences did not reach significance. The control group generally performed slightly better on pretraining measures related to orthographic learning, making it unlikely that the greater number of male participants and participants with Danish as a second language in the control group explained the differences in orthographic learning seen at posttest.

The generalizability of results may be limited. Participants were drawn from the same school and the same grade level. Moreover, they were selected based on a screening of vocabulary and spelling, and students with low scores on these measures were excluded. Hence, it remains for future research to determine whether findings generalize to other populations of students and whether findings generalize to students learning to read and spell in other orthographies. The generalizability of results may be further limited because only nonwords were used in training and in the orthographic learning task. There is a strong presumption that a great part of orthographic learning during independent reading takes place with words that are known from the spoken language but unknown in their written form. Therefore, the level of orthographic learning seen in studies with nonwords might not generalize to orthographic learning with real words (Cunningham, 2006).

Implications for practice

Findings of the present study carry important educational implications. First, enhanced knowledge of sublexical letter patterns was found to enhance students' memory for new word spellings. Second, as it was done in the present study, the way to build students' ability to remember complex word spellings may be to explicitly teach them the sound–spelling mappings of complex spelling patterns followed by learning instances of the patterns in

particular words. A clear strength was the finding that explicit instruction with a simple structure and a fairly short duration proved to be effective. Hence, the possibility of incorporating such training in reading and spelling instruction in schools seems promising.

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Appendix A

Table showing the sound-spelling patterns trained, the target words used during the orthographic learning phase, and the matched nonwords used at posttest

Table A1

Spelling	*Pronunciation*	*Complex letter unit*	*Target words*	*Matched nonwords*
igl	[iˀl][a] [i:l]	ig	brigl / frigle	trigl / vrigle
ygl	[yˀl] [y:l]	yg	krygl / vrygle	frygl / drygle
eds	[ɛs]	ds	kleds / medsk	fleds / nedsk
ods	[ʌs]	ds	gjods / podsk	kjods / dodsk
algt	[alˀd] [ald]	lg	balgt / nalgte	lalgt / palgte
ølgt[bc]	[ølˀd] [øld]	lg	vølgt / hølgte	mølgt / jølgte

[a]The Danish prosodic feature 'stød' (a type of creaky voice, cf. Grønnum, 2005) is denoted with ˀ. [b]The Danish letter *ø* is the standard letter for the sound [ø]. [c]The spelling pattern *ølgt* does not occur in any Danish word, but it conforms to the spellings patterns *algt*, *ulgt*, and *olgt* occurring in Danish words

Appendix B

Example of a drawing and the corresponding text used during the orthographic learning phase

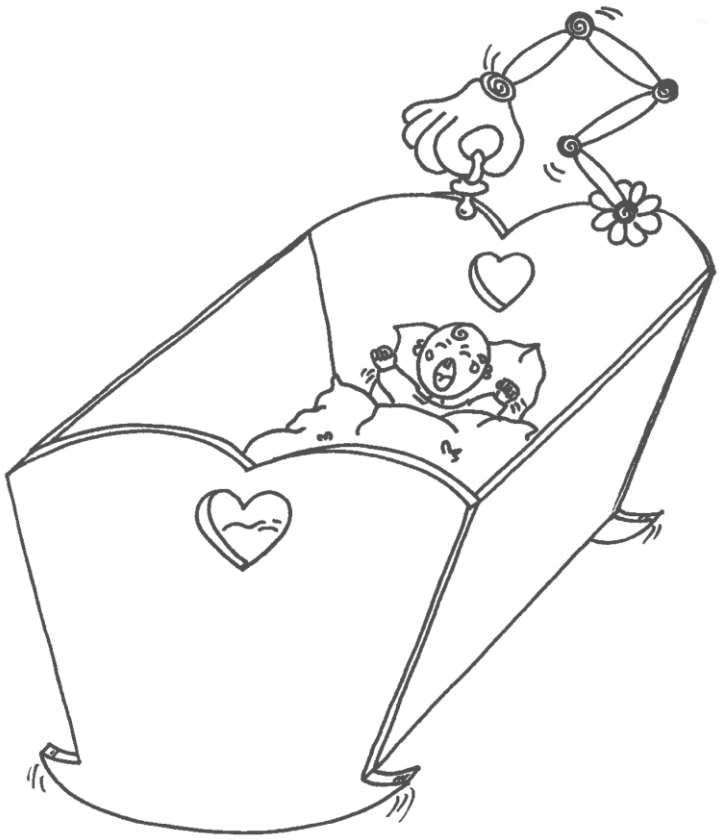

Figure B1

Da Professor Axel blev far, opfandt han en nalgte. Man sætter den fast på en vugge. Når babyen græder, kan en nalgte hurtigt finde sutten. En vrygle giver babyen sutten i munden. En vrygle er blød og varm og ligner en hånd.

'When Professor Axel became a father, he invented a nalgte. You fasten it to a cradle. When the baby cries, a nalgte quickly finds the pacifier. A vrygle places the pacifier in the baby's mouth. A vrygle is soft and warm and looks like a hand.'

