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DESENVOLVIMENTO DO CONHECIMENTO ORTOGRÁFICO LEXICAL E SUBLEXICAL NO PORTUGUÊS EUROPEU: RELAÇÕES COM A LEITURA E A ESCRITA

José Luís Marques Querido

Orientadores: Prof. Doutora Arlette Thérèse Marcelle Marie Joseph Verhaeghe
Prof. Doutor José Junça de Morais

Tese especialmente elaborada para a obtenção do grau de Doutor em Psicologia, Especialidade de Psicologia Cognitiva

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e

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DECLARAÇÃO

De acordo com o artigo 41º do Regulamento de Estudos Pós-Graduados da Universidade de Lisboa, aprovado pela Deliberação da Reitoria nº 1506/2006, esta dissertação engloba três artigos científicos, um submetido e dois a submeter para publicação em revistas internacionais indexadas, em colaboração com outros autores, para além dos orientadores.

A construção dos testes experimentais e a recolha dos dados utilizados nos 3 estudos empíricos aqui apresentados foram levadas a cabo no âmbito do projeto "*Estabelecimento de níveis de referência da leitura e da escrita do 1º ao 6º ano de escolaridade*", enquadrado no programa de acompanhamento e monitorização do Plano Nacional de Leitura, contratado pelo Gabinete de Estatística e Planeamento da Educação do Ministério da Educação e a Universidade de Lisboa, sob a coordenação científica do Professor Doutor José Morais, coorientador da presente dissertação. O autor integrou a equipa de investigação deste projeto, tendo sido o responsável da secção de estudo referente à "Escrita e ortografia lexical".

O autor declara ser responsável pela criação, cotação e supervisão da aplicação de todos os testes experimentais, pela revisão de literatura, elaboração das questões em estudo, análise, interpretação e discussão dos resultados, redação, submissão e revisão dos manuscritos dos artigos enviados para publicação, bem como pela redação das diferentes partes da presente dissertação.

José Luís Marques Querido

Resumo

A presente dissertação teve como objetivos gerais: 1) a análise das relações entre os componentes lexical e sublexical do conhecimento ortográfico, 2) a análise destas relações com os mesmos níveis de processamento (lexical e sublexical) da leitura e da escrita; e 3) o estudo do contributo do conhecimento ortográfico para o processo de composição escrita no decorrer da aprendizagem. Para a concretização dos presentes objetivos foram levados a cabo três estudos empíricos com carater longitudinal. Nos dois primeiros estudos (E1 e E2) foram testadas 170 crianças portuguesas oriundas de duas coortes. A coorte 1 era constituída por crianças acompanhadas do 2º ao 3º ano de escolaridade e a coorte 2 por crianças seguidas do 4º ao 5º ano de escolaridade, pertencentes a duas escolas públicas de Lisboa. O terceiro estudo (E3) foi conduzido com a primeira coorte referida que totaliza 83 crianças do 2º e 3º ano de escolaridade. O primeiro estudo teve o propósito específico de clarificar a relação entre os componentes lexical e sublexical do conhecimento ortográfico ao longo do desenvolvimento. Com o segundo estudo foi nosso objetivo analisar o contributo dos dois componentes (lexical e sublexical) do conhecimento ortográfico para os níveis de processamento lexical e sublexical da leitura e da escrita. No terceiro, e último estudo, examinámos o papel direto e mediado dos dois componentes do conhecimento ortográfico para a produção escrita. Os resultados obtidos (E1) mostraram que as crianças do 2º ano de escolaridade (início e final) com melhor recodificação fonológica apresentavam um melhor nível de conhecimento ortográfico (lexical e sublexical) do que as crianças com baixo nível de recodificação fonológica. Esta diferença, entre os dois grupos deixou de ser significativa do 3º ano em diante. Além disso, as análises de regressão sequencial revelaram um contributo significativo do conhecimento ortográfico lexical, no início do 2º ano, para o

desenvolvimento do conhecimento ortográfico sublexical, no final do 2º ano. Foi também observado um contributo significativo, embora mais fraco, no sentido inverso – do conhecimento ortográfico sublexical para o lexical. Estes dois componentes do conhecimento ortográfico mostraram ter um papel importante para a leitura e a escrita, de palavras e de pseudopalavras, ulteriores (E2). O conhecimento ortográfico lexical apresentou contributos significativos para as habilidades de leitura e de escrita quer de palavras quer de pseudopalavras em ambas as coortes de crianças. No entanto, o conhecimento ortográfico sublexical contribuiu apenas para a leitura e a escrita de pseudopalavras, revelando assim uma influência mais restrita (ao nível sublexical), nas duas coortes. Os dois componentes do conhecimento ortográfico desempenham ainda um papel importante para a produção escrita de texto (E3). Os nossos resultados (E3) revelaram um contributo significativo (durante o 2º ano de escolaridade) quer direto quer mediado para a composição escrita. De facto, o conhecimento ortográfico lexical apresentou um papel preditivo direto na composição escrita, enquanto o conhecimento ortográfico sublexical contribuiu de forma mediada, através da escrita de palavras, para a composição escrita. Assim, o conjunto de resultados sugere que as habilidades básicas (e.g., conhecimento ortográfico lexical e sublexical) contribuem de forma importante, e estão subjacentes às habilidades que lhes são hierarquicamente subsequentes (e.g., leitura de palavras) ao longo da aprendizagem da leitura e da escrita. Sublinhamos, 1) o papel da recodificação fonológica para os dois componentes do conhecimento ortográfico, 2) a importância do conhecimento ortográfico lexical para a promoção e desenvolvimento do conhecimento ortográfico sublexical, 3) o contributo dos componentes do conhecimento ortográfico para o sucesso na leitura e escrita de itens isolados (palavras familiares e desconhecidas), bem como 4) o importante papel preditivo do conhecimento ortográfico para a produção de texto.

Palavras-chave: Componentes do Conhecimento ortográfico, Lexical, Sublexical, Leitura, Escrita, e Composição escrita.

Abstract

The present thesis has as general purposes: 1) to analyze the relations between the lexical and sublexical components of orthographic knowledge; 2) the analysis of these relations with the same levels of processing (lexical and sublexical) of reading and spelling; and 3) the study of the contribution from orthographic knowledge on the writing composition process in the course of learning acquisition. To accomplish the present objectives, three empirical studies were conducted with a longitudinal design. In Studies 1 and 2 (S1 and S2), two cohorts of 170 Portuguese children from two public schools of Lisbon, were assessed. In Cohort 1 children were followed from Grade 2 to Grade 3, and in Cohort 2 children were followed from Grade 4 to Grade 5. The Study 3 (S3) was conducted with the first of those cohorts, totalizing 83 children accompanied from Grade 2 to Grade 3. Study 1 had the specific purpose of highlighting the relationship between the lexical and sublexical components of orthographic knowledge throughout the development. In the second study (S2), we aimed to analyze the contribution of the two components (lexical and sublexical) of orthographic knowledge to the lexical and sublexical processing levels of reading and spelling. In the third (S3) and last study, we examined the direct and mediated role of the two components of orthographic knowledge on writing composition. The results (S1) showed that children of Grade 2 (beginning and end) with superior phonological recoding had a higher level of orthographic knowledge (lexical and sublexical) than children with lower levels of phonological recoding. This difference between the two groups was no longer significant from Grade 3 onwards. Additionally, the sequential regression analysis revealed a significant contribution of lexical orthographic knowledge at the beginning of Grade 2 for the development of sublexical orthographic knowledge at the end of Grade 2. A significant contribution in the reverse way, although weaker, was also

observed – from sublexical orthographic knowledge on the lexical orthographic knowledge. These two components of orthographic knowledge revealed to have a role in reading and spelling of words and pseudowords (S2). In this way, lexical orthographic knowledge has made significant contributions to reading and spelling abilities either of words or pseudowords in both cohorts of children. However, the sub-lexical orthographic knowledge contributed only for reading and spelling of pseudowords, revealing a narrower influence (at the sublexical level) in both cohorts. The two components of the orthographic knowledge also play an important role in written composition (S3). Our results (S3) showed a significant contribution (during Grade 2) either direct or mediated on writing composition. In fact, lexical orthographic knowledge presented a direct predictive role in written composition while sublexical orthographic knowledge showed a mediated contribution, through word spelling, on writing composition. Thus, the whole set of results suggests that basic skills (e.g., lexical and sublexical orthographic knowledge) make an important contribution, and underpin skills hierarchically subsequent (e.g., word reading) along the learning of reading and spelling. It is important to underline, 1) the role of phonological recoding for the two components of orthographic knowledge, 2) the importance of lexical orthographic knowledge for the promotion and development of sublexical orthographic knowledge, 3) the contribution of the two components of orthographic knowledge for the success in reading and spelling of isolated items (familiar and unfamiliar words), and 4) the important predictive role of orthographic knowledge for text production.

Keywords: Components of Orthographic Knowledge, Orthographic Knowledge, Lexical, Sublexical, Reading, Spelling, and Writing Composition.

Índice Geral

PARTE I
Introdução Geral

CAPÍTULO 1

Introdução e apresentação dos estudos empíricos

Introdução

"*A pena é mais forte que a espada*". Esta citação, atribuída a Voltaire, espelha bem o grande poder da escrita, uma das mais fortes armas da humanidade, que todos reconhecemos.

A escrita é considerada um dos três vértices do triângulo dos três "*R*s" – leitura, escrita e aritmética (*R*eading, w*R*iting, and a*R*ithmetic) (National Commission on Writing - NCW, 2003). Apesar da reconhecida importância da escrita, durante várias décadas o foco da investigação centrou-se no desenvolvimento da leitura. Comparativamente à escrita, a investigação acerca da leitura tem uma história muito mais longa e rica. A escrita foi assim considerada pela *National Commission on Writing* o "R" negligenciado, referindo a necessidade de maior enfoque nesta área. Para além disso, no Nation's Report Card: Writing (2002) refere-se que apenas cerca de um terço das crianças testadas no 4º, 8º e 12º ano de escolaridade apresentavam um nível de escrita proficiente ou avançado. Uma década depois (Nation's Report Card: Writing, 2012) não se verificaram diferenças significativas nos dados. Ou seja, a maioria dos estudantes americanos continuavam num nível básico, ou abaixo, no que se refere à escrita.

Talvez os dados dos relatórios da NCW e da NAEP tenham impulsionado a investigação nesta área, pois só nas últimas duas décadas se começou a dar maior importância ao estudo dos processos envolvidos na escrita.

A investigação começou por se dedicar ao estudo dos processos envolvidos na escrita de palavras isoladas (conhecidas e desconhecidas). Este tipo de estudos dominou grande parte da investigação durante muito tempo. Poucos estudos se dedicavam à escrita de palavras num contexto, em frases, e menos ainda em textos. No entanto, as evidências dos estudos acerca da escrita de itens isolados, por si só, têm-se verificado de

grande utilidade para a construção de teorias cognitivas e para o delineamento de estratégias clínicas e educativas.

Mais recentemente, já se encontram na literatura vários estudos que se dedicam não só à escrita /ortografia de palavras, mas também à produção escrita de texto. Na verdade, para uma melhor compreensão dos processos e dificuldades associados à escrita é necessário ir além das palavras isoladas e examinar o desenvolvimento da habilidade de produção escrita de textos.

A investigação acerca dos processos envolvidos na aquisição da escrita quer de palavras quer de textos é, assim, necessária para desenvolver e testar modelos teóricos e veicular informação acerca das melhores estratégias de instrução e intervenção, neste caso em situações de dificuldade. No entanto, dada a complexidade subjacente ao processo de escrita em geral e, de texto, em particular, muito há ainda a investigar.

No âmbito dos estudos acerca do desenvolvimento desta complexa habilidade que é a escrita, em particular do desenvolvimento do conhecimento ortográfico, da sua relação com a aquisição da leitura e da escrita, bem como com a produção escrita de texto, desenvolvemos a presente dissertação.

Organizámos a dissertação em cinco capítulos. No primeiro capítulo encontra-se a revisão de literatura que enquadra teórica e empiricamente os três estudos empíricos levados a cabo, bem como os seus principais objetivos e hipóteses experimentais. Nos três capítulos seguintes são apresentados os estudos experimentais propriamente ditos. No último capítulo, dedicado a uma conclusão geral, são integrados os resultados dos três estudos empíricos, é feita uma reflexão acerca dos contributos e das limitações com indicações para estudos futuros e, por último, são apresentadas implicações práticas e pedagógicas do presente trabalho.

Introdução Teórica

Conhecimento ortográfico: conceções

"O que é exatamente uma representação ortográfica lexical? Temos de reconhecer que não sabemos ao certo" (Morais, Araújo, Leite, Carvalho, Fernandes & Querido, 2012, p. 69). No entanto, de acordo com Morais e colaboradores (Morais et al., 2012), uma representação ortográfica pode ser definida como "uma representação da sequência de grafemas de uma expressão da fala e da sua organização em unidades maiores" (p. 101) e uma representação lexical corresponderá a "uma representação mental das palavras sem representação da sua forma superficial (fones, isto é unidades fonéticas/letras) ou abstrata (fonemas/grafemas) ou do seu conteúdo (morfemas e lexias, isto é, palavras vistas só em termos do seu conteúdo semântico" (p.101).

De uma forma mais geral, e de acordo com Apel (2011), o conhecimento ortográfico refere-se à informação que é armazenada na memória e que nos permite saber como representar a linguagem falada na sua forma escrita. De facto, muitos investigadores da área usam o termo *conhecimento ortográfico* para designar as representações mentais das palavras escritas na memória a longo prazo (e.g., Frith, 1980; Treiman, 1993) Contudo, a definição e o uso do temo *conhecimento ortográfico* diferem na literatura (ver Apel, 2011, para uma revisão) e, por vezes referem-se apenas a uma parte desse conhecimento como um todo.

Alguns investigadores têm definido o conhecimento ortográfico ora como uma representação mental específica das palavras escritas representada na memória a longo prazo (e.g., Conrad, 2008; Papadopoulos, Georgiou, & Kendeou, 2009), ora como o

conhecimento de padrões ortográficos de uma determinada língua (e.g., Conrad, 2008; Georgiou, Parrila, & Kirby, 2009).

As representações mentais específicas das palavras também são apelidadas, na literatura, entre outras, de representações grafémicas mentais (e.g., Apel, 2010, 2011), imagens ortográficas mentais (e.g., Cunningham, 2006; Ehri, 1980), *sight word* ou ortografia visual (e.g., Ehri & Rosenthal, 2007), conhecimento ortográfico específico da palavra (e.g., Hilte & Reitsma, 2008; Conrad, Harris, & Williams, 2013), representações ortográficas armazenadas (e.g., Oullette & Seneshal, 2008) e exigem um processamento ortográfico lexical (Deacon, 2012). No presente trabalho, e com base na terminologia de Deacon (2012), referimo-nos a estas representações armazenadas como conhecimento ortográfico lexical. Este conhecimento refere-se, assim, às representações de sequências específicas de grafemas que representam as palavras escritas, dando-nos uma clara imagem mental da palavra, possibilitando-nos a sua escrita correta.

O conhecimento de padrões ortográficos, também denominado na literatura por conhecimento ortográfico geral (e.g., Hagiliassis, Pratt, & Johnston, 2006; Conrad et al., 2013), refere-se ao conhecimento das normas e/ou regras que nos permitem representar a linguagem oral em linguagem escrita e requer um processamento ortográfico sublexical (Deacon, 2012). Estes padrões incluem, por exemplo: 1) o conhecimento de como uma letra ou letras podem representar sons da fala – princípio alfabético; 2) quais as sequências de letras que podem ser combinadas numa palavra; e, 3) como representamos fonemas que obedecem, por exemplo a regras posicionais e/ou contextuais, indo além da correspondência fonema-grafema direta. Estas últimas regras são denominadas, muitas vezes, de regras ortotáticas ou conhecimento ortotático (Apel, 2011) ou segundo outros autores (e.g., Deacon, Conrad, & Pacton, 2008; Friend &

Olson, 2008), regularidades grafotáticas. Ao conhecimento de padrões ortográficos passaremos a chamar, no presente trabalho, *conhecimento ortográfico sublexical.*

Tal como o conhecimento das representações mentais específicas das palavras, o conhecimento de padrões ortográficos também se insere no construto de conhecimento ortográfico, pois, a escrita correta de palavras necessita de ambos os tipos de conhecimento (Apel, 2011).

Não obstante, estes dois componentes atuam a diferentes níveis de processamento. As representações mentais específicas das palavras atuam ao nível lexical, enquanto os padrões ortográficos, não específicos das palavras, operam a nível sublexical. Assim, num sentido mais lato do termo, processamento ortográfico refere-se à habilidade para adquirir, armazenar e usar quer o conhecimento lexical quer o sublexical.

Medidas do conhecimento ortográfico

Depois de uma breve revisão acerca das várias conceções do conhecimento ortográfico que se encontram na literatura, torna-se pertinente, para o presente trabalho, considerar como o processamento de cada componente deste conhecimento pode ser avaliado. De facto, várias medidas têm sido usadas para avaliar estes dois componentes do conhecimento ortográfico. Estas medidas podem dividir-se em dois grandes grupos, aquelas que avaliam a consciência dos padrões ortográficos e as que avaliam o conhecimento das representações mentais específicas das palavras. Contudo, trata-se de medidas do mesmo construto: do conhecimento ou processamento ortográfico. Assim, na literatura, o desempenho, nestes dois tipos de tarefas, é, por vezes, combinado formando uma medida compósita do conhecimento ortográfico (Apel, 2011). No

entanto, podem separar-se as medidas, uma vez que permitem a avaliação de diferentes aspetos deste conhecimento, nomeadamente o lexical e o sublexical.

Medidas do conhecimento ortográfico lexical

A medida mais comum, a mais utilizada na literatura, é uma variação da conhecida tarefa de escolha ortográfica ou de pseudohomófono (e.g., Conrad, 2008; Deacon, Benere, & Castles, 2012; Olson, Forsberg, Wise, & Rack, 1994) que pretende avaliar o processamento ortográfico ao nível lexical. Para tal, são consideradas sequências de padrões ortográficos/visuais específicos que identificam palavras individuais (Barker, Torgesen, & Wagner, 1992).

Na tarefa clássica de escolha ortográfica (e.g., Olson et al., 1994), é pedido à criança que selecione uma de duas alternativas fonologicamente plausíveis (e.g., *casa* e *caza*). Os pares incluem uma palavra corretamente escrita (e.g., *casa*) e uma segunda ortograficamente incorreta, mas plausível – pseudohomófona (e.g., *caza*). A resposta correta depende de se o indivíduo tem, ou não, a representação ortográfica da palavra armazenada. Assim, de uma forma geral, é consensual (e.g., Apel, 2011; Burt, 2006; Deacon et al., 2012), como referido anteriormente, que esta tarefa avalia o conhecimento ortográfico específico constituído e armazenado a longo prazo.

A tarefa utilizada por Berninger e colaboradores (e.g., Berninger, Abbott, Nagy, & Carlisle, 2010; Berninger et al., 2008) é uma variação da tarefa clássica, na medida em que avalia representações ortográficas específicas aprendidas recentemente e talvez temporariamente. Nesta tarefa são apresentadas pseudopalavras para posteriormente se avaliar a recordação, reconhecimento e ortografia das novas representações (ou aspetos destas) armazenadas (Apel, 2011).

De acordo com a revisão de Apel (2011) são ainda utilizadas, com o mesmo objetivo de avaliar o conhecimento ortográfico lexical, tarefas de verificação ortográfica (e.g., Stanovich & Siegel, 1994), leitura de palavras irregulares (e.g., Castles & Coltheart, 1993) e tarefas de cadeias de palavras (e.g., Georgiou et al., 2009).