Diskussion og perspektivering

Opsummering af hovedresultater

Studierne i afhandlingen belyste to hovedspørgsmål om ortografisk processering blandt danske børn på skolens begynder- og mellemtrin:

- *I hvilken grad bygger tilegnelse af ortografisk viden i senere faser af børns skriftsproglige udvikling på samme kognitive fundament som tilegnelse af fonologisk viden i tidligere faser af deres skriftsproglige udvikling?*

- *Hvilken betydning har viden om betingede stavemønstre for den fortsatte læse- og staveudvikling?*

Det første spørgsmål blev adresseret i langtidsundersøgelsen i studie 1 med fokus på prædiktion af stavefærdighed i en tidlig og en senere fase i staveudviklingen. Det andet spørgsmål blev adresseret i studie 2 og 3. Mens her og nu-undersøgelsen i studie 2 fokuserede på betydningen af viden om betingede stavemønstre for stavefærdighed blandt elever i 5. klasse, fokuserede træningsundersøgelsen i studie 3 på betydningen af viden om betingede stavemønstre for tilegnelse af nye ords stavemåde under selvstændig læsning blandt elever i 3. klasse. Hovedresultaterne fra de tre studier opsummeres nedenfor. Samlet set bidrager studierne med såvel replikationer af tidligere resultater fra andre ortografier som med nye bidrag til den samlede forskningsbaserede viden om ortografisk processering.

I studie 1 blev langtidsrelationerne mellem en række sproglige mål indsamlet i slutningen af 0. klasse og stavefærdigheder målt i begyndelsen af 2. og 5. klasse undersøgt med et udsnit med 140 dansktalende børn. Følgende prædiktorer var i fokus: fonemopmærksomhed, fonologisk korttidshukommelse, bogstavkendskab, hurtig seriel benævnelse (*rapid automatized naming*, RAN) samt indlæring af associationspar med ord og nonord (*paired associate learning,* PAL). På baggrund af resultater fra andre ortografier var det forventningen, at fonemopmærksomhed og bogstavkendskab ville være de stærkeste prædiktorer af stavefærdighed i den tidlige fase i udviklingen, mens det var et åbent spørgsmål, hvorvidt PAL kunne bidrage unikt til prædiktionen. Resultatet var en delvis replikation af tidligere resultater; en multipel regressionsanalyse viste, at mål for fonologisk processering (opmærksomhed og hukommelse) samt RAN forklarede unik variation i stavefærdighed i 2. klasse, men at det samme ikke var tilfældet for bogstavkendskab. Inkluderingen af PAL bidrog ikke til at forklare yderligere variation. Når det gjaldt prædiktionen af senere stavefærdigheder var det forventningen, at samtlige prædiktorer ville

falde i styrke pga. det længere tidsspænd, og at denne tendens ville være mindre for mål associeret med tilegnelse af ortografisk viden end for mål associeret med tilegnelse af fonologisk viden. Det var ligeledes en hypotese, at hvis et eller flere af de tidlige sproglige mål var specifikt relateret til tilegnelse af ortografisk viden, ville det eller de mål prædicere unik variation i stavefærdighed i 5. klasse efter kontrol for stavefærdighed i 2. klasse. Mod forventning sås kun et fald i prædiktionsstyrke for fonemopmærksomhed, fonologisk korttidshukommelse og RAN, mens prædiktionsstyrken for PAL med nonord blev signifikant stærkere. Prædiktionsmønstret for stavning i 5. klasse adskilte sig tydeligt fra prædiktionsmønstret i 2. klasse; en multipel regressionsanalyse viste, at kun RAN og PAL med nonord var unikke prædiktorer af senere stavefærdighed. Endelig viste en hierarkisk multipel regressionsanalyse, at stavefærdighed i 2. klasse var den stærkeste prædiktor for stavefærdighed i 5. klasse. Men derudover kunne PAL med nonord fortsat forklare en relativ stor del af variationen i stavefærdighed i 5. klasse (9%) efter kontrol for stavefærdighed i 2. klasse. Dermed peger resultaterne på et *specifikt* link mellem verbale indlæringsfærdigheder - *før* formel læse- og staveundervisning er påbegyndt - og senere tilegnelse af ortografisk viden, der er kritisk for udviklingen af automatiseret stavefærdighed. Og resultaterne peger dermed endvidere på, at tilegnelse af ortografisk viden i senere faser i staveudviklingen er *delvist* baseret på andre færdigheder end dem, der er nødvendige for tilegnelse af fonologisk viden i tidlige faser i staveudviklingen. På denne baggrund fremsættes følgende hypotese: Børn, der har vanskeligheder med at tilegne sig nye fonologiske former af en stabilitet og kvalitet, der muliggør umiddelbar *genkaldelse* (hvilket er et krav i PAL-test med verbalt output), har ligeledes vanskeligheder med at etablere fonologiske former, der korresponderer med betingede eller ordspecifikke stavemønstre, af en stabilitet og kvalitet der gør, at børnene er i stand til at *genkalde* stavemønstrene under stavning. I staveprøve 3, der blev anvendt som mål for stavefærdighed i studie 1, stilles krav om, at eleverne kan stave ord med komplekse stavemønstre. For at kunne stave ordene korrekt må eleverne enten trække på deres ordspecifikke ortografiske viden, eller de må trække på deres viden om stavemønstre, der optræder på tværs af ord. Stabile, velspecificerede fonologiske repræsentationer på subleksikalt niveau kan dermed være en afgørende forudsætning for at kunne stave ord med komplekse stavemåder.