Medidas do conhecimento ortográfico sublexical

Para examinar o processamento ortográfico ao nível sublexical, têm sido usadas tarefas que avaliam o conhecimento de padrões ortográficos (e.g., Cassar & Treiman, 1997; Georgiou et al., 2009). Estas tarefas focam-se, assim, em padrões sublexicais de letras consistentes e aceitáveis de acordo com as regras do código ortográfico de uma determinada língua. Uma das tarefas, mais comummente utilizada, é a chamada *wordlikeness choice task* (aqui denominada de tarefa de consciência ortográfica). Esta tarefa é semelhante à tarefa de escolha ortográfica, mas, neste caso, em vez de serem apresentadas duas alternativas, em que uma delas é uma palavra real correta e a outra é uma pseudopalavra, são apresentadas duas pseudopalavras (e.g., *trilo – rilot*). A tarefa do participante consiste na escolha da pseudopalavra que mais "se assemelha/lhe faz lembrar" uma palavra real, cumprindo os padrões ortográficos convencionais da língua (no exemplo, *trilo*) (e.g., Cunningham & Stanovich, 1993; Stanovich & Siegel, 1994). Para levar a cabo esta tarefa, perante pseudopalavras, os indivíduos têm que recorrer ao conhecimento sublexical dos padrões ortográficos específicos da língua e não às representações ortográficas específicas/conhecimento ortográfico lexical (Apel, 2011).

As tarefas acima descritas, que avaliam o conhecimento ortográfico sublexical, requerem o recurso à consciência da ortografia de forma explícita, na medida em que exigem um julgamento consciente relativamente à plausibilidade de um padrão

ortográfico numa determinada língua. No entanto, uma outra linha de investigação (e.g., Apel, 2010; Berninger et al., 2006; Apel et al., 2012; Wolter & Apel, 2010) tem demonstrado a consciência implícita de regularidades estatísticas da ortografia, em crianças pequenas. Nestes estudos, as crianças são expostas a pseudopalavras escritas em situações de leitura de histórias conduzidas por um adulto. Cada pequena série de histórias contém uma pseudopalavra nova. Após cada história é pedido à criança que escreva ou identifique, num conjunto de três, a pseudopalavra alvo. A probabilidade ortotática das pseudopalavras a que as crianças são expostas é manipulada, para averiguar a influência das regularidades estatísticas na aprendizagem das representações ortográficas. Os autores (e.g., Apel et al., 2012; Wolter & Apel, 2010) têm verificado que as crianças apresentam um melhor desempenho com pseudopalavras na condição de elevada probabilidade ortotática, quando comparada com a condição de baixa probabilidade. Assim, os resultados neste tipo de tarefas revelam uma consciência ortográfica implícita das crianças e uma sensibilidade precoce (ao nível da escolaridade pré-primária) às regularidades da ortografia.

Desenvolvimento do conhecimento ortográfico

O fator mais importante que parece determinar o sucesso na leitura e que tem sido considerado como altamente preditivo da mesma (e.g., National Reading Panel, 2000), é a consciência fonológica, a habilidade para aceder e manipular os sons da fala (e.g., Deacon et al., 2012; Morais, Alegria, & Content, 1997). Outro factor crucial, cuja importância tem vindo a ser reconhecida quer para a leitura (e.g., Cunningham, Perry, & Stanovich, 2001) quer para a escrita (e.g., Ouellette & Senechal, 2008), é o conhecimento ortográfico (e.g., Deacon et al., 2012). Vários estudos têm sido levados a

cabo no sentido de clarificar o desenvolvimento da consciência fonológica (e.g., Bertelson, Morais, Alegria, & Content, 1985). No entanto, no que diz respeito ao desenvolvimento do conhecimento ortográfico, e em particular ao dos seus dois componentes (lexical e sublexical) ainda há muito por clarificar. As investigações existentes, do nosso conhecimento, e até à data, centram-se no desenvolvimento ou de um, ou de outro componente, sem explorar a relação entre eles, e/ou o seu desenvolvimento em simultâneo (e.g., Wolter & Apel, 2010; Pacton et al., 2014). Estas questões serão exploradas no Capítulo 2 do presente trabalho.

Teoricamente, os modelos tradicionais da aquisição da leitura e da escrita, sugerem que as representações ortográficas – conhecimento ortográfico lexical – são estabelecidas principalmente através da recodificação fonológica repetida de palavras e, como tal, desenvolvem-se tardiamente (e.g., Ehri, 1997; Share, 1995), em consequência e depois de algum tempo de instrução da leitura. De facto, algumas evidências mostram que o contributo do conhecimento ortográfico para a leitura aumenta com a idade (e.g., Badian, 2001).

De acordo com estes modelos (e.g., Ehri, 1997; Share, 1995), a recodificação fonológica melhora o conhecimento ortográfico com impacto nos dois componentes, lexical e sublexical. Supõe-se (e.g., Share, 2004) que, no início da aquisição da leitura, a repetida recodificação fonológica seja particularmente importante para o rápido estabelecimento de representações ortográficas lexicais. Estas podem, por sua vez, também através da prática da leitura, ajudar a criança a extrair padrões/ sequências ortográficas relevantes (Conrad, 2008), i.e., a constituir o conhecimento ortográfico sublexical.

Share (e.g., 1999) denominou esta teoria, que atribui um papel central ao processo de recodificação fonologia, "*teoria do auto-ensino*". Ele propôs que a leitura

direta e precisa de palavras conduz à formação de representações ortográficas lexicais, possibilitando a leitura e a escrita correta de palavras daí em diante. Diversos estudos empíricos conduzidos, quer por Share (e.g., Share, 1999, 2004) quer por outros autores (e.g., Bowey & Muller, 2005; Cunningham, Perry, Stanovich, & Share, 2002) têm testado esta proposta. Na generalidade, nestes estudos é pedido a crianças entre o 1º e o 3º ano que leiam, em voz alta, histórias que contêm pseudopalavras. As crianças têm de identificar, alguns dias depois, de entre outras pseudopalavras que são homófonas (e.g., *vurd*) ou visualmente semelhantes (e.g., *vard*) a pseudopalavra alvo (e.g., *verd*). Os resultados mostram que as crianças escolhem mais vezes as pseudopalavras alvo (Bowey & Muller, 2005; Cunningham, Perry, Stanovich, & Share, 2002; Share, 1999, 2004) e, para além disso, também as leem mais rapidamente (Bowey & Muller, 2005; Share, 1999, 2004) e escrevem com maior precisão (Cunningham et al., 2002) relativamente às alternativas homófonas. Estas evidências, de que a aprendizagem das representações ortográficas lexicais das crianças foi influenciada pelas suas habilidades de recodificação fonológica, foram interpretadas pelos autores como concordantes com a *teoria do auto-ensino* que pressupõe que, como referido anteriormente, as representações ortográficas se estabelecem a partir da recodificação fonológica. Assim, mais e melhor leitura de palavras levarão a um melhor estabelecimento de novas representações ortográficas lexicais e, consequentemente, a um melhor desempenho quer na leitura, quer na escrita.

Este pressuposto e evidências empíricas (Bowey & Muller, 2005; Cunningham et al., 2002; Share, 1999, 2004) estão de acordo com a suposição de Ehri (1997, 2005) e Perfetti (1997) de que a leitura e a escrita partilham representações mentais, sugerindo que o que é aprendido através de uma habilidade beneficiará a outra. Também neste sentido, o estudo de Conrad (2008), com crianças do 2º ano de escolaridade, mostrou

que a prática repetida da leitura de palavras não familiares levou a um melhor desempenho na escrita das palavras praticadas e à generalização a novas palavras que partilhavam padrões ortográficos ao nível da rima. O mesmo padrão foi encontrado da escrita para a leitura, tendo havido, neste caso, uma generalização mais marcada.

Assim, pode dizer-se que a prática continuada da leitura tornará as representações em memória mais precisas, refletindo melhor as sequências ortográficas das palavras e o seu código fonológico. Deste modo, a leitura de palavras permitirá às crianças reconhecer padrões de letras comuns, fazer corresponder sons a letras e a padrões de letras, e desenvolver representações ortográficas completamente especificadas (Conrad, 2008). Por seu lado, a prática repetida da escrita de palavras, fazendo corresponder fonemas a grafemas, levará ao estabelecimento de representações ortográficas lexicais que, por sua vez, permitirão a leitura correta dessas palavras (Conrad, 2008).

Os modelos teóricos (e.g., Ehri, 1997; Share, 1995) da leitura e da escrita e as evidências empíricas (Bowey & Muller, 2005; Cunningham et al., 2002; Share, 1999, 2004; Conrad, 2008) acima descritos sugerem que o estabelecimento das representações ortográficas lexicais ocorre tardiamente no desenvolvimento. Contudo, existem evidências experimentais que mostram que o estabelecimento de representações ortográficas lexicais pode ocorrer cedo no desenvolvimento (e.g., Martinet, Valdois, & Fayol, 2004). O estudo de Martinet e colaboradores (Martinet et al., 2004) mostrou que crianças francesas do 1º ano, com pouca instrução de leitura, depois de terem sido expostas a palavras reais, foram capazes de escrever pseudopalavras por analogia às palavras reais. No estudo de Fernandes e colaboradores (Fernandes, Ventura, Querido, & Morais, 2008), realizado com crianças Portuguesas do 1º ano de escolaridade, foi observado não apenas um efeito de analogia na leitura e escrita (no início do primeiro

ano), mas também um efeito de lexicalidade. Assim, os autores (Fernandes et al., 2008) referiram que, desde o início do primeiro ano, as crianças participantes neste estudo faziam uso do conhecimento de representações ortográficas lexicais. Estas evidências sugerem, segundo os autores (Martinet et al., 2004; Fernandes et al., 2008), que as crianças estabelecem um conhecimento ortográfico lexical precocemente, desde o início da instrução da leitura, portanto, mais cedo do que o proposto pelos modelos anteriormente revistos de Ehri (1997) e Share (1995).

As evidências têm também sugerido que este estabelecimento precoce pode também ocorrer de forma implícita (e.g., Apel, Wolter, & Masterson, 2006; Wolter & Apel, 2010). Nestes estudos (e.g., Apel et al., 2006; Wolter & Apel, 2010), os autores examinaram a aquisição inicial de representações ortográficas para um conjunto de pseudopalavras em crianças da pré-primária com (Wolter & Apel, 2010) e sem (Apel et al., 2006; Wolter & Apel, 2010) défice de linguagem. Nestas investigações apresentavam-se às crianças doze histórias diferentes. Cada história continha uma nova pseudopalavra alvo escrita (e.g., *hess*) que a criança via e ouvia quatro vezes. Após cada história, era pedido às crianças que escrevessem a pseudopalavra alvo e que a identificassem num conjunto de três pseudopalavras (a pseudopalavra alvo – *hess*; uma pseudopalavra ortograficamente semelhante – *ness*; e uma pseudopalavra ortograficamente diferente – *peff*). Os resultados indicaram que as crianças da pré-escola com (Wolter & Apel, 2010) e sem défice de linguagem (Apel et al., 2006; Wolter & Apel, 2010) adquiriram representações ortográficas precoces após uma exposição mínima a novas palavras escritas. De facto, e a título de exemplo, no estudo de Wolter & Apel (2010), 68% e 100% das crianças (com e sem défice de linguagem, respetivamente) identificaram mais de quatro pseudoplavras alvo acima do nível do

acaso. Relativamente à escrita, 36 % das crianças com défice de linguagem e 96% sem défice de linguagem escreveram corretamente pelo menos uma das pseudopalavras.

Segundo os autores (Apel et al., 2006; Wolter & Apel, 2010), os resultados sugerem que as crianças em idade pré-escolar são capazes de estabelecer algum conhecimento ortográfico lexical precoce (embora menos robusto para as crianças com défice de linguagem) numa situação de aprendizagem implícita.

Ao nível sublexical, as evidências dos estudos de Apel e colaboradores (e.g., Apel et al., 2006; Apel et al., 2012; Wolter & Apel, 2010) também sugerem que a aquisição do conhecimento de padrões ortográficos se desenvolve precoce e implicitamente. Os resultados destes estudos, com o procedimento já descrito anteriormente (e.g., Apel et al., 2006), mostram que o desenvolvimento das representações ortográficas iniciais foi também implicitamente sensível às regularidades ortográficas. Nestes estudos (Apel et al., 2006; Apel et al., 2012; Wolter & Apel, 2010), os autores variaram as probabilidades ortotáticas das pseudopalavras às quais as crianças eram expostas (i.e., a frequência com a qual os grafemas e dígrafos da palavra ocorrem no Inglês). Deste modo, as crianças tiveram melhor desempenho com pseudopalavras na condição de elevada probabilidade ortotática do que na condição de baixa probabilidade ortotática. Ou seja, as regularidades estatísticas das palavras, de nível sublexical, influenciaram o estabelecimento das representações ortográficas lexicais das crianças.

De forma concordante com os estudos mencionados anteriormente (Apel et al., 2006; Apel et al., 2012; Wolter & Apel, 2010), outros estudos (e.g., Cassar & Treiman 1997, Hayes, Treiman, & Kessler, 2006) também demonstraram que, desde muito cedo (ao nível da pré-primária), as crianças são já conscientes das consistências ortográficas existentes na sua língua e usam esta informação aquando da leitura e da escrita. Neste

caso, a aquisição de um conhecimento implícito de sequências de letras aceitáveis (i.e., regras ortotáticas) beneficiou da informação contextual grafotática. Treiman e colaboradores investigaram a sensibilidade das crianças ao contexto vogal ou consoante aquando da escrita de consoantes (Treiman & Kessler, 2006) ou de vogais (Hayes et al., 2006). Nestes últimos estudos, os participantes desempenhavam tarefas onde a ortografia das letras alvo ou as escolhas ortográficas eram condicionadas pelo contexto envolvente. Por exemplo, apresentavam aos participantes sequências ortográficas incompletas (e.g., *gl___d ou gl___p*) bem como o som alvo dos itens (e.g., /glɛd/ ou /glɛp/) e a sua tarefa era preencher o espaço, escrevendo as letras em falta (Treiman & Kessler, 2006). No exemplo, /glɛd/ contém /ɛ/ com a cauda *d,* um contexto em que, no Inglês, a ortografia *ea* seria antecipada com base em palavras reais como *head* and *dead*. Os resultados sugeriram que as crianças usaram o contexto como ajuda à escrita de consoantes (Hayes et al., 2006) e de vogais (Treiman & Kessler, 2006) tirando partido da informação grafotática.

Mais recentemente, Pacton, Sobaco, Fayol, e Treiman (2014) levaram a cabo um estudo, com crianças francesas do 3º ano, onde investigaram se e como a escrita é influenciada pelo conhecimento de dois padrões ortográficos que não são explicitamente ensinados: as consoantes não podem ser duplicadas em posição inicial na palavra, bem como depois de consoantes simples. Os autores usaram uma "tarefa de aprendizagem ortográfica incidental" na qual as crianças liam textos com significado que continham três tipos de novas ortografias: sem consoantes duplas, com uma consoante dupla numa posição legal e contendo uma consoante dupla numa posição ilegal. Posteriormente, a aprendizagem ortográfica das crianças foi avaliada com uma tarefa de ditado. De um modo geral, as crianças recordaram/escreveram melhor os itens sem consoantes duplas do que os que continham este tipo de consoantes. Além disso, entre os itens com

consoantes duplas, as crianças apresentaram um melhor desempenho naqueles em que a consoante dupla era legal no Francês (e.g., *gupprane*) do que naqueles em que era ilegal (e.g., *guprrane*). Os resultados confirmaram que as crianças usaram o seu conhecimento ortográfico geral, sublexical, acerca dos padrões grafotáticos (as consoantes duplas podem ocorrer antes, mas não após consoantes simples) do seu sistema de escrita para escreverem corretamente (Pacton et al., 2014).

As evidências revistas anteriormente tornam claro que os dois componentes do conhecimento ortográfico, lexical e sublexical, se podem estabelecer cedo, no desenvolvimento. Contudo, o tipo de relação e o modo como estão relacionados estes dois componentes, ao longo do desenvolvimento, não tem sido alvo de investigação. Pode acontecer que o desenvolvimento de ambos os componentes ocorra de forma independente e paralela, sem qualquer influência de um sobre o outro; que exista apenas uma influência unidirecional; ou que ambos os componentes se influenciem mutuamente. Para além disso, esta (s) relação (ões) pode (m) variar no decorrer da aprendizagem da leitura e da escrita. Como referido anteriormente, é nosso objetivo, com o presente trabalho, contribuir para o esclarecimento destas questões (ver Capítulo 2).

Conhecimento ortográfico e a sua relação com o desenvolvimento da leitura e da escrita

Vários estudos têm contribuído para compreender o processo de aquisição da leitura e da escrita (e.g., Fernandes et al. 2008; Reis, Faísca, Castro, & Peterson, 2010). De entre as habilidades apontadas como tendo um papel nestas aquisições estão as habilidades de processamento (e.g., rapidez de nomeação) e de linguagem, mas também

as habilidades metalinguísticas (Apel et al., 2012). Deste modo, diferentes fatores, cognitivos e linguísticos, contribuem para o desenvolvimento das habilidades de literacia.

As evidências empíricas sugerem, assim, que entre as habilidades que influenciam o desempenho na leitura e na escrita se encontram, a rapidez de nomeação (rapidez automatizada de nomeação ou RAN), o conhecimento de vocabulário oral, bem como, o conhecimento de letras, a memória de curto prazo verbal, e o quociente de inteligência não-verbal, etc… (e.g., Bowers & Wolf, 1993; Jongejan, Verhoeven, & Siegel, 2007; Landerl & Wimmer, 2008; Muter & Diethelm, 2001; Nation & Snowling, 2004; Pae, Sevcik, & Morris, 2010).

A nomeação rápida diz respeito à velocidade com a qual um indivíduo consegue pronunciar os nomes de um conjunto de estímulos apresentados de forma sequencial e repetida (Moll, Ramus, Bartling, Bruder, Kunze et al., 2014). Portanto, as medidas de nomeação rápida ou tarefas de RAN, avaliam a rapidez e precisão com as quais as crianças conseguem recuperar etiquetas verbais, que são normalmente nomes de objetos, números, letras, ou cores (e.g., Wagner, Torgesen, & Rashotte, 1999; Reis et al., 2010). A velocidade de recuperação dos nomes patente no desempenho nas tarefas de nomeação rápida baseia-se, pelo menos parcialmente, na qualidade da informação armazenada acerca dos mesmos (Apel et al., 2012) e pode refletir a velocidade com a qual a criança aprende e armazena nova informação linguística (e.g., Bowers & Newby-Clark, 2002; Wolf & Bowers, 1999). Resultados empíricos têm sugerido que o desempenho em tarefas de nomeação explica até 28% de variância em medidas de leitura de palavras, além da explicada pelo vocabulário e consciência fonémica (Swanson, Trainin, Necoechea, & Hammill, 2003) e 8% a 10% da habilidade de escrita após o controlo da consciência fonémica (Savage, Pillay, & Melidona, 2008).

Relativamente à relação entre o conhecimento de vocabulário oral e a leitura e a escrita também se tem encontrado uma forte relação (e.g., Denckla & Rudel, 1976; Nation & Snowling, 2004; Riedel, 2007; Verhoeven & Van Leeuwe, 2008). Os resultados das investigações, quer com tarefas que avaliam a habilidade recetiva de vocabulário, quer com tarefas que avaliam a habilidade expressiva de vocabulário apontam para uma relação significativa entre o conhecimento de vocabulário e a leitura e escrita.