I studie 2 blev de samtidige relationer mellem fire typer fonologisk/ortografisk viden og stavefærdighed målt i begyndelsen af 5. klasse undersøgt i et udsnit med 133 dansktalende børn. Det centrale forskningsspørgsmål var, hvorvidt et nyudviklet mål for kendskab til fonologisk betingede stavemønstre kunne forklare unik variation i stavefærdighed udover mål for fonologisk afkodning, ordspecifik ortografisk viden og grafotaktisk viden. Forventningen var, at såvel fonologisk afkodning som ordspecifik ortografisk viden ville være stærkt korreleret med stavefærdighed. En hierarkisk multipel regressionsanalyse viste da

også, at de to mål tilsammen forklarede 65% af variationen i samtidig stavefærdighed. En yderligere hypotese var, at både mål for grafotaktisk viden og mål for fonologisk betingede stavemønstre ville bidrage unikt til at forklare variation i stavefærdighed. Hypotesen blev bekræftet; efter den stærke kontrol for fonologisk afkodning og ordspecifik ortografisk viden, kunne begge mål for subleksikal ortografisk viden forklare yderligere signifikant variation, selvom bidragene var begrænsede. I alt forklarede de fire prædiktorer 70% af variationen i samtidig stavefærdighed. At mål for ordspecifik ortografisk viden og grafotaktisk viden kan forklare unik variation i stavefærdighed efter kontrol for fonologisk viden er en replikation af tidligere resultater i ortografier som engelsk og tysk, mens det er en udbygning af tidligere resultater, at individuel variation i kendskab til betingede stavemønstre ligeledes er en unik prædiktor af stavefærdighed. Resultaterne bekræfter dermed antagelsen om, at børn trækker på forskellige typer viden, når de skal stave ord med komplekse stavemåder (fx Bourassa & Treiman, 2014, Treiman & Kessler, 2014). Mens der var lofteffekt på målet for grafotaktisk viden, var der stor variation i elevernes præstation på målet for kendskab til betingede stavemønstre. Det tyder på, at mange danske elever i 5. klasse fortsat er i gang med at tilegne sig viden om stavemønstre betinget af fonologisk kontekst.

I studie 3 blev overføringseffekten fra direkte undervisning målrettet betingede stavemønstre til graden og kvaliteten af ortografisk indlæring af nye ord, som indeholdt trænede stavemønstre, under selvstændig læsning undersøgt. Det centrale forskningsspørgsmål var, hvorvidt eksisterende viden om betingede stavemønstre fremmer ortografisk indlæring under selvstændig læsning hos dansktalende børn i 3. klasse. Togogfyrre elever blev matchet i par på baggrund af deres ordlæsning og stavning, hvorefter hvert par blev tilfældigt splittet i en eksperiment- og en kontrolgruppe. Eksperimentgruppen trænede seks forskellige stavemønstre, der alle indeholdt komplekse grafemer (fx *o<u>ds</u>* som i *trods*). Træningen fokuserede primært på at forbinde udtale og stavemåde i små staveopgaver. Kontrolgruppen modtog ingen eksperimentel undervisning. For at overføringseffekten fra træning til ortografisk indlæring kunne undersøges, deltog begge grupper i en ordindlæringsopgave, hvor de i seks korte tekster blev eksponeret for 12 målord (nonord), der indeholdt trænede stavemønstre (fx *gjods*). Hver deltager afkodede hvert målord fire gange. To til tre dage efter ordindlæringsopgaven blev deltagernes ortografiske indlæring af målordene målt med en stavetest, en *orthographic choice test* og en afkodningstest. Derudover afkodede deltagerne 12 nonord, der matchede målordene (kun det første bogstav var ændret fx *gjods* →*kjods*). Hypotesen var, at elever, der modtog direkte undervisning, ville danne forbindelser mellem udtale og stavemåde af de trænede stavemønstre og lagre dem i hukommelsen som ortografiske repræsentationer. Kendskab til de trænede stavemønstre ville fremme dannelsen af forbindelser mellem udtalen og stavemåden af målordene under selvstændig læsning, hvorved ortografiske repræsentationer af højere leksikal kvalitet ville blive etableret

sammenlignet med elever, der ikke havde modtaget eksperimentel undervisning. De to gruppers præstation under ordindlæringsopgaven og på posttestmålene blev sammenlignet i en række ko-variansanalyser. Under ordindlæringsopgaven sås signifikante gruppeforskelle på afkodningspræcision af målordene. Dermed synes børnene fra eksperimentgruppen at trække på deres viden om de trænede stavemønstre under afkodning af målordene. Begge grupper scorede over chanceniveauet, når de skulle vælge den korrekte stavemåde blandt fire mulige i *orthographic choice* testen, ligesom begge grupper var mere præcise og mere effektive til at afkode målordene end de matchede nonord. Ortografisk indlæring af målordene var dermed målbar efter fire afkodningsforsøg. Resultatet bekræfter tidligere resultater fra ortografier som engelsk og hollandsk og udvider det empiriske grundlag for selvindlæringshypotesen (Share, 1995, 2008b) til også at indbefatte dansk ortografi. Der var en moderat overføringseffekt fra træning til ortografisk indlæring målt som genkendelse af målordenes stavemåde (*orthographic choice*), mens overføringseffekten målt ved genkaldelse af målordenes stavemåde (stavning) var stærk. Derimod sås ingen gruppeforskel i afkodning af målordene ved posttest. Endelig afkodede eksperimentgruppen de matchede nonord mere effektivt end kontrolgruppen, men effekten var lille. Samlet set fungerer resultaterne som empirisk støtte for antagelsen om, at større stavemønstre anvendes til at danne forbindelser mellem udtale og stavemåde af nye ord (Ehri, 2005, 2014). Og resultaterne udbygger tidligere resultater fra korrelationsstudier ved at demonstrere i en træningsundersøgelse, at eksisterende ortografisk viden fremmer graden og kvaliteten af ortografisk indlæring under selvstændig læsning.

Begrænsninger ved resultaterne

Der knytter sig en række begrænsninger til resultaterne fra de tre studier, der har betydning for styrken af resultaterne og de konklusioner, der kan drages på baggrund af dem. Begrænsningerne diskuteres nedenfor under fem forskellige temaer.

Målenes kvalitet

Styrken af ovenstående resultater afhænger af kvaliteten af de mål, der indgår i undersøgelserne. I studie 1 havde flere prædiktorer i 0. klasse begrænset følsomhed, hvilket uvægerligt vil begrænse deres prædiktionsværdi. Bl.a. kendte mange elever allerede navnene på størstedelen af bogstaverne i slutningen af 0. klasse. Et mål for elevernes kendskab til bogstavernes standardlyde ville derfor have været relevant at medtage. Der kan også sættes spørgsmålstegn ved pålideligheden af PAL-testene, som blev anvendt i studie 1. Det ville have været en klar styrke, hvis flere mål for PAL var blevet inkluderet. Høje interne korrelationer mellem flere tætbeslægtede mål for fx visuel-verbal PAL med nonord ville underbygge, at der

var tale om pålidelige mål (Poulsen et al., 2012). Et argument for ikke at inddrage flere mål for PAL i denne langtidsundersøgelse var dog, at de deltagende børn i forvejen blev præsenteret for et omfangsrigt batteri af individuelle test, hvoraf de to PAL-test var blandt de mest ressource- og tidskrævende at gennemføre for børnene. At inddrage flere test af denne type ville øge risikoen for, at børnene ikke længere ønskede at medvirke.

Som beskrevet i rapporten "Udvikling af danske gruppetest af ortografisk viden" (s. 58-70) blev testene af ortografisk viden udviklet med elever i 3. klasse som målgruppe. Undervejs i udviklingen blev der mulighed for at medtage testene i Center for Læseforsknings langtidsundersøgelse, hvor deltagerne var elever i begyndelsen af 5. klasse. At mange elever scorede tæt på loftet på testen af ordspecifik viden, og i særlig grad på testen af grafotaktisk viden, i studie 2 skal derfor ses i lyset af, at testene blev udviklet med yngre elever som målgruppe. Selvom der i sagens natur ikke var tale om et optimalt match mellem testenes sværhedsgrad og klassetrin, var det en interessant mulighed at afprøve, hvordan elever på mellemtrinnet ville klare sig på de tre test af ortografisk viden og ikke mindst, hvordan deres præstationer på disse test relaterede sig til deres afkodnings- og stavefærdigheder. Testen af grafotaktisk viden og testen af viden om betingede stavemønstre blev anvendt i version 2 i studie 2, mens de blev anvendt i den tredje og endelige version i studie 3. Korrektionerne af testene fra version 2 til den endelige version synes som tidligere beskrevet at have forbedret testenes kvalitet på en række parametre, hvorfor det er en oplagt begrænsning ved resultaterne i studie 2, at testene ikke blev anvendt i deres endelige versioner.

I studie 3 var der tendens til lofteffekt på mål for deltagernes afkodningspræcision under tekstlæsning og ved posttest. En del af forklaringen kan være, at der i alt kun indgik 12 målord/12 matchede nonord i undersøgelsen. Et større antal målord kunne have givet anledning til en større spredning i deltagernes scorer - og dermed også et bedre udgangspunkt for at identificere mulige gruppeforskelle på mål for afkodningspræcision.

Fravær af betydningsfulde prædiktorer

Valget af prædiktorer til langtidsundersøgelsen i studie 1 og til her og nu-undersøgelsen i studie 2 har betydning for, hvor komplette de to undersøgelsesdesigns fremstår. Da en del af deltagerne i studie 1 allerede kendte størstedelen af bogstavernes navne, er det muligt, at en del af dem var i stand til at stave simple, lydrette ord. Og da tidlige stavefærdigheder er en stærk prædiktor af senere stavefærdigheder, ville det derfor have været en styrke for undersøgelsen, hvis et tidligt mål for stavefærdighed havde været inkluderet som prædiktor. Det er ligeledes en betydelig begrænsning ved undersøgelsen, at et mål for deltagernes morfologiske opmærksomhed ikke indgik som et af prædiktormålene i 0. klasse, da flere studier har vist, at børn trækker på morfologisk viden under stavning (fx, Boulware-Gooden, Joshi, & Grogorenko, 2015; Bourassa & Treiman, 2014). En tilsvarende begrænsning gør sig

gældende for studie 2. En undersøgelse med deltagelse af dansktalende elever i 6. klasse har bl.a. vist, at viden om bøjningsmorfemer har positiv sammenhæng med samtidig stavefærdighed (Juul, 2005). Undersøgelsesdesignet ville derfor have fremstået mere komplet, hvis et eller flere mål for morfologisk viden havde været inkluderet.