No que se refere às habilidades metalinguísticas, na literatura (Apel & Masterson, 2001; Bear & Templeton, 1998; Ehri & Mc Cormick, 1998; Moats, 2000; Schlagal, 2001), a consciência fonémica, a consciência morfológica e a consciência ortográfica têm sido consistentemente sugeridas como contribuindo para o sucesso da leitura e escrita.

A consciência fonológica (a habilidade para aceder, referir e manipular os sons da fala), e em particular a consciência fonémica (a habilidade para aceder, referir e manipular consciente e explicitamente os fonemas), tem sido o melhor fator, e mais bem examinado, que parece determinar e prever a aquisição da leitura e escrita (Morais, Alegria, & Content, 1987; Nation & Hulme, 1997; National Reading Panel, 2000; Anthony & Francis, 2005; Deacon, Bener, & Castles, 2012). Nas tarefas de consciência fonémica é, por exemplo, pedido às crianças que segmentem ou fundam fonemas ou manipulem a estrutura fonémica de palavras, subtraindo fonemas de palavras dizendo o que resta. A habilidade de consciência fonémica parece explicar entre 28% a 43% da variância do desempenho, em medidas de leitura e de escrita de palavras (ver Apel et al., 2012, para uma revisão).

No estudo transversal de Reis e colaboradores (Reis et al., 2010), com crianças portuguesas do 2º ao 4º ano de escolaridade, verificou-se que, embora a consciência

fonológica tenha sido um preditor importante da precisão e da fluência da leitura, o seu peso diminuiu com o aumento da escolaridade, dando lugar à contribuição de outras variáveis, como a nomeação rápida e o vocabulário.

Numa análise recente (Moll et al., 2014) acerca do papel do processamento fonológico (consciência e memória) e da nomeação rápida em cinco sistemas alfabéticos europeus, com crianças do 2º ao 7º ano de escolaridade, verificou-se que o padrão preditivo destas duas variáveis é comparável entre as várias ortografias. No entanto, o seu poder preditivo é maior no Inglês do que em ortografias mais consistentes. Além disso, a nomeação rápida mostrou ser melhor preditor da velocidade de leitura enquanto a consciência fonémica se revelou melhor preditor da precisão na leitura e na escrita.

A influência da consciência morfológica no desenvolvimento da leitura e da escrita, também tem sido alvo de atenção, embora em menor grau do que a influência da consciência fonológica (Apel et al., 2012). A consciência morfológica pode ser descrita como a habilidade de nos focarmos ou refletirmos conscientemente sobre a estrutura morfológica das palavras, incluindo as relações entre as palavras raíz e as suas formas de inflexão e derivação (e.g., Carlisle, 1995). As tarefas usadas variam muito na literatura, embora, na sua maioria, exijam o preenchimento de espaços. Por exemplo, podem consistir em criar novas formas de palavras relacionadas (e.g., "*Junir*. Ele gosta de Junir. Ontem ele _____."). Os estudos empíricos têm sugerido que a consciência morfológica está relacionada com a escrita, com a leitura de palavras e com a compreensão em leitura (e.g., Carlisle, 2003; Carlisle & Stone, 2005; Deacon & Kirby, 2004; Kirby, Deacon, Bowers, Izenberg, Wade-Woolley, & Parrila, 2012; Kuo & Anderson, 2006; Nagy, Berninger, & Abbott, 2006).

Uma outra habilidade metalinguística importante para o desenvolvimento da leitura e da escrita é a consciência ortográfica, referida anteriormente como conhecimento ortográfico sublexical. A consciência ortográfica corresponde à habilidade de compreender e/ou conhecer as regras e os padrões subjacentes ao modo como as palavras se podem escrever (e.g., Apel, 2011). As tarefas que avaliam este tipo de consciência exigem, como já referido, o julgamento acerca de qual de duas pseudopalavras se assemelha a uma palavra real. Estas tarefas avaliam, assim, o conhecimento das convenções ou padrões ortográficos não lexicais. No entanto, estas tarefas avaliam apenas um componente do denominado conhecimento ortográfico. O outro componente deste conhecimento – conhecimento ortográfico lexical – tem sido alvo de investigação através de tarefas que avaliam o conhecimento específico da palavra (ver secção *Medidas do conhecimento ortográfico*, para uma descrição mais detalhada destas tarefas), i.e., as representações ortográficas mentais das palavras (e.g., Wolter & Apel, 2010).

A relação destes dois componentes do conhecimento ortográfico com a leitura e a escrita e em particular o seu contributo para estas habilidades tem recebido particular interesse na literatura recente (e.g., Deacon et al., 2012; Rothe et al., 2013). Muito deste interesse empírico tem surgido pelo fato das variáveis mais comummente estudadas (e.g., consciência fonológica, nomeação rápida, etc.), deixarem ainda muita da variância do desempenho na leitura e escrita por explicar (e.g., Furnes & Samuelsson, 2009).

Parte deste *corpus* de investigação tem partido do pressuposto teórico de que a recodificação fonológica repetida leva ao estabelecimento de conhecimento ortográfico (e.g., Share, 1995, 1999).

Com base no pressuposto teórico do auto-ensino, Conners e colaboradores (Conners et al., 2011) examinaram, num mesmo momento de teste, o papel mediador do

conhecimento ortográfico na relação entre a recodificação fonológica e a identificação de palavras, em crianças de língua Inglesa, do 2º e 3º ano de escolaridade. Nesta investigação, a recodificação fonológica foi avaliada através da leitura de pseudopalavras, e a identificação de palavras avaliada através da leitura de palavras isoladas (subtestes pertencentes à bateria WRMT-R, Woodcock, 1998). Para avaliar os dois componentes do conhecimento ortográfico, estes autores também recorreram a tarefas clássicas quer ao nível lexical – tarefa de escolha ortográfica e tarefa de escolha homófonos (desenvolvidas por Olson, Forsberg, Wise, & Rack, 1994; e por Olson, Forsberg, & Wise, 1994) – quer ao nível sublexical – tarefa de consciência ortográfica (desenvolvida, por exemplo, por Stanovich & Siegel, 1994). Os autores propuseram que as crianças com uma melhor habilidade de recodificação fonológica adquiririam um maior conhecimento ortográfico e, assim, identificariam palavras mais eficazmente. Assim, o conhecimento ortográfico teria um papel mediador nesta relação. Os resultados confirmaram esta hipótese. Além disso, os resultados indicaram que os dois componentes do conhecimento ortográfico mediaram separadamente a relação entre a recodificação fonológica e a identificação de palavras. Os autores referiram que a recodificação fonológica é uma habilidade importante que leva à aquisição do conhecimento exato da estrutura ortográfica de palavras específicas (conhecimento ortográfico lexical) e que também ajuda as crianças a adquirir conhecimento ortográfico generalizado (conhecimento ortográfico sublexical) (Conners et al., 2011). Posteriormente, e com os mesmos participantes, os autores (Loveall, Channell, Phillips, & Conners, 2013) conduziram um novo estudo no qual concluíram que a recodificação fonológica contribui mais para o conhecimento ortográfico lexical (15% de variância explicada) do que para o conhecimento ortográfico sublexical (9% de variância explicada).

Assim, os resultados destes dois estudos (Conners et al., 2011 e Loveall et al., 2013) não longitudinais, sugerem que as crianças com melhores habilidades de recodificação fonológica têm um melhor conhecimento ortográfico, desenvolvendo, em particular, um melhor conhecimento lexical do que sublexical, que por sua vez levará a uma melhor identificação de palavras.

Enquanto os estudos acima descritos (Conners et al., 2011; Loveall et al., 2013) tentaram sobretudo clarificar o contributo da recodificação fonológica para o conhecimento ortográfico, uma outra linha de investigação tem-se debruçado sobre a influência que o conhecimento ortográfico, e em particular cada um dos seus componentes (sublexical e lexical), poderá ter na aquisição da leitura e escrita.

A influência do conhecimento ortográfico sublexical na aquisição da leitura e escrita foi já examinada quer apenas num mesmo momento de teste (e.g., Rothe, Schulte-Korne, & Ise, 2013) quer longitudinalmente (e.g., Ise, Arnoldi, & Schulte-Korne, 2014). Rothe e colaboradores (Rothe et al., 2013) testaram a relação entre a sensibilidade às regularidades ortográficas - conhecimento ortográfico sublexical – avaliada com uma tarefa de escolha forçada de pseudopalavras e o desempenho na leitura e escrita (ao nível lexical) em crianças de língua Alemã. Os resultados sugeriram que no final do 1º ano, o conhecimento ortográfico sublexical explica uma quantidade significativa de variância de desempenho na leitura (11%) e na escrita (7%). No entanto, num estudo com um desenho longitudinal, Ise e colaboradores (Ise et al., 2014) não encontraram qualquer relação entre o conhecimento ortográfico sublexical, avaliado na pré-primária, e o desempenho nas habilidades de leitura e escrita avaliadas no 2º ano de escolaridade. Segundo os autores (Ise et al., 2014), este ultimo resultado é consistente com a abordagem de que as crianças, em ortografias mais transparentes, confiam menos

nos padrões de letras frequentes durante a leitura e a escrita quando comparadas com as crianças que aprenderam a ler e escrever em ortografias mais opacas.

Num estudo também longitudinal, realizado ao longo de três anos com crianças Inglesas do 1º ao 3º ano de escolaridade, Deacon e colaboradores (Deacon et al., 2012) examinaram a relação bidirecional entre os dois componentes do conhecimento ortográfico e a precisão na leitura de palavras. Os dois componentes do conhecimento ortográfico foram avaliados através de uma tarefa lexical, onde era pedido à criança que escolhesse a ortografia correta de entre duas alternativas fonologicamente possíveis para uma determinada palavra (e.g., *boal* e *bowl*), e de uma tarefa sublexical, na qual a criança tinha de escolher qual de três padrões/sequências de letras era o melhor para escrever uma pseudopalavra em Inglês (e.g., *screigh*, *scraie* e *scrism* para a pseudopalavra alvo /skrel/). A leitura de palavras foi avaliada com uma tarefa de identificação de palavras da bateria Woodcock Reading Mastery Test-Revised (WRMT-R, Woodcock, 1998). Os autores verificaram que o desempenho na leitura de palavras foi preditor do conhecimento ortográfico quer ao nível sublexical, quer ao nível lexical. Contudo, os resultados não revelaram qualquer contributo no sentido inverso, ou seja, do conhecimento ortográfico, após o controlo da habilidade fonológica, para a leitura de palavras. Segundo os autores, os resultados sugerem que as crianças, entre o 1º e o 3º ano, adquirem o conhecimento ortográfico através da leitura, e que o seu conhecimento ortográfico não desempenha um papel independente de apoio à aquisição da leitura.

Apesar de não encontrarem qualquer contributo significativo longitudinal dos componentes do conhecimento ortográfico na leitura de palavras (nível lexical), Deacon e colaboradores (Deacon et al., 2012) referem que não se deve pôr de parte a possibilidade do processamento ortográfico ser determinante para a leitura. Consideram que talvez esse contributo se manifeste, num outro ponto do desenvolvimento, ou

recorrendo a outras medidas que avaliem o conhecimento ortográfico, ou com uma medida de leitura de palavras que não avalie apenas a precisão, mas também a fluência (Deacon et al., 2012).

De facto, Conrad, Harris e Williams (2013) tentaram clarificar qual o contributo do conhecimento ortográfico, enquanto construto multidimensional (incorporando o conhecimento ortográfico lexical e sublexical), para a leitura e para a escrita e encontraram um resultado diferente do obtido por Deacon e colaboradores (Deacon et al., 2012). Nesta investigação (Conrad et al., 2013), esta questão foi examinada, num mesmo momento de teste, com uma amostra de crianças de língua Inglesa, entre os 7 e os 8 anos de idade. Quer a leitura quer a escrita de palavras foram avaliadas com recurso a subtestes da bateria Woodcock-Johnson Tests of Achievement – III (WJ-III; Woodcock, McGrew, & Mathers, 2001). Os dois componentes do conhecimento ortográfico foram avaliados com tarefas clássicas semelhantes às já descritas anteriormente nos estudos revistos (e.g., Conners et al., 2011; Deacon et al., 2012). Os resultados deste estudo indicaram que o conhecimento ortográfico tem um contributo significativo quer para a leitura (12%) quer para a escrita (15%). Além disso, observou-se um contributo mais elevado do conhecimento ortográfico lexical do que do sublexical quer para a leitura de palavras (β=.33 e β=.22, respetivamente para o contributo do componente lexical e sublexical do conhecimento ortográfico), quer para a escrita de palavras (β=.32 e β=.29, respetivamente para o contributo do componente lexical e sublexical do conhecimento ortográfico).

De forma sumária, pode dizer-se que tem sido demonstrado que, num mesmo momento de teste, a habilidade de recodificação fonológica contribui para ambos os componentes do conhecimento ortográfico, sublexical e lexical (Conners et al., 2011; Loveall et al., 2013). Além disso, as evidências empíricas (Conrad et al., 2013) sugerem

que cada componente do conhecimento ortográfico contribui de forma única quer para a leitura quer para a escrita, quando avaliados também no mesmo momento de teste. No entanto, com *designs* longitudinais, o conhecimento ortográfico, apesar de ser promovido pela habilidade de leitura (Deacon et al., 2012), não parece apresentar um papel preditivo relativamente à leitura de palavras (Deacon et al., 2012; Ise et al., 2014) ou à escrita de palavras (Ise et al., 2014).

Deste modo, a maioria dos estudos tem-se debruçado sobre o contributo da habilidade de recodificação fonológica, ao nível do processamento sublexical, para o conhecimento ortográfico a ambos os níveis sublexical e lexical. Não obstante, são poucos os estudos que têm examinado o contributo do conhecimento ortográfico ao nível sublexical, lexical ou dos dois em simultâneo, para a leitura ou escrita de palavras (ao nível lexical de processamento).

Além disso, do nosso conhecimento, nenhum estudo se debruçou acerca do contributo longitudinal dos componentes sublexical e lexical do conhecimento ortográfico para os níveis lexical e sublexical da leitura e da escrita, e como esse contributo poderá variar ao longo do desenvolvimento. É do nosso interesse explorar estas questões, no presente trabalho (ver Capítulo 3).

O conhecimento ortográfico enquanto preditor da composição escrita

A habilidade de nos exprimirmos pela escrita constitui um prazer individual, mas é também um dos principais objetivos da instrução da literacia. A expressão escrita é uma habilidade necessária e essencial para o desenvolvimento de qualquer sociedade. Assim, no decurso do processo de ensino, as crianças são envolvidas em tarefas de escrita aquando ou em simultâneo com as tarefas de leitura. Não obstante, durante

muitos anos a investigação preocupou-se mais em examinar os processos de desenvolvimento associados à leitura, desde os mais básicos (e.g., reconhecimento de letras e decodificação) aos mais complexos (e.g., fluência e compreensão na leitura de textos), do que aos que fazem parte ou contribuem para o desenvolvimento da escrita.

De facto, a esc*R*ita foi o "R" negligenciado (National Commission of Writing, 2003) durante várias décadas em que a leitu*R*a e a a*R*itmética foram o alvo dos investigadores. Contudo, durante os últimos vinte anos a investigação acerca da escrita tem crescido e a distância relativamente à leitura e à aritmética tem vindo a diminuir (Wagner, Puranik, Foormen, Foster, Wilson, Tschinkel, & Kantor, 2011). Ainda assim, apesar de já existir uma vasta literatura acerca dos processos envolvidos na escrita de texto, quer no adulto (e.g., Connelly, Campbell, MacLean, & Barnes, 2006), quer ao longo do desenvolvimento (e.g., Berninger & Swanson, 1994), estão ainda por clarificar as habilidades que contribuem de forma mais ou menos importante para este tipo de expressão/composição escrita. Por isso, a investigação acerca do processo da aquisição da habilidade de escrita de textos torna-se necessária para testar e desenvolver modelos teóricos dos processos de escrita. Para levar a cabo este propósito, é necessário que a investigação se foque na relação entre a composição escrita e os seus processos subjacentes. É nosso objetivo, com o presente trabalho (ver Capítulo 3) contribuir para o conhecimento nesta área.

Escrever um texto interligado, i.e., uma composição escrita, é uma tarefa altamente complexa quer requer processos múltiplos (Kim, Otaiba, Sidler, & Gruelich, 2014), entre os quais, habilidades de linguagem oral, de transcrição, e memória (de longo prazo e de trabalho) (Berninger, Abbott, Graham, & Richards, 2002; Berninger & Swanson, 1994; McCutchen, 2006; Shanahan, 2006).

A *Simple View of Writing (SVW)*

O primeiro modelo de escrita a ganhar reconhecimento foi proposto por Hayes e Flowers (1980) e revisto por Hayes (1996). Estes autores foram pioneiros a conceber um modelo que nos forneceu uma primeira compreensão acerca dos processos de escrita. Neste modelo, a escrita hábil do adulto é conceptualizada como recorrendo a três processos cognitivos principais para produzir um texto: tradução, planeamento, e revisão (do original: *translating*, *planning* e *reviewing/revising*).

A tradução refere-se aos processos cognitivos através dos quais as ideias são convertidas em linguagem escrita (Hayes & Flowers, 1980), mais tarde este processo foi redenominado *produção de texto*, tendo em consideração o trabalho de Chenoweth e Hayes (2001).

O planeamento engloba, definir objetivos, gerar conteúdo e organizar esse conteúdo relativo ao texto em desenvolvimento. Os planos podem ser mais gerais ou mais locais e podem ser realizados previamente à escrita ou levados a cabo durante a mesma. Posteriormente (Hayes, 1996), este processo foi subordinado à categoria de *reflexão* que engloba, a resolução de problemas (incluindo o planeamento), a tomada de decisão e a inferência.

O processo de revisão (Hayes, 1996, 2004) envolve a leitura guiada por um esquema, a avaliação do texto e a reescrita, quando necessária. Este processo de revisão foi expandido de forma a incluir a interpretação de texto, a reflexão embutida e a produção de texto, todos sob o controlo de um esquema específico da tarefa de revisão (Hayes, 2004).

Na revisão de 1996, Hayes, incorporou ainda, no modelo original, além dos processos cognitivos usados na escrita, aspetos como, a motivação para a escrita, o contexto de escrita, e a memória de longo prazo e de trabalho.

O modelo de Hayes e Flowers (1980; Hayes, 1996) derivou de protocolos de pensamento em voz alta de adultos e, por isso, não se refere ao desenvolvimento das habilidades de escrita/produção de texto. De qualquer forma, serviu de ponto de partida para a conceptualização de modelos de desenvolvimento da escrita de crianças (Berninger, Winn, MacArthur, Graham, & Fitzgerald, 2006).

A *Simple View of Writing* (Juel, Griffith, & Gough, 1986) surge, neste contexto, baseada na teoria de Hayes e Flowers (1980; Hayes, 1996) e por analogia à *Simple View of Reading*. Na sua conceptualização original (Juel et al., 1986), a *Simple View of Writing* propõe que a escrita (do original *writing*) é composta pela idealização (do original *ideation*) e pela escrita de palavras (do original: *spelling*). Os autores consideram que, à primeira vista, este modelo pode parecer simplista. No entanto, sublinham que cada componente é complexo por si só e pode ser dividido em diversos subcomponentes (Juel, 1988). Nesta conceptualização, a idealização refere-se à habilidade de gerar e organizar ideias, i.e., gerar pensamentos criativos e organizá-los em frases e estruturas textuais (Juel, 1988). A escrita de palavras, por sua vez, só pode ser levada a cabo pelo conhecimento do código ortográfico (do original *orthographic cipher*) – o conjunto de regras de correspondência ortografia-som de determinada língua – e pelo conhecimento ortográfico – o conhecimento de itens específicos e das regras que podem, ou não, aplicar-se a palavras particulares (Juel et al., 1986). Segundo os autores (Juel et al., 1986), a exposição às palavras escritas é o único modo de estabelecer conhecimento lexical. A combinação do conhecimento do código ortográfico e do conhecimento lexical disponibiliza a informação necessária para a

escrita de palavras e, por sua vez, a combinação da escrita de palavras e das ideias leva à produção escrita. Deste modo, "na ausência de ideias, a escrita de palavras é uma habilidade vazia, e as melhores ideias não podem ser escritas sem pelo menos uma módica habilidade de escrita de palavras" (Juel et al., 1986, p.244).

Além disso, segundo este modelo, os dois componentes, escrita de palavras e idealização, são suficientes para caracterizar as principais habilidades de nível inferior (do original *lower level skills*) e de nível superior (do original *higher level skills*), respetivamente. Assim, pobres processos de nível inferior impedirão o desenvolvimento de processos de nível superior e, portanto, o desenvolvimento do processamento automático de nível inferior é necessário para que a atenção se foque nos processos de composição de nível superior (Juel, 1988).

Posteriormente, numa versão revista da *Simple View of Writing*, Berninger e colaboradores (Berninger, Vaughan, Abbott, Begay, Byrd, Curtin, Hawkins, & Graham, 2002) conceptualizaram que o desenvolvimento da escrita pode ser representado por um triângulo sobre a envolvência da memória de trabalho, no qual as habilidades de transcrição e as funções executivas de autorregulação são os vértices da base que permitem a produção de texto, no vértice do topo do triângulo. Assim, a transcrição e as funções executivas são as bases fundacionais da produção de texto, a diferentes níveis de linguagem (palavras, frases e texto).

Esta conceptualização tem por base os modelos de Hayes e Flowers (1980) e de Juel e colaboradores (Juel et al., 1986; Juel, 1988). Deste modo, a transcrição e a produção de texto correspondem ao componente de tradução do modelo de escrita do adulto de Hayes e Flowers (1980). A produção de texto baseia-se quer na produção de ideias, quer na tradução dessas ideias para representações de linguagem. As habilidades de transcrição, que incluem a escrita de palavras e a escrita manual, dão a possibilidade

ao escritor de traduzir essas representações de linguagem em símbolos ortográficos, usando a caneta, o lápis, ou o teclado. À semelhança do modelo de Juel e colaboradores (Juel et al., 1986; Juel, 1988), também nesta conceptualização, a automaticidade das habilidades de nível inferior, de transcrição, libertará recursos de capacidade limitada e memória de trabalho para as habilidades de nível superior, da composição. As estratégias de autorregulação, providenciadas pelas funções executivas, guiam o processo de escrita e englobam, por exemplo, fazer planos para atingir objetivos, monitorizar processos em curso, e rever o texto produzido, correspondendo aos componentes de planeamento e revisão de Hayes e Flowers (1980).

Mais recentemente, e de forma a melhor refletir a atividade extraordinariamente complexa que é a escrita, Berninger e colaboradores (Berninger et al., 2006) expandiram a SVW para a *Not-so Simple View of Writing* de modo a incorporar as relações entre a memória de trabalho e a memória de longo prazo e enfatizar o papel supervisor da atenção, relativamente às funções executivas.

Estas perspetivas teóricas do desenvolvimento da escrita (e.g., Juel et al., 1986; Juel, 1988; Berninger et al., 2002) assumem então que diversos fatores cognitivos e linguísticos são necessários para o desenvolvimento da escrita, englobando processos de nível inferior e de nível superior. De um modo geral, os processos de nível superior referem-se às funções executivas e incluem o planeamento, a revisão e a tradução, i.e., idealização. Relativamente aos processos de nível inferior, a transcrição consiste na escrita manual (Berninger et al., 2002) e na escrita de palavras (e.g., Juel et al., 1986; Juel, 1988; Berninger et al., 2002). Adicionalmente, é também argumentado que o processo de composição escrita requer a coordenação *online* eficiente dos processos de nível inferior e superior (Fayol, 2012).

A preponderância dos processos de nível inferior e de nível superior na composição escrita varia no decorrer do desenvolvimento. No início da aprendizagem, os escritores aprendizes apoiam-se mais nas habilidades de nível inferior. Para além disso, nesta fase, estas habilidades requerem um ensino e prática continuados até que a automaticidade seja atingida. Só desta forma se libertarão os recursos necessários para os processos cognitivos exigentes e complexos (e.g., Connely, Dockrell, & Barnett, 2012). Os escritores mais experientes, cujas habilidades de transcrição estão mais automatizadas têm um planeamento e revisão mais eficazes porque precisam de se focar menos nas habilidades de nível inferior, de transcrição. Consequentemente, os processos de transcrição explicarão a maioria das diferenças individuais na habilidade de escrita nos escritores aprendizes, enquanto nos escritores experientes, os processos estratégicos de planeamento e de revisão são os que explicarão estas diferenças. No presente trabalho, é nosso objetivo examinar o papel dos processos de transcrição e o seu contributo para a produção de texto (ver Capítulo 4). Não descurando a sua importância, não nos debruçaremos acerca da influência das funções executivas na composição escrita.

Os componentes chave das habilidades de transcrição são, como foi anteriormente mencionado, a escrita manual e a ortografia (precisão na escrita de palavras). A investigação acerca do desenvolvimento da escrita tem demonstrado que estas duas habilidades de transcrição explicam uma grande parte da variância em medidas de qualidade da composição escrita (ver Berninger, 1999, para uma revisão). De facto, vários estudos com crianças com desenvolvimento normal (e.g., Berninger & Swanson, 1994; Graham, Berninger, Abbott, & Whitaker, 1997) têm vindo a sugerir que a fluência da escrita manual (i.e., número de letras do alfabeto escritas corretamente independentemente da ordem, e/ou número palavras escritas corretamente e na ordem

adequada copiadas de uma frase) é um forte preditor da composição escrita. Mais recentemente, Wagner e colaboradores (Wagner et al., 2011) verificaram que a fluência na escrita manual se correlaciona moderadamente no 1º ano de escolaridade e fortemente no 4º ano de escolaridade, com vários fatores da composição escrita (e.g., macroorganização, complexidade e produtividade). Em particular, a relação mais forte verificou-se entre a fluência na escrita manual e a produtividade, avaliada através de uma medida compósita da qual faziam parte, o número total e o número de diferentes palavras escritas.

Também tem sido observada uma influência da escrita de palavras, o outro componente crucial da transcrição, na composição escrita, quer em crianças com dislexia (e.g., Berninger, Nielson, Abbott, Wijman, & Raskind, 2008), quer em crianças com desenvolvimento normal (e.g., Abbott, Berninger, & Fayol, 2010). Berninger e colaboradores (Berninger et al., 2008) examinaram 122 crianças de língua inglesa (entre os 7 e os 14 anos de idade com dislexia) e verificaram que a escrita de palavras, avaliada através de um ditado de palavras, foi o preditor chave da qualidade global da composição escrita. Também num estudo longitudinal, com coortes sobrepostas, se verificou que a escrita de palavras explica uma variância considerável da composição escrita, em crianças de língua inglesa, do 1º ao 7º ano de escolaridade. Os autores avançaram uma interpretação para esta relação longitudinal robusta: "as crianças com habilidades de escrita mais fortes traduzem mais provavelmente ideias em palavras escritas e combinam as palavras escritas para produzir um texto escrito, melhor do que as que têm habilidades de escrita mais fracas" (Abbott et al., 2010, p.294). Adicionalmente, de acordo com os autores, as habilidades de ortografia foram as mais estáveis de todas as habilidades preditoras da escrita ao longo dos 5 anos.

Para além destas habilidades constituintes dos processos de transcrição, é teoricamente plausível (e.g., Juel et al., 1986; Juel, 1988) que outras habilidades que lhes estão subjacentes possam ter um contributo específico para o desenvolvimento da habilidade de composição escrita. Pensamos ser este o caso do conhecimento ortográfico, uma habilidade crucial para o desempenho na escrita de palavras.

De facto, evidências empíricas têm apontado o conhecimento ortográfico (lexical e sublexical) como um dos factores preditores da aquisição da escrita (e.g., Conrad et al., 2013; Rothe et al., 2013; Querido, Fernandes, Verhaeghe, Carvalho, & Morais, 2015; para uma revisão destes estudos, ver secção *O conhecimento ortográfico e a sua relação com o desenvolvimento da leitura e da escrita*, no presente Capítulo).

Estes estudos demonstram que quer o conhecimento ortográfico lexical quer o sublexical têm um papel importante na escrita, não apenas com crianças de língua inglesa (Conrad et al., 2013) ou alemã (Rothe et al., 2013), mas também com crianças de língua portuguesa (Querido et al., 2015).

Assim, a escrita de palavras é uma habilidade que sofre a influência dos dois componentes do conhecimento ortográfico e que, como já mencionado, influencia a diretamente a produção escrita (e.g., Abbott et al., 2010). A questão de se os componentes do conhecimento ortográfico têm um papel preditivo direto e/ou mediado pela escrita de palavras no processo de produção escrita, continua por clarificar (esta questão será explorada no Capítulo 4 do presente trabalho).

Apresentação dos estudos empíricos

Os objetivos do presente trabalho são, em termos gerais, examinar 1) as relações entre os componentes lexical e sublexical do conhecimento ortográfico; 2) as suas relações com os mesmos níveis de processamento da leitura e da escrita (lexical e sublexical); e 3) o seu contributo para o processo de composição escrita ao longo do desenvolvimento.

Com este propósito, foram levados a cabo três estudos empíricos longitudinais, para os quais foram testadas duas coortes de crianças (do 2º ao 5º ano de escolaridade), de duas escolas públicas da região de Lisboa com várias tarefas experimentais (ver representação esquemática do *design* experimental integrado dos três estudos na Figura 1).

Estudo 1

O segundo capítulo do presente trabalho corresponde ao primeiro estudo empírico que intitulámos "*Relationships between lexical and sublexical componentes of orthographic knowledge during learning to read"*.

Neste primeiro estudo pretendemos clarificar o tipo de relação que existe entre os componentes lexical e sublexical do conhecimento ortográfico e verificar como é que esta relação varia ao longo do desenvolvimento. Assim, ambicionamos responder às seguintes questões: 1) estará o estabelecimento do conhecimento ortográfico, lexical e sublexical, associado ao nível de eficiência da habilidade de recodificação fonológica? 2) qual a relação de influência que existirá entre os dois componentes do conhecimento ortográfico ao longo do desenvolvimento: o desenvolvimento dos dois componentes ocorrerá em paralelo e de forma independente, sem qualquer influência, um do outro, em qualquer direção; existirá apenas uma influência unidirecional entre os

componentes; ou haverá uma influência mútua entre eles; 3) será que esta relação, a existir, varia ao longo da aprendizagem?

Conduzimos este estudo com uma amostra de duas coortes longitudinais de crianças do 2º ao 5º ano de escolaridade: as crianças testadas no início do 2º ano foram também, testadas no final do 2º e 3º ano de escolaridade, e as crianças testadas no início do 4º ano foram também testadas no final do 5º. Para avaliar a habilidade do processamento ortográfico, recorremos a duas tarefas mais comummente usadas na literatura: a tarefa de escolha ortográfica (e.g., Olson, Forsberg, Wise, & Rack, 1994) e a tarefa de consciência ortográfica (e.g., Stanovich & Siegel, 1994), cada uma a um nível diferente de processamento, lexical e sublexical, respetivamente.

Com base nas teorias da aprendizagem da leitura (e.g., Ehri, 1997; Share, 1995) testámos a hipótese (H1) de que o estabelecimento das representações ortográficas e o conhecimento de padrões ortográficos estão associados ao nível de eficiência da habilidade de recodificação fonológica. Assim, bons leitores (com uma habilidade de recodificação fonológica eficiente) apresentarão melhor conhecimento ortográfico lexical e sublexical, relativamente aos leitores menos eficientes. Além disso, e uma vez que a habilidade de recodificação fonológica se desenvolve no início da aquisição da leitura, a associação entre esta habilidade e o conhecimento ortográfico será mais forte nos anos iniciais desta aprendizagem.

Os modelos de aquisição da leitura (Ehri, 1997; Share, 1995) sugerem que as representações ortográficas específicas de palavras são estabelecidas através da sua recodificação fonológica repetida. A partir do momento em que a criança começa a adquirir estas representações, tem a possibilidade de extrair padrões ortográficos relevantes para a escrita de outras palavras (e.g. Conrad, 2008). Assim, formulámos também a hipótese (H2) de que será o conhecimento ortográfico lexical a apoiar o

desenvolvimento de padrões ortográficos e não o contrário. Esperamos, assim, observar efeitos preditivos das representações ortográficas específicas das palavras no conhecimento de padrões ortográficos e que este contributo seja mais forte no início da aprendizagem.

Examinámos os efeitos com um intervalo temporal através de Análises de Regressão Sequencial (ARS), com controlo autorregressivo. Este controlo permitiu-nos extrair o contributo único de uma variável num momento inicial para outra, num momento mais tardio, subtraindo o efeito imediato entre ambas no momento inicial. Esta metodologia usada na investigação do desenvolvimento permite estabelecer relações bidirecionais entre duas variáveis (e.g., Deacon, Benere, & Castles, 2012; Fernandes, 2013) porque os efeitos são calculados com conjuntos de dados diferentes, sendo o preditor numa análise, o controlo autorregressivo na outra, e vice-versa.

Estudo 2

O segundo estudo empírico apresentado no Capítulo 3 do presente trabalho foi intitulado "*Does orthographic knowledge influence reading and spelling acquisition? A longitudinal study."* Com este estudo, tal como o título indica, é nosso objetivo examinar o contributo do conhecimento ortográfico (lexical e sublexical) para a leitura e a escrita, nos mesmos níveis de processamento.

Testámos as mesmas duas coortes longitudinais de crianças (do 2º ao 5º ano de escolaridade), descritas na apresentação do estudo anterior.

Uma vez mais, com base nas teorias do desenvolvimento da leitura e da escrita (e.g., Ehri, 2005), colocamos a hipótese (H1) de que a aquisição da leitura e da escrita é apoiada pelo conhecimento ortográfico. Deste modo, esperamos observar efeitos preditivos do conhecimento ortográfico lexical para os níveis lexical e sublexical das

habilidades de leitura e escrita e do conhecimento ortográfico sublexical para os níveis lexical e sublexical das habilidades de leitura e escrita. Ou seja, as representações ortográficas lexicais serão preditoras da leitura e da escrita de palavras; e o conhecimento de padrões ortográficos será preditor da leitura e da escrita de pseudopalavras. Esperamos ainda observar efeitos cruzados: o conhecimento ortográfico específico da palavra será preditor da leitura e da escrita de pseudopalavras e o conhecimento de padrões ortográficos será preditor da leitura e da escrita de palavras.

O conhecimento ortográfico (lexical e sublexical) foi avaliado recorrendo às mesmas tarefas utilizadas no *Estudo 1.* A leitura e a escrita foram avaliadas através de tarefas de leitura e de escrita de palavras e de pseudopalavras isoladas (semelhantes às utilizadas no estudo de Fernandes et al., 2008).

Testámos a nossa hipótese recorrendo às análises de regressão sequencial descritas no *Estudo 1*.

Estudo 3

No estudo intitulado "*The influence of orthographic knowledge on writing composition: A longitudinal path analysis.*" (Capítulo 4), examinámos o contributo do conhecimento ortográfico para a composição escrita. Este contributo poderá ocorrer de uma de três formas: 1) através de uma mediação total – a relação entre o conhecimento ortográfico e a composição escrita será completamente explicada e mediada pela influência do conhecimento ortográfico na habilidade de escrita de palavras; 2) por uma mediação parcial – e, neste caso, o conhecimento ortográfico contribuirá diretamente para a composição escrita e terá um contributo adicional mediado pela escrita de

palavras; 3) ou, finalmente, a relação entre o conhecimento ortográfico e a composição escrita ocorrerá sem qualquer mediação, ou seja, diretamente.

Assim, colocámos como primeira hipótese que, se os dois componentes do conhecimento ortográfico contribuem para a escrita de palavras e esta, por sua vez, influencia a habilidade de produção de texto escrito, então deverá existir um contributo de ambos os componentes deste conhecimento para o processo de composição escrita (H1).

A verificar-se a H1, supomos ainda que (H2) o conhecimento ortográfico lexical terá um impacto direto ou mediado na composição escrita mais elevado, ou mesmo exclusivo, relativamente ao do conhecimento ortográfico sublexical. Esta hipótese baseia-se nos resultados de Querido e colaboradores (Querido, Fernandes, Verhaeghe, Carvalho, & Morais, 2015) que mostraram uma influência do conhecimento ortográfico lexical, mas não do sublexical, sobre a escrita de palavras.

Uma vez que o conhecimento ortográfico terá maior impacto na habilidade de escrita de palavras e se desenvolve sobretudo nos anos mais iniciais, neste terceiro estudo testámos apenas a primeira das duas coortes longitudinais de crianças (do 2º ao 3º ano de escolaridade), descritas na apresentação dos estudos anteriores.

A avaliação do conhecimento ortográfico (lexical e sublexical) e a escrita de palavras foi realizada com recurso às mesmas tarefas utilizadas nos *Estudos 1 e 2*. A composição escrita foi cotada relativamente à diversidade lexical – número de palavras diferentes escritas.

As hipóteses foram testadas através de análises *path*. Este tipo de análise permitiu-nos construir e testar três modelos estruturais que refletem as relações hipotetizadas (ver Figura 1 do Capítulo 4). Assim, pudemos quantificar a porção de variância única que uma medida explica na outra. Esta variância foi representada por

um *coeficiente path* (β). Além disso, através dos métodos de *bootstrapping* (Efron & Tibshirani, 1993), percentil e enviesamento corrigido, foi possível estimar os efeitos indiretos, específicos e totais nos modelos com mediação (Preacher & Hayes, 2008).

Com uma metodologia mais sofisticada, este terceiro estudo complementou as evidências encontradas no segundo, dado que continuou a examinar o contributo dos dois componentes do conhecimento ortográfico na escrita de palavras.

Os efeitos analisados entre as diversas habilidades nos três estudos empíricos encontram-se esquematizados na Figura 2.