Begrænsninger i studiernes design

Som beskrevet i indledningen er der i afhandlingens studier gjort brug af tre forskellige undersøgelsesdesigns, der genererer evidens af forskellig styrke. En iboende begrænsning ved her og nu-undersøgelsesdesignet i studie 2 er, at det ikke er muligt at svare på, hvorvidt variation i forskellige typer ortografisk viden kan prædicere *fremgang* i stavefærdighed, eller hvorvidt de positive korrelationer mellem stavefærdighed og ortografisk viden kan forklares fuldstændigt af fælles underliggende faktorer som fonologisk viden og skriftsprogserfaring. Spørgsmålet om en mulig årsagssammenhæng er derfor helt centralt at adressere i fremtidige træningsstudier, som det bl.a. blev gjort i studie 3.

En klar begrænsning ved resultaterne fra træningsundersøgelsen i studie 3 er, at designet kun inkluderede en ikke-trænet kontrolgruppe. Det betyder, at det ikke er muligt at udelukke, at gruppeforskellene ved posttest skyldes en generel træningseffekt og ikke en specifik effekt af øget kendskab til de trænede stavemønstre. Denne begrænsning i undersøgelsesdesignet kan imødekommes ved ikke blot at inkludere en ikke-trænet kontrolgruppe, men også en trænet kontrolgruppe, der modtager træning i det samme omfang og af den samme type som eksperimentgruppen, men med materiale der indeholder stavemønstre, der ikke indgår i målordene i den efterfølgende ordindlæringsopgave. Fravalget af en trænet kontrolgruppe i studie 3 blev taget på baggrund af, at alle faser i træningsundersøgelsen skulle kunne gennemføres af én person. Der var altså tale om en vurdering af tilgængelige ressourcer. En anden måde at imødekomme begrænsningen i undersøgelsesdesignet ville være at gennemføre træningsundersøgelsen med et *within-subject* design, hvor deltagerne fungerer som deres egen kontrol. Dette design blev anvendt i pilotundersøgelsen beskrevet i rapporten s. 97-105. Et *with-in subject* design blev fravalgt til den endelige træningsundersøgelse på baggrund af en bekymring for såkaldte *carryover effects*. Det vil sige, at deltagernes medvirken i én betingelse påvirker deres præstation under en anden betingelse. I dette tilfælde var bekymringen, at træningen i udvalgte stavemønstre kunne påvirke den efterfølgende ortografiske indlæring af nye ord med ikke-trænede stavemønstre. Det endelige design indeholdt derfor en maksimal kontrast mellem betingelserne: trænede over for ikke-trænede deltagere.

To resultater synes umiddelbart at tale for, at effekten af træningen kan tolkes som en specifik effekt på øget kendskab til trænede stavemønstre og ikke blot en generel effekt. For det første viste pilotundersøgelsen, at deltagernes ortografiske indlæring var stærkere for ord

med trænede mønstre end for ord med ikke-trænede mønstre. Et resultat der ikke kan forklares med en generel træningseffekt, da et *within-subject* design blev anvendt. For det andet sås i studie 3 en meget stærk sammenhæng mellem eksperimentgruppens præstation på stavetesten ved posttest og deres viden om betingede stavemønstre, *før* træningen blev iværksat (r = ,77). Til sammenligning sås kun svage til moderate sammenhænge mellem stavetesten ved posttest og fonologisk afkodning (r = ,21), ordspecifik ortografisk viden (r = ,32) og stavning (r = ,48) testet før træningen blev påbegyndt. En mulig forklaring på disse sammenhænge er, at overføringseffekten fra træning til ortografisk indlæring øgedes som funktion af mængden af eksisterende viden om betingede stavemønstre. Dvs. at eksisterende viden om betingede stavemønstre fremmede indlæringen af nye stavemønstre, når de blev trænet eksplicit.

Resultaternes generaliserbarhed

Generaliserbarheden af resultaterne i studie 3 begrænses af, at ordmaterialet i undervisningen og ordindlæringsopgaven udelukkende bestod af nonord. En stor del af den ortografiske indlæring, der foregår under selvstændig læsning, må i vid udstrækning formodes at finde sted med ord, der er kendte fra det talte sprog, men ukendte i deres skrevne form. Det er dermed muligt, at niveauet af ortografisk indlæring, der ses i studier med nonord, ikke kan generaliseres til ortografisk indlæring af eksisterende ord (Cunningham, 2006). Denne problematik kan enten imødekommes ved at anvende rigtige ord, eleverne kender fra det talte sprog, men som de med stor sandsynlighed endnu ikke kender stavemåden af (fx Cunningham, 2006) - en fremgangsmåde der bliver vanskeligere at anvende, jo mere skriftsprogserfaring deltagerne har. Alternativt kan man træne deltagernes kendskab til udtalen og betydningen af en række nonord op til et specifikt kriterium, hvorefter deltagerne præsenteres for nonordenes stavemåde i en ordindlæringsopgave (fx Wang et al., 2012). Dermed simuleres hverdagslæsning i højere grad, end det er tilfældet i ordindlæringsopgaver, hvor nonordenes udtale og betydning ikke er blevet trænet på forhånd. Da der er tale om en meget ressourcekrævende fremgangsmåde, blev metoden fravalgt til træningsundersøgelsen i studie 3.

Væsentlige sammenhænge der ikke undersøges

Staveprøve 3, der blev anvendt som mål for stavefærdighed i studie 1, er et generelt stavemål, hvis items stiller krav til forskellige typer viden såsom morfologisk viden (fx *bekymrer, syngende*), viden om betingede stavemønstre (fx *nænne, blunder*) og viden om ordspecifikke stavemåder (fx *heldigvis, kende*). Det kan ses som en begrænsning ved undersøgelsen, at den ikke kan svare på, hvilken type ortografisk viden PAL med nonord i 0. klasse prædicerer, men

blot opstiller en hypotese om, at verbal indlæring er specifikt relateret til tilegnelse af betingede eller ordspecifikke stavemønstre. Er denne hypotese korrekt, må det antages, at PAL-nonord i 0. klasse kan prædicere individuel variation i kendskab til betingede stavemønstre i 5. klasse. Da deltagerne i studie 1 og 2 er trukket fra det samme udsnit af elever i 5. klasse, er det muligt at undersøge hypotesen nærmere inden for afhandlingens rammer, idet studie 2 netop inkluderede et nyudviklet mål for kendskab til betingede stavemønstre. Hypotesen blev undersøgt i en analyse præsenteret i forbindelse med *The Society of the Scientific Studies of Readings* konference i 2014 (Nielsen, Poulsen, & Juul, 2014). PAL-nonord målt i 0. klasse korrelerede moderat og signifikant med kendskab til betingede stavemønstre i 5. klasse (r = ,32), og en hierarkisk regressionsanalyse viste, at PAL med nonord bidrog signifikant og unikt til at forklare variation i kendskab til betingede stavemønstre (R^2 = ,05, p = ,006) efter kontrol for bogstavkendskab, fonologisk opmærksomhed og RAN. Resultatet understøtter dermed umiddelbart hypotesen fremsat på baggrund af resultaterne i studie 1.

Det kan ses som en begrænsning ved studie 2, at der kun indgik et mål for stavefærdighed og ikke et mål for afkodningsfærdighed som afhængig variabel. Studie 1 og 2 fokuserer på udviklingen af stavefærdigheder, men individuel variation i ortografisk viden og ortografisk indlæring er som beskrevet også væsentlig for udviklingen af afkodningsfærdigheder. Testbatteriet i Center for Læseforsknings langtidsundersøgelse indeholdt også individuelle mål for afkodningsfærdighed, men på det tidspunkt hvor designet af studie 2 blev planlagt, var målene for deltagernes afkodningsfærdighed endnu ikke tilgængelige. Efterfølgende er det dog blevet muligt forsøgsvis at gentage analysen fra studie 2 med afkodning af enkeltord som afhængig variabel. Som en del af testbatteriet skulle deltagerne bl.a. afkode 32 uregelmæssigt stavede ord af 5-12 bogstavers længde (fx *streng, regnestykke*) præsenteret i korte ordlister. Deltagernes afkodningseffektivitet blev opgjort som antal korrekt afkodede ord pr. minut. De 132 deltagere fra studie 2 afkodede gennemsnitligt 69,7(SD = 22,9) ord korrekt i minuttet. Tabel 8 viser korrelationerne mellem ordafkodning, fonologisk afkodning (præcision i afkodning af nonord) samt de tre mål for ortografisk viden.

Tabel 8 Korrelationer mellem ordafkodning, fonologisk afkodning og test af ortografisk viden i 5. klasse

	Fonologisk afkodning	*Ordspecifik viden*	*Grafotaktisk viden*	*Viden om betingede stavemønstre*
Ordafkodning (ok per minut)	,56**	,59**	,29**	,42**

** p < ,01

Der er tale om moderate til stærke korrelationer mellem målet for ordafkodningseffektivitet og de fire prædiktorer. Der ses en forventet stærk sammenhæng mellem fonologisk afkodning og ordafkodning. Ligeledes ses en stærk sammenhæng mellem ordafkodning og ordspecifik ortografisk viden. En hierarkisk multipel regressionsanalyse svarende til analysen i studie 2 blev gennemført, men med ordafkodning som afhængig variabel. Resultatet af analysen fremgår af tabel 9.

Tabel 9 Multipel regressionsanalyse for prædiktion af ordafkodning i 5. klasse

Trin	*Prædiktor*	R^2	ΔR^2	*β (endelig model)*
1	Fonologisk afkodning	,31	,31	,32***
2	Ordspecifik viden	,47	,16	,38***
3	Grafotaktisk viden	,47	,00	,07
4	Viden om betingede stavemønstre	,50	,03	,19**

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

De fire prædiktorer forklarer tilsammen halvdelen af variationen i ordafkodningseffektivitet. Til sammenligning forklarer de 70% af variationen i stavefærdighed. Efter kontrol for fonologisk afkodning og ordspecifik ortografisk viden kan målet for viden om betingede stavemønstre bidrage unikt med yderligere 3%, mens målet for grafotaktisk viden ikke bidrager med unik variation. At grafotaktisk viden kan forudsige unik variation i stavning, men ikke i læsning skal måske forklares med, at genkaldelse af ords stavemåde generelt betragtes som en sværere opgave end genkendelse af ords stavemåde. En anden mulig forklaring er, at der er tale om forskelligt ordmateriale i stave- og afkodningstesten. Overordnet set er prædiktionsmønstret for de to mål for stavning og afkodning i 5. klasse dog i høj grad overensstemmende, hvilket er forventeligt ud fra en antagelse om, at udvikling af afkodnings- og stavefærdigheder er to sider af samme sag (Ehri, 1997; Perfetti, 1997). Og væsentligt for spørgsmålet om betydningen af viden om betingede stavemønstre blandt danske elever rejst i denne afhandling, bidrager målet for viden om betingede stavemønstre med unik variation i såvel stavning som ordafkodning blandt dansktalende elever i 5. klasse.