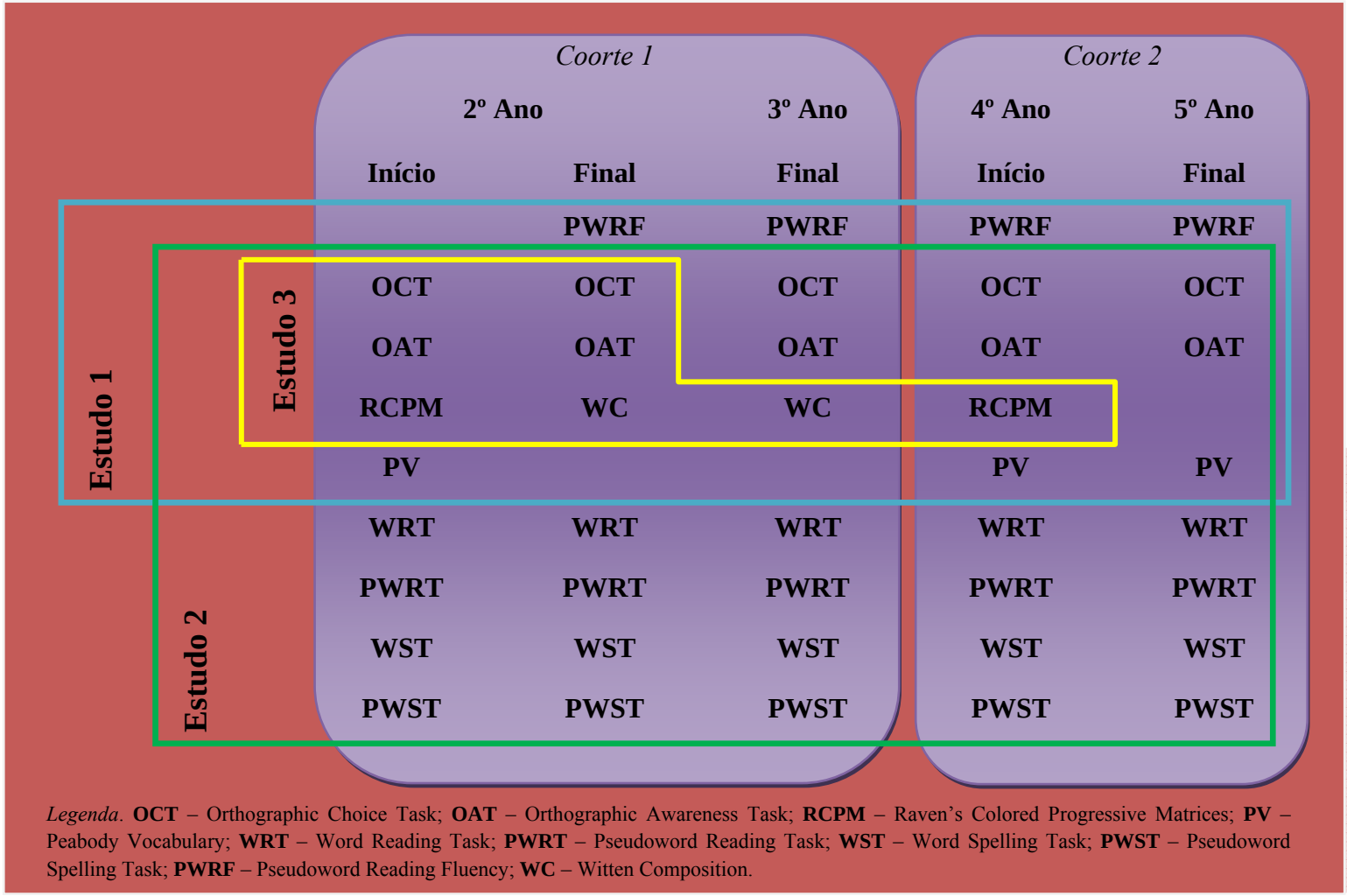

Figura 1. Representação esquemática do desenho experimental integrado dos três estudos empíricos.

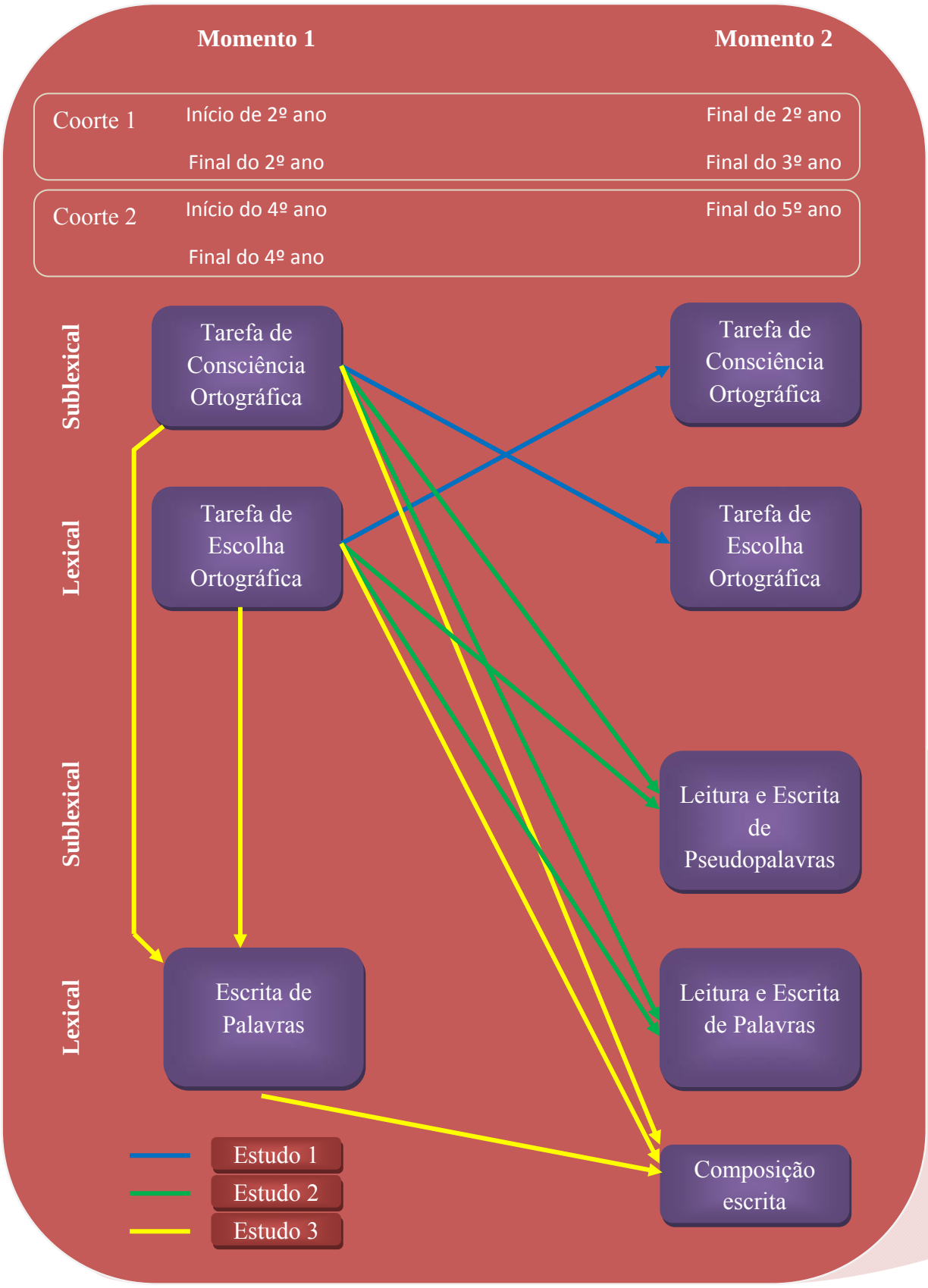

Figura 2. Efeitos analisados entre as tarefas que avaliam as diversas habilidades nos três estudos empíricos.

PARTE II
Estudos Empíricos

CAPÍTULO 2

Relationships between lexical and sublexical components of orthographic knowledge during learning to read

Relationships between lexical and sublexical components of orthographic knowledge during learning to read.[1]

Abstract

In this study we tested a model about the development of the two components of orthographic knowledge – lexical and sublexical - and about the direction of their relationship, in two cohorts of Portuguese graders. Participants were 170 Portuguese children belonging to cohort 1 (Grades 2 and 3) and cohort 2 (Grades 4 and 5). The comparison between two groups with different levels of phonological recoding (higher and lower) allowed to establish that, as expected, phonological recoding is crucially associated with orthographic knowledge. This association does occur on both processing levels (lexical vs. sublexical), arises very early in reading development (at the beginning of Grade 2), and interestingly, is no more present at advanced levels of development (from third grade on). The sequential regression analysis with autoregressive control showed that, consistent with our predictions, lexical orthographic knowledge at the beginning of Grade 2 significantly contributed to sublexical orthographic knowledge at the end of Grade 2. Surprisingly, in this cohort (C1) we also observed an effect in the reverse direction. Globally, the results of the present study highlight the development of lexical and sublexical orthographic knowledge and their temporally limited relationship with decoding ability. At an early stage of reading acquisition, efficient phonological recoding has a key role in the development of both components of orthographic knowledge. Moreover, lexical orthographic representations

[1] Querido, L., Fernandes, S., Verhaeghe, A., Carvalho, C., & Morais, J. (submetido). Relationships between lexical and sublexical components of orthographic knowledge during learning to read.

have a predictive effect on sublexical or pattern orthographic knowledge. Interestingly, although weaker, a predictive effect on the opposite direction was also observed.

Keywords: orthographic knowledge; orthographic representations; orthographic pattern knowledge; lexical and sublexical orthographic knowledge

Introduction

The most prominent factor that determines reading success appears to be phonological awareness – the ability to access and manipulate speech sounds (Morais, Alegria, & Content, 1997; Anthony & Francis, 2005; Deacon, Bener, & Castles, 2012) – which has been established as highly predictive of reading acquisition (e.g., National Reading Panel, 2000). Another crucial factor is orthographic knowledge, which, according to Apel (2011, p. 592), "represents the information stored in memory that tells us how to represent spoken language in written form".

Many researchers use orthographic knowledge to designate the mental representations of the words' spelling in long term memory (e.g., Frith, 1980; Treiman, 1993). The classic Orthographic Choice Task (e.g., Olson, Forsberg, Wise, & Rack, 1994) in which children are asked to choose between two possible phonological alternatives (e.g., rain-rane) requires this type of knowledge. However, stored word orthographic representation is but one component of orthographic knowledge. Indeed, another component is the knowledge of the sublexical letter chunks operant within a language's orthography, including the permissible combinations of adjacent letters; for example, while -ld- is a legal sequence in European Portuguese, found in "calda" (syrup), "molde" (mold), etc., -dl- is illegal – the corresponding phonetic form exists but it is always spelled with an intermediate silent "e" (Apel, 2011). The wordlikeness choice task, in which participants have to choose, among two or more non-words the one that most resembles a word (e.g., Stanovich & Siegel, 1994), focuses on the sublexical letter patterns consistent with the rules of the language's orthographic code.

Both lexical orthographic representations and sublexical orthographic patterns are part of orthographic knowledge and necessary to write correctly. These two

components act, however, at different levels. Orthographic representations are word-specific and act at the lexical level, whereas orthographic patterns are not word-specific and operate at the sublexical level.

Theoretically, reading acquisition models suggest that orthographic representations are established primarily through the repeated phonological recoding of words (Ehri, 1997; Share, 1995). As soon as children acquire orthographic representations through practice with words, they begin to extract relevant orthographic patterns for spelling other words (e.g., Conrad, 2008). Alternatively, children could acquire knowledge of particular regularities through phonological recoding (e.g., Ehri, 1994) or statistical learning (e.g., Deacon, Conrad, & Pacton, 2008) and that knowledge could support the development of reliable orthographic representations (e.g., Deacon et al., 2009).

The repeated phonological recoding of words allows children to acquire and store orthographic representations (e.g., Ehri, 1992; Share, 1995, 2004), but this is not the only path to lexical orthographic knowledge development. There is experimental evidence that some development of stored word orthographic representations could occur early and implicitly (e.g., Wolter & Apel, 2010). These authors examined the initial acquisition of orthographic representations for a set of pseudowords by kindergarteners both with and without language impairment. The children were exposed to novel written pseudowords within adult-led storybook reading situations. Each series of short stories contained one novel pseudoword. Following each story, they were required to spell the target pseudoword and identify it in a set of three pseudowords. Their results suggest that the children demonstrated some initial orthographic representation acquisition in a relatively implicit learning situation.

At the sublexical level, the knowledge of orthographic patterns also seems to develop early and implicitly. The studies by Apel and colleagues (e.g., Wolter & Apel, 2010; Apel, Thomas-Tate, Wilson-Fowler, & Brimo, 2012) provide evidence that the initial development of orthographic representation was also implicitly sensitive to orthographic regularities. The authors varied orthotactic probabilities of the pseudowords to which children were exposed. In both studies, the statistical regularities of the words affected the children's orthographic representation learning: participants performed better with pseudowords in the high orthotactic probability condition than in the low orthotactic probability condition.

Other studies (e.g., Cassar & Treiman, 1997; Hayes, Treiman, & Kessler, 2006) leading to similar conclusions also demonstrated that the acquisition of implicit knowledge of acceptable letter chunks (i.e., orthotactic rules) benefits from contextual graphotactic information. Treiman and her colleagues investigated children's sensitivity to vowel or consonant context when spelling consonants (Treiman & Kessler, 2006) or vowels (Hayes et al., 2006), respectively. In those studies, participants – who ranged from kindergarten through high school – performed tasks where the letter spelling was conditioned by the surrounding context. For example, participants heard /glɛd/ or /glɛp/ while seeing gl__d or gl__p and their task was to fill in the missing letters (Treiman & Kessler, 2006). In this example, /glɛd/ contains /ɛ/ with the coda d, an environment in which the ea spelling would be anticipated on the basis of real words such as head or dead. The authors predicted performance to be conditioned by the preceding or the following context (consonant or vowel). In both studies (Treiman & Kessler, 2006; Hayes et al., 2006), the results suggest that children use context to help spell with consonants (Hayes et al., 2006) and vowels (Treiman & Kessler, 2006), taking advantage of graphotactic information.

More recently, Pacton, Sobaco, Fayol, and Treiman (2013) conducted a study to investigate whether and how spelling acquisition by French third graders is influenced by two orthographic patterns that are not typically taught explicitly: consonants cannot double in word-initial position consonants and consonants cannot double after single consonants. They used an incidental orthographic learning task where children read meaningful texts containing three types of novel spellings: those with no doublet, those with a doublet in a legal position and those containing a doublet in an illegal position. Children's orthographic learning was accessed with a task of spelling to dictation. Overall, items without doublets were better recalled than with. Additionally, among the items with doublets, children performed better on those in which the doublet is legal in French (e.g., gupprane), than on those in which they were illegal (e.g., guprrane). These results would confirm that children use their general knowledge about the graphotactic patterns of their writing systems – double consonants can occur before but not after single consonants – to produce correct spellings (Pacton et al., 2013).

Although there is evidence that both the lexical and sublexical components of orthographic knowledge begin to develop early, the type of relationship between them and how this relationship (if one exists) would change throughout development remains to be investigated. In our study, we attempted to clarify this issue. Does the development of both components of orthographic knowledge occur in parallel and independently of each other, with no influence in either direction? Alternatively, is there a unidirectional influence? Or, do both components impact each other? Moreover, do these relationships vary in the course of the learning process?

In our study we used two of the most common measures of orthographic processing skill – Ortographic Choice Task and an Orthographic Awareness Task – each at a different level of processing – lexical and sublexical, respectively.

We tested two hypotheses concerning the developmental relationships between these two components of orthographic knowledge.

According to theoretical models of reading (Ehri, 1997; Share, 1995), phonological recoding improves orthographic knowledge with an impact on both its components, i.e., at the lexical and sublexical level. Nevertheless, the mayority of empirical data supporting this prediction come from studies in English language (e.g. Share, 1999, 2004). The European Portuguese alphabetic system presents orthographic characteristics that are different from other languages, namely from English (e.g., Fernandes, Ventura, Querido, & Morais, 2008). The European Portuguese orthographic code is more transparent than the French one, although more similar to the French than to the English. Although the phonological recoding is associated with orthographic knowledge, its weight may vary as a function of script transparency. Based on this assumption, our first hypothesis (H1) is that the establishment of lexical and sublexical orthographic knowledge is associated with phonological recoding regarding the level of efficiency, in children who were native speakers of an orthography of intermediate depth (European Portuguese). We anticipated that this association will be in line with results obtained in English orthography, once European Portuguese orthography is closer from opaque orthographies than from transparent ones. Thus, we expected good readers, with efficient phonological recoding (measured from pseudoword reading), to show an advantage with respect to both components of orthographic knowledge – lexical and sublexical – relative to poor readers. In other words, we expected good readers to outperform poor readers both in orthographic choice and orthographic awareness tasks. Moreover, taking into account that phonological recoding develops mainly in the early stages of reading acquisition, we further expected to find a stronger association between that skill and orthographic knowledge in the early grades.

Going a step further in learning to read, our Hypothesis 2 (H2) is that lexical orthographic knowledge support the development of sublexical orthographic knowledge. We thus expected to observe predictive effects of lexical orthographic knowledge on sublexical orthographic knowledge (e.g., Conrad, 2008), but not the reverse (i.e., sublexical orthographic knowledge to influence lexical orthographic knowledge). Furthermore, this relationship would presumably be stronger in the early school years.

We examined long-term effects using cross-lag Sequential Regression Analyses (SRA) with autoregressive controls. The inclusion of an autoregressive control allows for the extraction of a variable's unique effect at an earlier time on another at a later time by subtracting the immediate effect between the two at the earlier time. This methodology has been used in developmental research to establish a bidirectional relationship between two variables (e.g., Deacon, Benere, & Castles, 2012). We also incorporated several control variables before the autoregressive control (e.g., age and non-verbal reasoning) to reduce the possibility that any effects be due to a spurious third variable (see Kenny, 1975). Phonemic awareness was also included in the analysis to control for the effects of phonological skills when determining whether lexical orthographic knowledge contribute uniquely and/or reciprocally to sublexical orthographic knowledge. This ability has been used elsewhere to demonstrate the unique effect of orthographic knowledge on both reading (e.g., Stanovich, West, & Cunningham, 1991) and spelling (e.g., Ouellette & Senechal, 2009).

This methodology makes it possible to test bidirectional effects, because the effects are calculated on different data sets with the predictor in one analysis being the autoregressive control in the other.

The development and relationships of both components of orthographic knowledge were examined in two longitudinal cohorts of students from second through fifth grade. Students tested at the beginning of Grade 2 were also tested at the end of Grades 2 and 3, and students tested at the beginning of Grade 4 were also tested at the end of Grade 5.

Method

Participants

A total of 170 children from two public schools in the Lisbon district participated in the study. Two cohorts were tested in three testing periods: (i) in the initial three months of the school year in one grade; (ii) in the final three months of that same school year; (iii) in the last three months of the subsequent grade. Cohort 1 (83 children, of whom 37 girls) was tested in Grades 2 and 3; Cohort 2 (87 children, of whom 46 girls), in Grades 4 and 5. Depending on the specific test, for Cohort 1 a minimum of 75 and 78 children participated in testing periods 2 and 3, respectively; for Cohort 2, a minimum of 79 and 69 children were participants.

Students came from two different classrooms per grade in each school. They were all native speakers of European Portuguese and had an average or above average cognitive functioning – 25th percentile or higher on the Raven's Coloured Progressive Matrices (Simões, 1994). Children flagged by their parents or teachers as having learning, emotional, or sensory disabilities were not included in the sample. These screening criteria determined the ineligibility of 15 and 13 children from Cohort 1 and 2, respectively. Data on educational background from a questionnaire answered by the children's parents (accounting for 74.3% of the participants) indicated only 6.4% of fathers and 4.7% of mothers with less than a high school diploma, 11.7% of parents with high school graduation, 38.6% of fathers and 48.5% of mothers with university degrees, and, additionally, 9.9% of fathers and 7.6% of mothers with post-graduate education (including 2.9% of fathers and 2.3% of mothers with a PhD). Only one father (and no mother) was reported as unemployed. Our sample is thus not representative of

the Portuguese population on the whole, but overwhelmingly constituted by children from middle and upper middle class families.

Tests[2]

(a) Verbal and nonverbal abilities.

Vocabulary Peabody Picture Test (VPPT).

The first author adapted the VPPT from the Spanish version (Dunn, Padilla, Lugo, & Dunn, 1986). Four pictures with different meanings are presented per item and the participant is required to point to the picture that corresponds to a given spoken word. The test was administered to Cohort 2 in testing periods 1 and 3, and to Cohort 1 only in period 1 because of time constraints.