Perspektiver for fremtidig forskning

Resultaterne fra afhandlingens studier giver anledning til en række perspektiver for fremtidig forskning. En del af disse retter sig mod at replikere resultaterne og forbedre de anvendte mål og designs, mens andre retter sig mod nye forskningsspørgsmål.

Replikation

Det bør af flere grunde undersøges, om resultaterne af studie 1 kan genfindes i nye langtidsstudier. For det første er resultater fra tilsvarende undersøgelser meget sparsomme, da prædiktionsstudier af stavning primært har fokuseret på den tidlige staveudvikling. For det andet adskiller resultaterne sig fra langtidsstudiet af Lervåg og Hulme (2009), der er mest sammenligneligt med studie 1. Udover at søge at genfinde resultaterne i et nyt udsnit af danske elever vil det være interessant at sammenligne resultater fra parallelle studier på tværs af ortografier med varierende dybde. Én mulig forklaring på forskellen mellem resultaterne i studie 1 og Lervåg og Hulmes studie med norske elever kan muligvis findes i forskelle mellem dansk og norsk ortografi. De mange afvigelser fra én til én sammenhæng mellem fonemer og grafemer i dansk ortografi stiller sandsynligvis større krav til tilegnelse af ortografisk viden for børn, der skal lære at mestre det danske skriftsprog sammenlignet med børn, der skal lære at mestre det mere regelmæssige norske skriftsprog – ikke mindst i de senere faser i staveudviklingen.

I kommende prædiktionsundersøgelser, der inkluderer PAL, vil det være informativt at adskille den verbale indlæringsdel i PAL-opgaver (indlæring af nye fonologiske former) fra den associerende del (kobling af nye fonologiske former med visuelle former). Det er muligt, at PAL-opgaverne anvendt i studie 1 er mere følsomme for individuel variation i verbal indlæring blandt elever, der scorer i den lave ende på testen sammenlignet med fx PAL-testene anvendt af Lervåg og Hulme (2009). Og dermed at det er individuel variation i verbal indlæring, der er kritisk for sammenhængen med senere tilegnelse af ortografisk viden, snarere end individuel variation i evnen til at associere nye fonologiske former med visuelle former. En sådan tilgang blev anvendt i et nyere studie med deltagelse af engelsktalende børn i alderen 8-13 år inddelt i en gruppe med dyslektiske vanskeligheder og en aldersmatchet kontrolgruppe med en normal skriftsproglig udvikling (Litt & Nation, 2014). Studiet viste, at der kun var forskelle mellem grupperne på deres løsning af PAL-opgaver i de tilfælde, hvor et verbalt output var krævet, men ikke hvor outputtet var visuelt. For at belyse det kritiske aspekt ved dyslektiske børns vanskeligheder med PAL-opgaver med verbalt output, blev testen delt op i to dele svarende til den verbale indlæringsdel og den associative del. I en indledende verbal træningsfase skulle eleverne først indlære udtalen af fem nonord. Den indledende fase bestod af ti eksponeringer af hvert nonord samt fire blokke med fri genkaldelse af de fem nonord. Gruppen af børn med dyslektiske vanskeligheder præsterede på niveau med kontrolgruppen på gentagelse af nonordene, men de klarede sig dårligere, når det gjaldt fri genkaldelse af de nye fonologiske former. Det tyder på, at de dyslektiske børn havde vanskeligheder med at fastholde præcise fonologiske former i hukommelsen over en relativ kort tidsperiode (ibid.). I den næste fase skulle de fem nonord associeres med visuelle stimuli. Som forventet klarede de dyslektiske børn sig dårligere end kontrolbørnene på PAL-

opgaven. Men afgørende for tolkningen af den lavere præstation var, at de dyslektiske børns dårligere præstation *fuldt ud* kunne forklares med deres præstation i den forudgående verbale træningsfase. Resultatet er en yderligere indikation af, at det kritiske element i PAL-opgaver for elever med dyslektiske vanskeligheder er indlæring af nye fonologiske former. Det er op til fremtidige studier at vise, hvorvidt disse resultater kan generaliseres til andre målgrupper.

Resultaterne af studie 2 fremhæver betydningen af forskellige typer fonologisk og ortografisk viden for stavefærdighed blandt danske elever i 5. klasse. Fremtidige studier med parallelle designs vil fremstå som mere komplette, hvis de også inddrager mål for morfologisk viden som prædiktor af stavefærdighed, som diskuteret ovenfor. Ligeledes vil det sikre mere pålidelige resultater, hvis fremtidige studier inkluderer flere mål for de forskellige typer viden, der opereres med. Mens der findes forskellige forlæg for test af fonologisk viden, grafotaktisk viden og ordspecifik ortografisk viden at tage udgangspunkt i, foreligger der et arbejde i at udvikle følsomme test af kendskab til betingede stavemønstre – både når det gælder fonologisk og morfologisk betingede stavemønstre.