Raven's Colored Progressive Matrices.

The Portuguese adaptation of the Raven's Colored Progressive Matrices (Simões, 1994) was used to measure general nonverbal intellectual ability. It was administered to both cohorts only in period 1.

(b) Phonemic Awareness (PA).

We used a phoneme deletion test where children were asked to say aloud the phonological segment obtained after deleting the initial phoneme of a monosyllabic pseudoword. Ten CCV stimuli (e.g., *blu* and *fla*) were presented over headphones.

[2] All tests considered in this study were developed and administered to the participants as part of the project "Developmental benchmarks of reading and writing in European Portuguese from the 1st to 6th grades" (2008-2010), conducted under the auspices of the National Reading Plan.

Experimental items were preceded by three familiarization trials, which could be re-administered if the child failed to understand the task, or asked the experimenter to repeat any part of the instruction. This test was administered in all testing periods.

(c) Reading Skill.

Pseudoword Reading Fluency Task.

To assess reading ability, participants were administered the *Pseudoword Reading Fluency Task.*

The pseudowords were constructed from words of a text. The order of presentation was randomized. The child was asked to read the items as rapidly and accurately as possible. The number of pseudowords read correctly and the reading times were recorded and scored as number of pseudowords correctly read per minute.

(d) Orthographic Knowledge.

Two tasks were used, one involving an orthographic choice, the other examining orthographic awareness. Both were administered to cohort 1 in all testing periods and to cohort 2 in periods 1 and 3.

Ortographic Choice Task.

In the Orthographic Choice Task, children were shown 32 sets of five stimuli (e.g., *braço – brasso – draço – braco – arbço*). Only one member of each set correctly matched a listened target word (e.g., *braço*). The other members corresponded to one pseudo-homophone foil (e.g., *brasso*); a word or pseudoword with a visual similarity in

the first syllable (e.g., *draço*); a word or pseudoword with a visual similarity in the last syllable (e.g., *braco*); and a non-word that combined the letters of the target word in an illegal sequence for European Portuguese (e.g., *arbço*). In each set, stimuli were randomly presented in a centered column of an A5 sheet. The task was to select the member of each set that "matched" the heard word.

Orthographic Awareness Task.

In the Orthographic Awareness Task, children were shown 14 pairs of pronounceable pseudowords (e.g., *trino – rinot* and *drulo – srulo*). One member of each pair contained a string that never occurs in European Portuguese in the initial (e.g., *srulo*) or final (e.g., *rinot*) position; the other member of the pair contained an orthographically legal string in the same position. The task was to select the member of each pair that "could be a word" or "looks like a word".

General Procedure

The Vocabulary Peabody Picture and the Phonemic Awareness tests were administered to each child individually by a trained graduate student. They took place in a quiet setting provided by the school and were conducted in separate sessions. The Raven's Colored Progressive Matrices and the Orthographic Knowledge tests were administered also in different sessions by a trained graduate student, but to large groups of participants.

Table 1

Means and standard deviations for correct responses and response times in the various tests for each cohort of students by testing period

	Cohort 1						Cohort 2			
	Grade 2				Grade 3		Grade 4		Grade 5	
	N= 83				N= 83		N= 87		N= 74	
	Beginning		End		End		Beginning		End	
	M	SD	M	SD	M	SD	M	SD	M	SD
Matrices	28.95	4.16					33.08	2.37		
Peabody Vocabulary	125.31	10.62					124.64	11.96	128.55	12.03
Phoneme Deletion (accuracy)	.66	.31	.82	.25	.85	.23	.86	.22	.92	.15
Pseudoword reading fluency task			36.12	11.33	45.07	12.36	51.42	11.73	52.22	12.71
Orthographic Choice Task* (accuracy)	.71	.17	.81	.13	.91	.09	.88	.10	.93	.13
Corrected values	.64	.21	.76	.16	.89	.11	.85	.13	.91	.13
Orthographic Awareness Task** (accuracy)	.76	.16	.83	.14	.82	.16	.78	.15	.85	.19
Corrected values	.53	.31	.66	.28	.66	.25	.57	.30	.74	.27

Note. 1) **Beginning** = November-January; **End** = April-June; 2) **accuracy** = mean proportion of correct responses; * Chance level for complete test was .20; ** Chance level for complete test was .50; the means and standard deviations presented in each cell of the table were calculated for all participants who accomplished the task.

Table 2

Correlation Matrix for all measures in Cohort 1.

* p < .05 ** p < .01

	Variable	1	2	3	4	5	6	7	8	9	10	11
1	Matrices	1	.17	.17	.22	.02	.12	.25*	.00	.02	.28*	-.16
2	Peabody Vocabulary at **beginning of Grade 2**		1	.04	.11	-.09	.14	.26*	-.08	-.05	.00	.08
3	Phonemic Awareness accuracy at **beginning of Grade 2**			1	.35**	.07	.26*	.41**	.03	.21	.24*	-.10
4	Orthographic Choice Task at **beginning of Grade 2**				1	.17	.33**	.66**	.24*	.17	.41**	-.04
5	Orthographic Awareness Task at **beginning of Grade 2**					1	.14	.29**	.17	.15	-.07	-.04
6	Phonemic Awareness accuracy at **end of Grade 2**						1	.43**	-.04	.50**	.16	.21
7	Orthographic Choice Task at **end of Grade 2**							1	.11	.30**	.48**	-.07
8	Orthographic Awareness Task at **end of Grade 2**								1	-.11	.07	-.07
9	Phonemic Awareness accuracy at **end of Grade 3**									1	.35**	.11
10	Orthographic Choice Task at **end of Grade 3**										1	.04
11	Orthographic Awareness Task at **end of Grade 3**											1

Table 3

Correlation Matrix for all measures in Cohort 2.

	Variable	1	2	3	4	5	6	7	8
1	Matrices	1	.26*	.23*	-.07	.20	.14	-.09	.20
2	Peabody Vocabulary at **beginning of Grade 4**		1	.20	.01	.49**	.08	-.18	-.05
3	Orthographic Choice Task at **beginning of Grade 4**			1	.04	.31**	.29*	.14	.13
4	Orthographic Awareness Task at **beginning of Grade 4**				1	.05	.06	.23	.10
5	Peabody Vocabulary at **end of Grade 5**					1	.15	.09	-.04
6	Phonemic Awareness accuracy at **end of Grade 5**						1	.21	.00
7	Orthographic Choice Task at **end of Grade 5**							1	.35**
8	Orthographic Awareness Task **end of Grade 5**								1

* p < .05 ** p < .01

Results

Descriptive statistics are presented in Table 1. The means for VPPT are at or slightly above the norms (we used the Spanish population norms; see Dunn, Padilla, Lugo, & Dunn, 1986) according to the test manuals for each age group. For both orthographic tasks, accuracy scores were expressed as proportion of correct responses and as chance-corrected proportion (.50 and .20, respectively, for the Orthographic Choice Task and Orthographic Awareness Task).

A summary of concurrent and longitudinal correlations between measures is presented in Tables 2 (Cohort 1) and 3 (Cohort 2).

Evolution of orthographic knowledge and comparison between higher and lower "phonological recoders"

To examine the association between phonological recoding and orthographic knowledge, we extracted from the initial sample two groups[3] of participants for each cohort. The groups were created based on the participant's performance on a Pseudoword Reading Fluency Task reflecting recoding ability. Thus, for each cohort, there were a group of readers with higher recoding skills (performance above the 65th percentile in the Pseudoword Reading Fluency Task) and a group with lower recoding skills (performance below the 35th percentile in the same task).

The data for each forced-choice task (Orthographic Choice Task and Orthographic Awareness Task) were the proportion of chance-corrected successful detections. The chance level was different for each task (.20 and .50, respectively, for

[3] We are aware that the media split procedure could be problematic because it leads, in some cases, to a loss of power and, under some circumstances, to spurious effects (e.g., Cohen, 1983; MacCallum, Zhang, Preacher, & Rucker, 2002). However, as it is widely used in reading research (e.g., Jenkins, Stein, & Wysocki, 1984; Ozuru, Dempsey, & McNamara, 2009; Stanovich, Feeman, & Cunningham, 1983), we decided to keep it for comparison purposes.

Orthographic choice and Orthographic awareness, respectively), and the compensation for chance success was accomplished using the formula $p = (p' - c) / (1 - c)$, where p = the corrected detection proportion; p' = the raw proportion; and c = the probability of being correct by chance (e.g., Clark, Rutschmann, Link, & Brown, 1963).

Descriptive statistics for the two groups are presented in Table 4. Analyses of variance (ANOVA) were carried out separately for each cohort on corrected proportions of successful detections considering the following factors: *Session* (three levels for Cohort 1: beginning and end of Grade 2 and end of Grade 3; and two levels for Cohort 2: beginning of Grade 4 and end of Grade 5); *Type of orthographic knowledge* (lexical versus sublexical); and *Recoding level* (higher versus lower recoding skills). The first two factors were within-subject factors, and the last one was a between-subject factor. Significant effects and interactions were explored using posthoc Bonferroni corrections.

In Cohort 1, there were significant main effects of *Session* ($F [2, 84] = 23.88$, $p < .0001$), *Type of orthographic knowledge* ($F [1, 42] = 12.69$, $p = .001$) and *Recoding level* ($F [1, 42] = 11.99$, $p = .001$). The effect of *Session* revealed that performance on orthographic tasks increased with session (mean = .54, .70 and .76 for the beginning and end of Grade 2 and the end of Grade 3, respectively). The *Type of orthographic knowledge* effect was due to an advantage of performance on the Orthographic Choice Task (mean = .72) over the Orthographic Awareness Task (mean = .62). Concerning the *Recoding level* effect, the group of readers with higher recoding skills outperformed the group with lower recoding skills in the orthographic tasks overall (mean = .72 and .61, respectively).

The *Session* x *Type of orthographic knowledge* and *Session* x *Recoding level* interactions were significant ($F [2, 84] = 4.03$, $p < .05$ and $F [2, 84] = 3.45$, $p < .05$, respectively), while all other interactions were non significant (*Type of orthographic knowledge* x *Recoding level*, $F [1, 42] < 1$; *Session* x *Type of orthographic knowledge* x *Recoding level*, $F [2, 84] < 1$). The *Session* x *Type of orthographic knowledge*

interaction can be explained by the fact that performance on the two orthographic tasks differed between them only at the end of Grade 3 (mean = .87 and .66 for Orthographic choice and Orthographic awareness, respectively [$F(1, 42) = 26.16$, $p < .0001$]). In contrast, performance on the two orthographic tasks was similar in Grade 2 (beginning of Grade 2, mean = .57 and .52, for Orthographic choice and Orthographic awareness, respectively, $F [1, 42] < 1$; and end of Grade 2, mean = .72 and .67, respectively for Orthographic choice and Orthographic awareness, respectively, $F [1, 42] = 1.04$, $p > .10$). The *Session* x *Recoding level* interaction reflects the fact that higher decoders outperformed lower decoders on orthographic tasks only in Grade 2, both at the beginning (mean = .46 and .63, respectively [$F(1, 42) = 8.80$, $p = .005$]) and the end of the grade (mean = .62 and .76, respectively [$F(1, 42) = 11.09$, $p = .002$]) but not at the end of Grade 3 (mean = .76 and .77, respectively, [$F(1, 42) < 1$]).

In Cohort 2, there were only significant main effects for *Session* ($F [1, 44] = 14.79$, $p < .0001$) and *Type of orthographic knowledge* ($F [1, 44] = 84.62$, $p < .0001$), indicating the same trend as the one observed in Cohort 1: overall increased performance from Grade 4 to Grade 5 and better performance on the Orthographic Choice Task compared to the Orthographic awareness one. In Cohort 2, though, the *Recoding level* effect was not significant ($F [1, 44] = 1.23$, $p > .10$). Nor was any interaction (*Session* by *Type of orthographic knowledge*, $F [1, 44] = 1.71$, $p > .10$; *Session* x *Recoding level*, $F [1, 44] = 2.12$, $p > .10$; *Type of orthographic knowledge* x *Recoding level*, $F [1, 44] = 1.18$, $p > .10$; *Session* x *Type of orthographic knowledge* x *Recoding level*, $F [1, 44] = 3.04$, $p = .09$).

In sum, we observed an improvement in performance on orthographic tasks from Grades 2 through 5. The fact that performance was better, especially for the more difficult Orthographic Awareness Task, in Grade 3 than in Grade 4 may be due to either or both following factors: (1) participants belonging to different cohorts; (2) Grade 3 and Grade 4 children being tested at the end and the beginning of the school year,

respectively. The higher recoding groups always outperformed the lower ones, except on the Orthographic Awareness Task in Grades 3 and 4, for which the trend was the opposite. This may be related partially to the reasons indicated above and partially to the fact that, for both high and low decoders, performance on this task strongly increased from the beginning to the end of Grade 2 but was not followed by remarkable increases until Grade 5. In spite of a fall in the fourth graders, at the end of Grade 5 performance was only slightly better than at the end of Grade 2. In contrast, performance on Orthographic choice increased steadily, except between Grades 3 and 4, which, as mentioned above, may be biased by either/both the change of sample and the time of testing.

Table 4

Means and standard deviations for proportion of correct responses in the two orthographic tasks for Cohorts 1 and 2 at the different testing periods.

		Cohort 1						Cohort 2			
		Grade 2				Grade 3		Grade 4		Grade 5	
		Beginning		End		End		Beginning		End	
		M	SD	M	SD	M	SD	M	SD	M	SD
Lower recoding level group	**Orthographic Choice Task***	.49	.15	.64	.17	.84	.12	.81	.13	.90	.09
	Orthographic Awareness Task*	.43	.27	.60	.26	.68	.25	.61	.29	.67	.27
Higher recoding level group	**Orthographic Choice Task***	.65	.22	.80	.15	.90	.11	.89	.12	.96	.04
	Orthographic Awareness Task*	.60	.35	.74	.25	.63	.28	.52	.36	.79	.22

Notes: 1) **Beginning** = November-January; **End** = April-June; 2) **accuracy** = mean proportion of correct responses; * Chance level compensation was applied.

Sequential Regression Analyses

SRAs are used to model relationships between the present variables and to predict the value of a dependent variable from one or more independent variables, i.e. the predictors. Here, we first specified the set of predictors that make up the model. Next, we specified their order of entry, which reflects our theoretical framework and previous research findings. Then, we tested the relative contribution of each predictor to the dependent variable in a sequential regression model.

For all SRAs reported here, age, nonverbal reasoning, vocabulary and phonemic ability were entered first to control for the contributions of age, general nonverbal and language abilities, and phonemic awareness.

Long-term bidirectional effects between lexical and sublexical orthographic knowledge.

The long-term bidirectional effects between *lexical and sublexical orthographic knowledge* were examined by means of cross-lag SRAs. Figure 1 shows a schematic representation of cross-lag SRAs. We evaluated whether cross-lag contributions of the predictor variable (A at Time 1), entered at the third step, to an outcome variable (dependent variable B, at Time 2) survived the additional control of B at Time 1, entered in the second step. After the first cross-lag SRA, an additional SRA was conducted with the same control steps, switching the predictor and outcome variables. For example, when the long-term effect of *lexical orthographic knowledge* at the end of Grade 2 on *sublexical orthographic knowledge* at the end of Grade 3 was examined, the Grade 2 *sublexical orthographic knowledge* was entered as a control variable in the third step to examine the contribution of *lexical orthographic knowledge* to the change in *sublexical orthographic knowledge* from the end of Grade 2 to the end of Grade 3.

Subsequently, the same was done to evaluate the long-term effect of *sublexical orthographic knowledge* at the end of Grade 2 on *lexical orthographic knowledge* at the end of Grade 3. This procedure was applied to both cohorts.

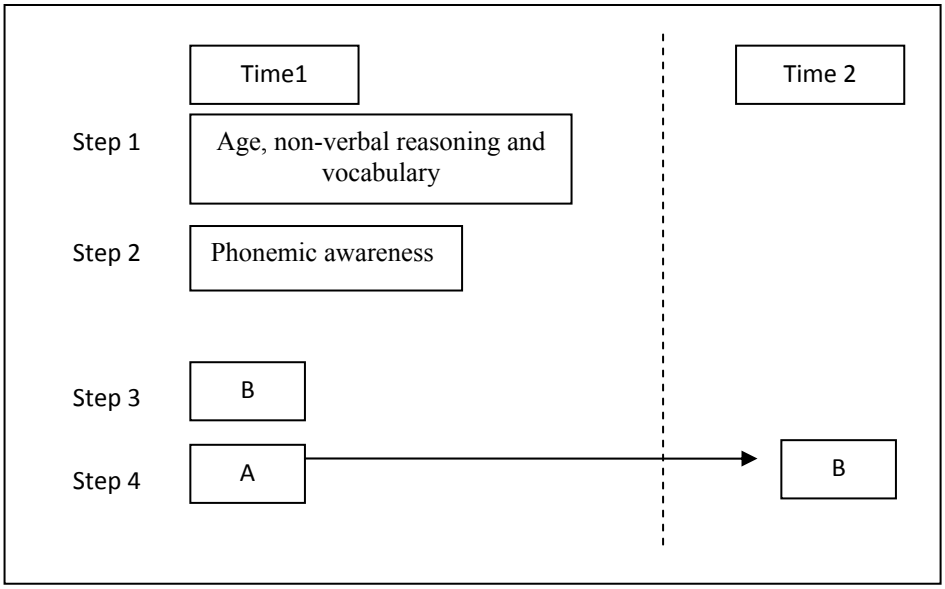

Figure 1. General procedure of the cross-lag SRA.

Interactive relationships between the two components of orthographic knowledge at successive times.

The results of the cross-lagged SRAs are presented in Figure 2. This set of sequential regressions showed significant contributions (only in Cohort 1; see Table A1 and A2 of Appendix) between lexical and sublexical orthographic knowledge. In fact, performance on Orthographic Choice Task at the beginning of Grade 2 accounted for significant variance in the performance on Orthographic Awareness Task at the end of Grade 2 (8%). In the reverse direction, the performance on Orthographic Awareness Task at the beginning of Grade 2 accounted for significant variance in performance on Orthographic Choice Task at the end of Grade 2 (3%). In Cohort 2, with autoregressive control, there were no significant contributions (see Table A3 and A4 of Appendix) from performance on Orthographic Choice Task to the performance on Orthographic Awareness Task nor were there contributions in the reverse direction.

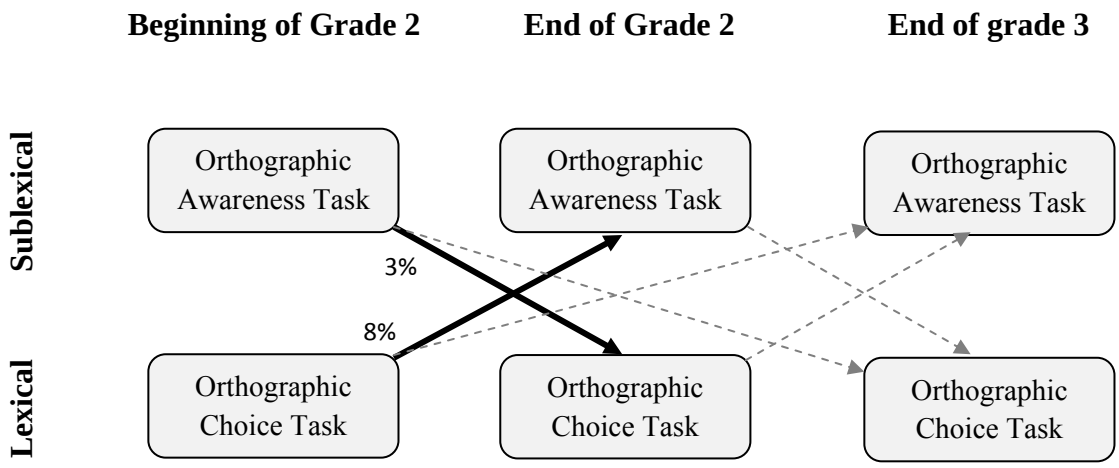

Figure 2. Results of SRA in Cohort 1. Arrows in bold denote a significant relationship between sublexical and lexical orthographic knowledge as tested in the longitudinal regression analysis.

Discussion

In this study, we tested a developmental model of two components of orthographic knowledge – lexical and sublexical – and the direction of their relationship among Portuguese students from the second to the fifth grades.

The suggested model proposes an association between overall orthographic knowledge and efficiency in phonological recoding, which is consistent with influential theories of reading acquisition (e.g., Ehri, 1992; Share, 1995). It also assumes that lexical orthographic knowledge support the development of implicit knowledge (e.g., Wolter & Apel, 2010) of relevant orthographic patterns. That is, efficient and repeated phonological recoding is assumed to be crucial for the development of both types of orthographic knowledge, particularly for orthographic representations (e.g., Share, 2004), which, in turn, would allow children, through reading practice, to extract relevant orthographic sequences or patterns (Conrad, 2008).

The aim of the present work was thus to verify whether efficient phonological recoding and orthographic knowledge are associated (H1) and whether stored representations of lexical orthography contribute in the long-term to the development of sublexical orthographic knowledge (H2). Considering that phonological recoding is a skill that develops mainly in the beginning of reading acquisition, we further expected the association to be stronger in earlier than in later grades.

H1 was tested by comparing two groups with different levels of phonological recoding (higher and lower). This hypothesis was corroborated. The higher recoding level group outperformed the lower one at the beginning and end of Grade 2 in both tasks of orthographic knowledge – lexical and sublexical. Moreover, as predicted, the performance on Orthographic Choice Task and Orthographic Awareness Task no longer differed between groups from Grade 3 onwards (end of Grade 3, beginning of Grade 4

and end of Grade 5). Therefore, the advantage attributable to the level of phonological recoding only occurs at a very early stage of reading acquisition.

Based on these data, we could establish that, as expected (Share, 1995; Ehri, 1992), phonological recoding is crucially associated with orthographic knowledge. This result is not surprising and is consistent with those reported in other studies (e.g., Share, 1999, 2004). The novelty is that we confirmed it using a procedure that allows us to distinguish between two levels of processing – lexical and sublexical. The Orthographic Choice Task requires access to an orthographic representation at the lexical level, whereas the Orthographic Awareness Task requires orthographic pattern knowledge and operates at some sublexical level. Thus, the present data introduce a new finding: the association between efficient phonological recoding and orthographic knowledge occurs at both processing levels (lexical and sublexical) and arises very early in reading development (in Grade 2). Interestingly, this association is no longer present at advanced levels of development, where we see a marked difference in performance between the two components of orthographic knowledge.

However, contrary to what we had expected, the association between phonological recoding and orthographic knowledge in the early stages of reading acquisition seems to be independent of the type of orthographic knowledge. Following Ehri (1992) and Share (1995), it would be more plausible to expect this association to be stronger, or even to occur only, between efficient phonological recoding and orthographic representations, i.e., repeated phonological recoding would primarily result in the establishment of lexical orthographic knowledge. Loveall, Channell, Phillips, and Conners (2013) supported this hypothesis with English-speaking children in Grades 2 and 3. In fact, they observed that, consistent with self-teaching studies, phonological recoding was related to orthographic knowledge, the relationship being stronger with lexical orthographic representations than with orthographic pattern knowledge. The discrepancy between those results and ours may have several explanations. Firstly,

Loveall et al.'s participants might not present the same level of recoding ability as ours. Our own results suggest that the relationship between recoding and the two tested types of orthographic knowledge depends on recoding ability. Secondly, that relationship may also depend on the characteristics of the orthographic code, particularly, its degree of transparency and, on the type and size of the orthographic patterns that are used for English and Portuguese.

Additionally and more importantly, the present study shows, at least for an orthographic code as semitransparent as that of Portuguese, that orthographic knowledge, in either of its components, dissociates from phonological recoding from Grade 3 onwards. As a matter of fact, it seems that once children reach a relatively efficient level of reading ability, phonological recoding is no longer crucial for the ongoing development of orthographic knowledge as it is for its establishment in the very beginning of reading acquisition. This was seen here regardless of the large developmental differences between the two types of orthographic knowledge. The increase of lexical orthographic knowledge occurred, in fact, at an accelerated rate, quickly reaching ceiling values, while the increase in sublexical orthographic knowledge was slow and residual.

Our second hypothesis was that the development of sublexical orthographic knowledge would be supported and influenced by the establishment of lexical orthographic knowledge, not the reverse. Additionally, we hypothesized that this relationship would be stronger in the early grades.

The present results tend to confirm this hypothesis. Consistent with our hypothesis, the results of the sequential regression analysis with autoregressive control showed that the performance on Orthographic Choice Task at the beginning of Grade 2 significantly contributed to the performance on Orthographic Awareness Task at the end of Grade 2 (8%). This outcome is consistent with previous theoretical accounts (e.g., Conrad, 2008) suggesting that, as soon as children acquire lexical orthographic

representations through practice with words, they begin to extract relevant orthographic patterns. However, in the cohort in question (C1), we also observed an effect, although weaker, in the reverse direction: performance on Orthographic Awareness Task at the beginning of Grade 2 significantly influenced the performance on Orthographic Choice Task at the end of Grade 2 (3%). This result suggests that sublexical orthographic knowledge contributed to the development of reliable orthographic representations, as theoretically advanced by Deacon and colleagues (Deacon et al., 2009). For the second and older cohort (C2), no significant contribution was observed in either direction. Thus, our results reveal a bidirectional relationship between both components of orthographic knowledge. Nevertheless, this mutual influence is limited to the early stages of reading acquisition (during Grade 2). Furthermore, this influence is apparently stronger from lexical orthographic knowledge to sublexical orthographic knowledge (8%) than in the reverse direction (3%).

In conclusion, both H1 and H2 were supported to a large extent. The results of the present study highlight the development of lexical and sublexical orthographic knowledge and their temporally circumscribed relationship with recoding ability. At an early stage of reading acquisition, efficient phonological recoding has a key role in the development of both components of orthographic knowledge. Moreover, lexical orthographic representations have a predictive effect on sublexical or pattern orthographic knowledge. Interestingly, a predictive, albeit weaker, effect in the opposite direction was also found.

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References

Anthony, J. L., & Francis, D. J. (2005). Development of phonological awareness. *Current Directions in Psychological Science*, *14*(5), 255-259. doi: 10.1111/j.0963-7214.2005.00376.x

Apel, K. (2011). What is orthographic knowledge?. *Language, Speech, and Hearing Services in Schools*, *42*(4), 592-603. doi: 10.1044/0161-1461(2011/10-0085)

Apel, K., Thomas-Tate, S., Wilson-Fowler, E. B., & Brimo, D. (2012). Acquisition of initial mental graphemic representations by children at risk for literacy development. *Applied Psycholinguistics*, *33*(02), 365-391. doi: 10.1017/S0142716411000403

Cassar, M., & Treiman, R. (1997). The beginnings of orthographic knowledge: Children's knowledge of double letters in words. *Journal of Educational Psychology*, *89*(4), 631-644. doi: 10.1037/0022-0663.89.4.631

Clark, W. C., Rutschmann, J., Link, R., & Brown, J. C. (1963). Comparison of flicker-fusion thresholds obtained by the methods of forced-choice and limits on psychiatric patients. *Perceptual and motor skills*, *16*(1), 19-30. doi: 10.2466/pms.1963.16.1.19

Cohen, J. (1983). The cost of dichotomization. *Applied Psychological Measurement, 7*(3), 249-253. doi: 10.1177/014662168300700301

Conrad, N. J. (2008). From reading to spelling and spelling to reading: transfer goes both ways. *Journal of Educational Psychology*, *100*(4), 869-878. doi: 10.1037/a0012544

Deacon, S. H., Wade-Woolley, L., & Kirby, J. R. (2009). Flexibility in young second-language learners: examining the language specificity of orthographic processing. *Journal of Research in Reading*, *32*(2), 215-229. 0.1111/j.1467-9817.2009.01392.x

Deacon, S. H., Benere, J., & Castles, A. (2012). Chicken or egg? Untangling the relationship between orthographic processing skill and reading accuracy. *Cognition*, *122*(1), 110-117. doi: 10.1016/j.cognition.2011.09.003

Deacon, S. H., Conrad, N., & Pacton, S. (2008). A statistical learning perspective on children's learning about graphotactic and morphological regularities in spelling. *Canadian Psychology/Psychologie Canadienne*, *49*(2), 118-124. doi: 10.1037/0708-5591.49.2.118

Padilla, E. R., Lugo, D. E., & Dunn, L. M. (1986). *Test de Vocabulario en Imágenes Peabody (TVIP)*. Circle Pines, MN: AGS.

Ehri, L. C. (1992). Reconceptualizing the development of sight word reading and its relationship to recoding. In P. Gough (Ed.), *Reading acquisition* (pp.107-143). Hillsdale, NJ: Erlbaum.

Robbins, C., & Ehri, L. C. (1994). Reading storybooks to kindergartners helps them learn new vocabulary words. *Journal of Educational Psychology*, *86*(1), 54-64. doi: 10.1037/0022-0663.86.1.54

Ehri, L. C. (1997). Learning to read and learning to spell are one and the same, almost. In C. Perfetti, L. Rieben & M. Fayol (Eds.), *Learning to spell: Research, theory, and practice across languages* (pp. 237-268). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Fernandes, S., Ventura, P., Querido, L., & Morais, J. (2008). Reading and spelling acquisition in European Portuguese: A preliminary study. *Reading and Writing*, *21*(8), 805-821. doi: 10.1007/s11145-007-9093-7

Frith, U. (1980). Unexpected spelling problems. In U. Frith (Ed.), *Cognitive processes in spelling* (pp.495-515). London: Academic Press.

Hayes, H., Treiman, R., & Kessler, B. (2006). Children use vowels to help them spell consonants. *Journal of Experimental Child Psychology*, *94*(1), 27-42. doi: 10.1016/j.jecp.2005.11.001

Jenkins, J. R., Stein, M. L., & Wysocki, K. (1984). Learning vocabulary through reading. *American Educational Research Journal*, *21*(4), 767-787. doi: 10.3102/00028312021004767

Kenny, D. A. (1975). Cross-lagged panel correlation: A test for spuriousness. *Psychological Bulletin*, *82*(6), 887-903. doi: 10.1037/0033-2909.82.6.887

Loveall, S. J., Channell, M. M., Phillips, B. A., & Conners, F. A. (2013). Phonological recoding, rapid automatized naming, and orthographic knowledge. *Journal of Experimental Child Psychology*, *116*(3), 738-746. doi: 10.1016/j.jecp.2013.05.009

MacCallum, R. C., Zhang, S., Preacher, K. J., & Rucker, D. D. (2002). On the practice of dichotomization of quantitative variables. *Psychological methods*, *7*(1), 19-40. doi: 10.1037/1082-989X.7.1.19

Morais, J., Alegria, J., & Content, A. (1987). The relationships between segmental analysis and alphabetic literacy: an interactive view. *Cahiers de Psychologie Cognitive*, 7, 415-443.

National Reading Panel (US), National Institute of Child Health, & Human Development (US). (2000). *Report of the national reading panel: Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction: Reports of the subgroups*. National Institute of Child Health and Human Development, National Institutes of Health.

Olson, R. K., Forsberg, H., Wise, B., & Rack, J. (1994). Measurement of word recognition, orthographic, and phonological skills. In G. R. Lyon (Ed.), *Frames of reference for the assessment of learning disabilities: New views on measurement issues* (pp. 243–277). Baltimore, MD: Brookes.

Ouellette G., & Sénéchal M. (2008). Pathways to literacy: a study of invented spelling and its role in learning to read. *Child Development, 79*, 899–913. doi: 10.1111/j.1467-8624.2008.01166.x

Ozuru, Y., Dempsey, K., & McNamara, D. S. (2009). Prior knowledge, reading skill, and text cohesion in the comprehension of science texts. *Learning and instruction*, *19*(3), 228-242. doi: 10.1016/j.learninstruc.2008.04.003

Pacton, S., Sobaco, A., Fayol, M., & Treiman, R. (2013). How does graphotactic knowledge influence children's learning of new spellings? *Frontiers in Psychology*, *4*, 1-10. doi: 10.3389/fpsyg.2013.00701

Share, D. L. (1995). Phonological recoding and self-teaching: sine qua non of reading acquisition. *Cognition*, *55*(2), 151-218. doi: 10.1016/0010-0277(94)00645-2

Share, D. L. (1999). Phonological recoding and orthographic learning: A direct test of the self-teaching hypothesis. *Journal of Experimental Child Psychology*, *72*(2), 95-129. doi: 10.1006/jecp.1998.2481

Share, D. L. (2004). Orthographic learning at a glance: On the time course and developmental onset of self-teaching. *Journal of Experimental Child Psychology*, *87*(4), 267-298. doi: 10.1016/j.jecp.2004.01.001

Simões, M.R. (1994). *Investigações no âmbito da aferição nacional do teste das Matrizes Progressivas Coloridas de Raven (M.P.C.R.)*. Dissertação de Doutoramento. Coimbra: Universidade de Coimbra.

Stanovich, K. E., & Siegel, L. S. (1994). Phenotypic performance profile of children with reading disabilities: A regression-based test of the phonological-core variable-difference model. *Journal of Educational Psychology*, *86*(1), 24-53. doi: 10.1037/0022-0663.86.1.24

Stanovich, K. E., Feeman, D. J., & Cunningham, A. E. (1983). The development of the relation between letter-naming speed and reading ability. *Bulletin of the Psychonomic Society*, *21*(3), 199-202. doi: 10.3758/BF03334686

Stanovich, K. E., West, R. F., & Cunningham, A. E. (1991). Beyond phonological processes: Print exposure and orthographic processing. *Phonological processes in literacy: A tribute to Isabelle Y. Liberman*, 219-235.

Treiman, R., & Kessler, B. (2006). Spelling as statistical learning: Using consonantal context to spell vowels. *Journal of Educational Psychology*, *98*(3), 642-652. doi: 10.1037/0022-0663.98.3.642

Treiman, R. (1993). *Beginning to spell: A study of first-grade children*. New York: Oxford University Press.

Wolter, J. A., & Apel, K. (2010). Initial acquisition of mental graphemic representations in children with language impairment. *Journal of Speech, Language, and Hearing Research*, *53*(1), 179-195. doi: 10.1044/1092-4388(2009/07-0130)

Appendix A

Appendix A - Summary of Sequential Regression Analysis (SRA) for the study of long-term bidirectional effects between lexical and sublexical orthographic knowledge.

Table A1

Summary of Sequential Regression Analysis (SRA) for the study of long-term effect of lexical orthographic knowledge (LOK) on sublexical orthographic knowledge (SUBLOK) in cohort 1

		Summary of statistics from LOK at beginning of Grade 2 to SUBLOK at end of Grade 2 as dependent variable						Summary of statistics from LOK at beginning of Grade 2 to SUBLOK at end of Grade 3 as dependent variable						Summary of statistics from LOK at end of Grade 2 to SUBLOK at end of Grade 3 as dependent variable			
		R^2	Δ R^2	ΔF	β			R^2	Δ R^2	ΔF	β			R^2	Δ R^2	ΔF	β
Step	**IV**					**Step**	**IV**					**Step**	**IV**				
	A				.03		A				-.24		A				-.22
1	M	.01	.01	0.21	-.05	1	M	.07	.07	1.53	-.12	1	M	.07	.07	1.55	-.09
	V				-.09		V				.00		V				.07
2	PA	.01	.00	0.06	-.09	2	PA	.07	.00	.15	.00	2	PA	.08	.01	.54	.16
3	SUBLOK	.04	.03	2.26	.11	3	SUBLOK	.08	.01	.33	.10	3	SUBLOK	.08	.00	.02	.05
4	LOK	.13	.08	6.26*	.33	4	LOK	.09	.01	.91	-.13	4	LOK	.11	.03	2.00	-.20

Note. IV = Independent variables; A = Age; M = Matrices; V = Vocabulary; PA = Phonemic Awareness; LOK= Lexical orthographic knowledge; SUBLOK = Sublexical orthographic knowledge.

* p ≤ .05

Table A2

Summary of Sequential Regression Analysis (SRA) for the study of long-term effect of sublexical orthographic knowledge (SUBLOK) on lexical orthographic knowledge (LOK) in cohort 1

		Summary of statistics from SUBLOK at beginning of Grade 2to LOK at end of Grade 2 As dependent variable						Summary of statistics from SUBLOK at beginning of Grade 2 to LOK at end of Grade 3 as dependent variable						Summary of statistics from SUBLOK at end of Grade 2 to LOK at end of Grade 3 as dependent variable			
		R^2	Δ R^2	ΔF	β			R^2	Δ R^2	ΔF	β			R^2	Δ R^2	ΔF	β
Step	**IV**					**Step**	**IV**					**Step**	**IV**				
	A				.06		A				-.07		A				-.17
1	M	.11	.11	2.93*	.04	1	M	.09	.09	2.06	.21	1	M	.09	.09	2.14	.23
	V				.20		V				-.09		V				-.19
2	PA	.24	.12	11.28***	.18	2	PA	.13	.05	3.49	.09	2	PA	.11	.02	1.57	-.04
3	SUBLOK	.53	.29	42.10****	.54	3	SUBLOK	.26	.13	11.17***	.41	3	SUBLOK	.30	.19	18.01****	.51
4	LOK	.56	.03	4.63*	.19	4	LOK	.28	.02	1.38	-.13	4	LOK	.30	.00	.00	.00

Note. IV = Independent variables; A = Age; M = Matrices; V = Vocabulary; PA = Phonemic Awareness; LOK= Lexical orthographic knowledge; SUBLOK = Sublexical orthographic knowledge.

**** p < .0001; *** p ≤ .001; ** p ≤ .01; * p ≤ .05;

Table A3

Summary of Sequential Regression Analysis (SRA) for the study of long-term effect of lexical orthographic knowledge (LOK) on sublexical orthographic knowledge (SUBLOK) in cohort 2

		Summary of statistics from LOK at beginning of Grade 4 to SUBLOK at end of Grade 5 As dependent variable			
		R^2	ΔR^2	ΔF	β
Step	**IV**				
	A				-.04
1	M	.02	.02	.55	.14
	V				-.04
2	PA	.04	.02	1.27	-.16
3	SUBLOK	.05	.01	.79	.09
4	LOK	.10	.05	3.28	.23

Note. IV = Independent variables; A = Age; M = Matrices; V = vocabulary; PA = Phonemic Awareness; LOK= Lexical orthographic knowledge; SUBLOK = Sublexical orthographic knowledge.

Table A4

Summary of Sequential Regression Analysis (SRA) for the study of long-term effect of sublexical orthographic knowledge (SUBLOK) on lexical orthographic knowledge (LOK) in cohort 2

		Summary of statistics from SUBLOK at beginning of Grade 4 to LOK at end of Grade 5 As dependent variable			
		R^2	ΔR^2	ΔF	β
Step	**IV**				
	A				.06
1	M	.03	.03	.56	-.17
	V				-.07
2	PA	.03	.00	.08	-.08
3	SUBLOK	.30	.28	24.30****	.55
4	LOK	.30	.00	.01	-.01

Note. IV = Independent variables; A = Age; M = Matrices; V = vocabulary; PA = Phonemic Awareness; LOK= Lexical orthographic knowledge; SUBLOK = Sublexical orthographic knowledge.