Resultaterne fra træningsundersøgelsen i studie 3 kalder på opfølgende undersøgelser. Det vil for det første være interessant at replikere resultaterne i træningsundersøgelser med andre populationer såsom yngre og ældre elever samt populationer med større spredning i væsentlige forudsætninger for ortografisk indlæring. I studie 3 blev deltagere med lave scorer på mål for ordforåd og stavefærdighed fravalgt pga. det begrænsede deltagerantal, det var muligt at medtage. Men netop elever med mangelfulde forudsætninger for ortografisk indlæring under selvstændig læsning må forventes at være en relevant målgruppe for direkte undervisning i betingede stavemønstre. Det vil ligeledes være interessant at iværksætte parallelle træningsundersøgelser i forskellige ortografier. Ikke mindst vil det være interessant at se, hvorvidt resultaterne fra studie 3 kan genfindes i den uregelmæssige engelske ortografi.

Nye forskningsspørgsmål

Det var uden for denne afhandlings rammer at undersøge langtidsprædiktionen af afkodningsfærdigheder. Men et oplagt perspektiv for fremtidige undersøgelser på baggrund af resultaterne i studie 1 vil være at undersøge betydningen af verbale indlæringsfærdigheder for udviklingen af afkodningsfærdigheder i en tidlig og en senere fase blandt danske elever.

I forlængelse af resultaterne i studie 3, vil det være relevant med et studie, hvis design tilvejebringer resultater, der i højere grad kan generaliseres til undervisningspraksis. Fx en træningsundersøgelse med et længere undervisningsforløb målrettet fonologisk og morfologisk betingede stavemønstre. Her kunne man undersøge den direkte træningseffekt (indlæring af trænet ordmateriale), overføringseffekten til indlæring af nye ord med trænede og utrænede stavemønstre samt effekten på standardiserede læse- og stavemål. I forbindelse

med en sådan undersøgelse ville der ligge et arbejde i at opstille kriterier for, hvilke betingede stavemønstre/hvilke komplekse grafemer der vil være de mest funktionelle at inddrage i undervisningen. Og det vil være oplagt at arbejde med rigtige ord fremfor nonord i såvel undervisnings- som testmaterialer.

Perspektiver for undervisning

Udbyttet af direkte, systematisk staveundervisning blev vurderet i en nyere metaundersøgelse (Graham & Santangelo, 2014). På tværs af klassetrin fra indskoling til udskoling viste undervisningen positiv effekt på stavefærdighed, skrivning og læseforståelse. Spørgsmålet synes derfor ikke at være, hvorvidt lærere skal sætte fokus på staveundervisning på forskellige klassetrin, men snarere hvad den direkte, systematiske undervisning skal indeholde for at opnå størst effekt hos forskellige elevgrupper.

Ambitionen med studie 1 var at bidrage til en større forståelse af det kognitive fundament for staveudviklingen i en tidlig (fonologisk) og i særlig grad en senere (ortografisk) fase. Den bagvedliggende motivation var at blive klogere på, hvordan staveundervisning kan og bør indrettes for at støtte børns tilegnelse af automatiserede stavefærdigheder. Faktorer udover anerkendte forudsætninger som bogstavkendskab og fonologiske færdigheder synes at være vigtige; særligt børn med begrænsede færdigheder i verbal indlæring udpeges som en målgruppe, der kan have brug for mere eksplicit instruktion. Og dermed udpeges *indlæring* af nye fonologiske former på såvel subleksikalt som leksikalt niveau og *kobling* af fonologiske former og stavemåder som kritiske elementer i staveundervisning.

Undersøgelsen i studie 2 illustrerede, at der fortsat er stor variation i danske elevers stavefærdigheder i 5. klasse, og at denne variation i stor grad kan forklares af viden om simple fonem-grafem-forbindelser, ordspecifik ortografisk viden, grafotaktisk viden og viden om fonologisk betingede stavemønstre. Resultatet peger på, at staveundervisning med fordel kan inkludere forskellige fonologiske og ortografiske elementer, herunder stavemønstre betinget af fonologisk kontekst.

Vigtige implikationer for undervisningspraksis kan udledes af resultaterne fra studie 3. Først og fremmest gav øget viden om betingede stavemønstre anledning til stærkere indlæring af ortografiske repræsentationer af nye ord under selvstændig læsning. En måde at støtte elevers hukommelse for komplekse stavemåder synes at være direkte instruktion i sammenhængen mellem udtale og stavemåde efterfulgt af øvelser med stavning og afkodning af ord, der indeholder trænede mønstre. Træningen, der blev gennemført i studie 3, var både simpelt opbygget og relativ kortvarig, hvilket giver gode muligheder for at implementere en lignende undervisning i skolen. Endelig synes der at være muligheder i systematisk at sammentænke staveundervisning med aktiviteter med selvstændig læsning. Resultaterne kan

dog ikke sige noget om, hvilke stavemønstre der vil være de mest funktionelle at inddrage i undervisningen. Da deltagerne i træningsundersøgelsen var elever med nogen skriftsprogserfaring, blev stavemønstrene valgt ud fra det kriterium, at de kun skulle optræde sjældent i danske ord. Kriteriet mindskede sandsynligheden for, at eleverne allerede havde lagret stavemønstrene som ortografiske repræsentationer i hukommelsen. Med undervisningspraksis for øje vil valget af stavemønstre følge helt andre kriterier. Her må det netop være afgørende, at der er tale om stavemønstre, der hyppigt optræder i danske ord eller ofte giver anledning til vanskeligheder i afkodning og/eller stavning for mange elever. Endelig kan fremtidige undersøgelser være med til at svare på, hvornår i afkodnings- og staveudviklingen direkte undervisning i betingede stavemønstre med fordel kan introduceres og for hvilke elevgrupper.

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