**** $p < .0001$

.0001; *** $p \leq .001$; ** $p \leq .01$; * $p \leq .05$

CAPÍTULO 3

Does orthographic knowledge influence reading and spelling acquisition? A longitudinal study.

Does orthographic knowledge influence reading and spelling acquisition? A longitudinal study [1].

Abstract

Orthographic knowledge is one of several contributors to reading and spelling performance. However, empirical research is unclear concerning a long-lasting contribution of orthographic knowledge to reading and spelling development. This study aimed to examine if both lexical and sublexical levels of reading and spelling benefit from a longitudinal influence of the same levels of orthographic knowledge. We investigated this question in a longitudinal study with two cohorts of Portuguese children from Grade 2 to Grade 5. We used common measures of orthographic knowledge, reading and spelling, all at the lexical and sublexical level, as well as controls of vocabulary, nonverbal intellectual ability and phonemic awareness. Using regression analysis, the current study shows a longitudinal separate and unique contribution from lexical and sublexical orthographic knowledge to both reading and spelling abilities. Our results suggest that, between Grades 2 and 5, specific orthographic knowledge is useful to read and spell familiar as well unknown words; and orthographic pattern knowledge is important to read and spell unknown words. Thus, this data illustrate the importance of orthographic knowledge for the development of reading and spelling skills.

Keywords: orthographic knowledge; lexical; sublexical; reading; spelling; longitudinal analysis.

[1] Manuscrito em preparação.

Introduction

The ability of accessing and manipulating speech sounds, which involves phonological awareness, is one of the factors that appear to best determine and predict reading and spelling acquisition (Anthony & Francis, 2005; Deacon, Benere, & Castles, 2012; Morais, Alegria, & Content, 1987; Nation & Hulme, 1997; National Reading Panel, 2000). Other factors, such as letter knowledge, vocabulary and verbal short-term memory (e.g., Sprenger –Charolles et al., 2003), are also known to influence reading and spelling acquisition, and, recently, several studies investigated the role of orthographic knowledge (e.g., Conners, Loveall, Moore, Hulme, & Maddox, 2011; Conrad et al., 2013; Deacon et al., 2012; Loveall et al., 2013; Rothe, Schulte-Körne, & Ise, 2013). In the present study, we attempted to examine independently two types of orthographic knowledge, relative to the reading and spelling of either the word or its constituents.

Many researchers use orthographic knowledge to designate the mental representations of the words' spelling in long term memory (e.g., Frith, 1980; Treiman, 1993). The classic *Orthographic Choice Task* (Olson, Forsberg, Wise, & Rack, 1994), in which children are asked to choose between two possible phonological alternatives (e.g., *rain-rane*), requires this type of knowledge. However, stored word orthographic representation is only but one component of orthographic knowledge. Indeed, another component is the knowledge of the sublexical letter chunks operant within a language's orthography, including the permissible combinations of adjacent letters; for example, while *-ld-* is a legal sequence in European Portuguese, found in "calda" (syrup), "molde" (mold), etc., *-dl-* is illegal – the corresponding phonetic form exists but it is always spelled with an intermediate silent "e" (Apel, 2011) . The *Wordlikeness Choice*

Task, in which participants have to choose, among two or more non-words, the one that most resembles a word (Stanovich & Siegel, 1994) focuses on the sublexical letter patterns consistent with the rules of the language's orthographic code. Thus, both lexical and sublexical orthographic representations are part of orthographic knowledge, yet acting at different levels and, while the former type of knowledge is conscious, the latter is not necessarily so.

Some recent studies aimed to examine the relationship between these components of orthographic knowledge and reading and spelling acquisition (e.g., Deacon et al., 2012; Rothe et al., 2013).

A first line of research was based on the theoretical assumption that, in children, repeated phonological recoding (Share, 1995, 1999) leads to the acquisition of the orthography of words. Based on this self-teaching hypothesis, Conners and colleagues (Conners et al., 2011) examined, on children in Grades 2 and 3, the mediating role of orthographic knowledge in the relation between phonological recoding (measured from pseudoword reading) and word identification (measured from word reading). They showed that children with better phonological recoding skill acquire a greater orthographic knowledge, being, in turn, better in word identification. They also found that the two components of orthographic knowledge – sublexical and lexical – mediate separately the relation between phonological recoding and word identification. In another study with the same participants, Loveall, Channell, Phillips and Conners (2013) examined whether phonological recoding differently relates to the two components of orthographic knowledge. In this respect, the authors found that phonological recoding is more closely related to word-specific orthographic knowledge (15% of explained variance) than to general orthographic knowledge (9% of explained variance). Thereby, phonological recoding seems to be an important skill that leads to

acquisition of knowledge of exact orthographic structure of specific words and also helps children to acquire generalized orthographic knowledge.

In sum, the results of these two non-longitudinal studies (Conners et al., 2011, Loveall et al., 2013) suggest that children with stronger phonological recoding skills have better orthographic knowledge, in particular they might develop a greater accumulation of word-specific rather than general orthographic knowledge, and that, in turn, leads to better word identification.

Another important line of research concerns not only the influence from orthographic knowledge on reading and spelling acquisition but also, although less studied, the relationship between the two components of orthographic knowledge (at lexical and sublexical level) and reading and spelling.

The influence of orthographic pattern knowledge, at sublexical level, on reading and spelling has been examined at same time of test (e.g., Rothe et al., 2013) and longitudinally (e.g., Ise, Arnoldi, & Schulte-Korne, 2014). Rothe and colleagues (Rothe et al., 2013) tested the relationship between the sensitivity to orthographic regularities (at sublexical level) measured with a nonword forced choice task and reading and spelling performance (at lexical level) in German-speaking children. Their results showed that, at the end of first grade, the sensitivity to orthographic regularities explained a significant amount of variance in reading (11%) and spelling (7%) performance. Contrary, with a longitudinal design, Ise at al. (2014) found no systematic relationship between orthographic knowledge at sublexical level and both reading and spelling children's performance from kindergarten to second grade. The authors suggests that this result is consistent with the view that children in transparent orthographies rely less on frequent letter patterns during reading and spelling compared to children in deep orthographies.

In a three –year longitudinal study with English children from Grades 1 to 3, Deacon and colleagues (Deacon et al., 2012) explored the bidirectional relationship between each component of orthographic knowledge and word reading accuracy. They found that word reading predicted orthographic knowledge either at sublexical or lexical level. However, no contribution was observed in the reverse way, i.e., from the orthographic knowledge to word reading. According to the authors, children acquire orthographic knowledge through their reading practice; nevertheless, this knowledge does not play an independent role in supporting reading acquisition.

Although Deacon and colleagues (Deacon et al., 2012) did not find any influence of the components of orthographic knowledge on word reading (lexical level of processing), we consider that orthographic knowledge might possibly influence reading and spelling acquisition. Conceivably, the use of a pseudoword reading/spelling task (assessing reading and spelling skills at a sublexical level) would reveal an influence of orthographic knowledge. In addition, the relationship between reading / spelling and orthographic knowledge could vary depending on the time interval between tests and the developmental phase of reading and spelling acquisition. In their study, Deacon and colleagues (Deacon et al., 2012) had a range of influence between variables of one or two years (from the 1st to 2nd or 3rd and from the 2nd to 3rd). Possibly the influence of orthographic knowledge on reading failed to survive such a long time.

In a different way, Conrad and colleagues (Conrad, Harris, & Williams, 2013) examined the contribution of orthographic knowledge, as a multi-dimensional construct (consisting of both word-specific and general orthographic knowledge), to reading and spelling skill, concurrently (at same time of test), in English-speaking children aged between 7 and 8 years. The authors observed that both types of orthographic knowledge contribute uniquely and separately to both reading and spelling.

It is worth noting that, in a concurrent study, Conrad and colleagues (Conrad et al., 2013) observed a contribution of orthographic knowledge both for reading (12%) and spelling (15%). Furthermore, they observed a higher level of contribution of the lexical orthographic knowledge in comparison to the sublexical one either for word reading (β = .33 and β = .22 for lexical and sublexical orthographic knowledge, respectively) or word spelling (β = .32 and β = .29 for lexical and sublexical orthographic knowledge, respectively).

To summarize, it has been shown that phonological recoding concurrently contributes to both components of orthographic knowledge - sublexical and lexical (Conners et al., 2011; Loveall et al., 2013); moreover, each component appears to uniquely contribute to both reading and spelling (e.g., Conrad et al., 2013). However, in longitudinal studies, orthographic knowledge do not predict neither reading (Deacon et al., 2012; Ise et al., 2014) or spelling (Ise et al., 2014) although it is acquired through reading ability.

In this way, most of the studies examined the contribution of phonological recoding, a sublexical level of processing, to orthographic knowledge, at sublexical and lexical levels. Nonetheless, few studies examined the contribution of the sublexical, lexical or both levels of orthographic knowledge to word reading or spelling (at lexical level of processing).

A final missing piece of the puzzle is that none of these studies tested the relationship longitudinally in a way allowing to examine the contribution of sublexical and lexical components of orthographic knowledge to sublexical and lexical levels of reading and spelling skills.

Although there is evidence that both the lexical and sublexical components of orthographic knowledge are related with reading and spelling skills, the relationship

between the sublexical and lexical levels of orthographic knowledge and the same levels of reading and spelling skills, and how this relationship would change throughout development remain to be investigated. The main aim of present study was to explore this issue.

In our study we used two of the most common measures of orthographic processing skill – Orthographic Choice Task and an Orthographic Awareness Task – each at a different level of processing – lexical and sublexical, respectively. We also assessed reading and spelling skills through a set of Word and Pseudoword Reading and Spelling Tasks (similar to those used in Fernandes et al., 2008) that also reflected lexical and sublexical processing.

We tested one hypothesis concerning the developmental relationships between these two levels of orthographic knowledge and reading and spelling skills.

According to literature (e.g., Conrad et al., 2013), both lexical and sublexical components of orthographic knowledge are related with reading and spelling, at least concurrently. In accordance with theoretical models of reading (Ehri, 1997; Share, 1995), phonological recoding improves orthographic knowledge with an impact on both its components, i.e., at the lexical and sublexical level. Furthermore, still according to Ehri (2005, see Figure 1), lexical orthographic knowledge (word specific) supports sight word reading - children read and spell familiar words directly from word specific representations stored in memory. Unknown words could also be read and spell using analogies to stored words in memory. Moreover, sublexical orthographic knowledge could be useful to read and spell familiar and unknown words supplying expectations and constrains (Ehri, 2005) about how a word could be read or spelled accordingly with knowledge of recurring letter patterns. This knowledge of recurrent letter patterns could

be used to remember specific words by forming connections, contributing in this way to the establishment of lexical orthographic knowledge (Conrad, 2013).

Based on this theoretical assumption, our hypothesis is founded on the view that orthographic knowledge supports the development of reading and spelling acquisition. We expected to observe predictive effects of each level of orthographic knowledge to both levels of reading and spelling abilities. We thus expected to observe predictive effects of orthographic representations (at a lexical processing level) on word reading and spelling (also at a lexical processing level), and from orthographic pattern knowledge (at a sublexical processing level) on pseudoword reading and spelling (at a sublexical processing level). Cross predictive effects from the orthographic knowledge at lexical level on reading and spelling at sublexical level or from orthographic knowledge at sublexical level on reading and spelling at lexical level, are also expected.

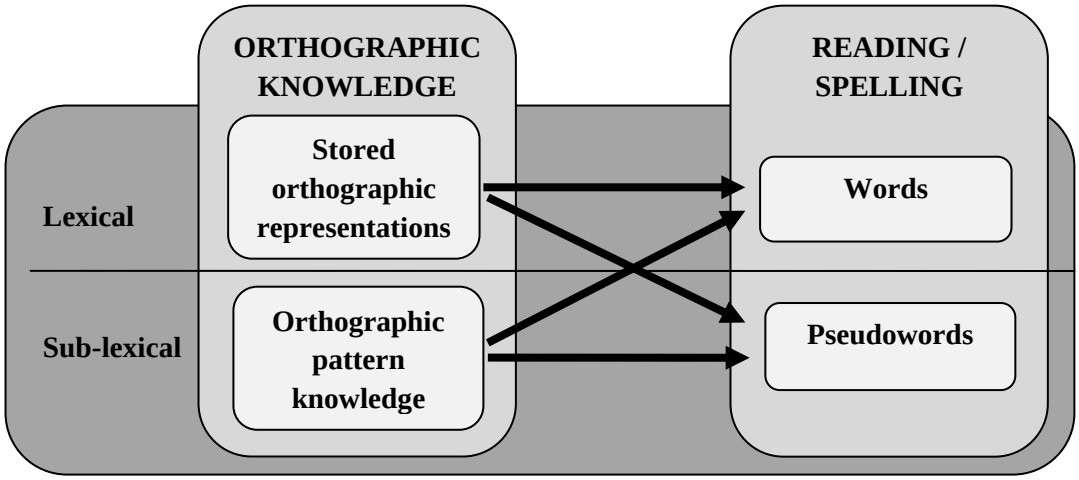

Figure 1. Schematic representation of the relationships between orthographic knowledge and reading and spelling (based on Ehri, 2005).

We examined long-term effects using cross-lag Sequential Regression Analyses (SRA) with autoregressive controls. The inclusion of an autoregressive control allows for the extraction of a variable's unique effect at an earlier time on another at a later

time by subtracting the immediate effect between the two at the earlier time. This methodology has been used in developmental research to establish a bidirectional relationship between two variables (e.g., Deacon, Benere, & Castles, 2012). We also incorporated several control variables before the autoregressive control (e.g., non-verbal reasoning and vocabulary) to reduce the possibility that any effects be due to a spurious third variable (see Kenny, 1975). Phonemic awareness was also included in the analysis to control for the effects of phonological skills when determining whether orthographic knowledge contribute uniquely to reading and spelling skills. This ability has been used elsewhere to demonstrate the unique effect of orthographic knowledge on both reading (e.g., Stanovich, West, & Cunningham, 1991) and spelling (e.g., Ouellette & Senechal, 2009).

The influence of orthographic knowledge on reading and spelling was examined in two longitudinal Cohorts of students from Grade 2 to Grade 5. Students tested at the beginning of Grade 2 were tested again twice, at the end of Grade 2 and at the beginning of Grade 3, and students tested at the beginning of Grade 4 were tested again at the end of Grades 4 and 5.

Method

Participants

A total of 170 children from two public schools in the Lisbon district participated in the study. Two Cohorts were tested in three testing periods: (i) in the initial three months of the school year in one grade; (ii) in the final three months of that same school year; (iii) in the last three months of the subsequent grade. Cohort 1 (83 children, of whom 37 girls) was tested in Grades 2 and 3; Cohort 2 (87 children, of whom 46 girls), in Grades 4 and 5. Depending on the specific test, for Cohort 1 a minimum of 75 and 78 children participated in testing periods 2 and 3, respectively; for Cohort 2, a minimum of 79 and 69 children were participants.

Students came from two different classrooms per grade in each school. They were all native speakers of European Portuguese and had an average or above average cognitive functioning – 25th percentile or higher on the Raven's Coloured Progressive Matrices (Simões, 1994). Children flagged by their parents or teachers as having learning, emotional, or sensory disabilities were not included in the sample. These screening criteria determined the ineligibility of 15 and 13 children from Cohort 1 and 2, respectively. Data on educational background from a questionnaire answered by the children's parents (accounting for 74.3% of the participants) indicated only 6.4% of fathers and 4.7% of mothers with less than a high school diploma, 11.7% of parents with high school graduation, 38.6% of fathers and 48.5% of mothers with university degrees, and, additionally, 9.9% of fathers and 7.6% of mothers with post-graduate education (including 2.9% of fathers and 2.3% of mothers with a PhD). Only one father (and no mother) was reported as unemployed. Our sample is thus not representative of the Portuguese population on the whole, but overwhelmingly constituted by children from middle and upper middle class families.

Tests[5]

(a) Verbal and nonverbal abilities

Vocabulary Peabody picture test (VPPT)

The first author adapted the VPPT from the Spanish version (Dunn, Padilla, Lugo, & Dunn, 1986). Four pictures with different meanings are presented per item and the participant is required to point to the picture that corresponds to a given spoken word. The test was administered to Cohort 1 and 2 at beginning of Grades 2 and 4 respectively.

Raven's colored progressive matrices

The Portuguese adaptation of the Raven's Colored Progressive Matrices (Simões, 1994) was used to measure general nonverbal intellectual ability. It was administered to both Cohorts at beginning of Grades 2 and 4.

(b) Phonemic Awareness (PA).

We used a Phoneme Deletion Test where children were asked to say aloud the phonological segment obtained after deleting the initial phoneme of a monosyllabic pseudoword. Ten CCV stimuli (e.g., *blu* and *fla*) were presented over headphones. Experimental items were preceded by three familiarization trials, which could be re-administered if the child failed to understand the task, or asked the experimenter to repeat any part of the instruction. Stimuli presentation was controlled by E- Prime 1.1 (Schneider, Eschman, & Zuccolotto, 2002a, b) running on a Pentium PC.

This test was administered to both Cohorts at beginning of Grades 2 and 4.

[5]All of the tests considered in this study were developed and administered to the participants as part of the project "Developmental benchmarks of reading and writing in European Portuguese from the 1st to 6th grades" (2008-2010), which was conducted under the auspices of the National Reading Plan.

(c) Reading aloud and spelling tasks.

Stimuli

Three word categories were used: simple regular (n = 12), complex regular (n = 12), and irregular words (n = 12). Each category contained 6 high frequency words and 6 low frequency words. Words were selected from Portulex, a lexical and frequency database for European Portuguese (Teixeira & Castro, 2007). High and low frequency words were roughly matched on number of syllables in oral pronunciation, more precisely, for high frequency words there were six disyllabic words and twelve trisyllabic words; and for low frequency words there were five disyllabic words and thirteen trisyllabic.

A word was defined as regular when its letter sequence was in accordance with the rules of Portuguese grapheme–phoneme and phoneme–grapheme correspondences. A word was defined as irregular when its letter sequence was not completely in accordance with these rules. Following Sprenger-Charolles et al.'s (1998) and Fernandes al.'s (2008) criteria, the irregular words chosen contained either a grapheme whose phonetic realization is unusual (for example, in "trânsito" the "s" is pronounced /z/ in only 25 words out of 125, according to the Portuguese database "Porlex" (Gomes & Castro, 2003), or a silent grapheme in a non-terminal position (e.g., "h" in hora).

An item was considered simple when each of its graphemes corresponded to one letter only (e.g., fita). It was considered complex if one of its graphemes contained more than one letter. Two types of digraphs were used: a vocalic digraph ou and four consonantal digraphs, nh, lh, ch and rr. These digraphs were selected because (i) either alternative spelling, although less frequent, exists for them (as is the case of ou and ch), or

(ii) there is no alternative spelling (as is the case of nh and lh). Other than this, these digraphs pose no more difficulties in spelling than in reading.

Pseudowords were constructed from simple and complex regular words by modifying the initial consonant letter and other letters of the high frequency words in a way that made it impossible to find the word from which they were derived. Simple and complex pseudowords shared the number of syllables in oral pronunciation, two disyllabic and four trisyllabic items. For the complex pseudowords, we selected one for each type of digraph, ou, nh, lh, rr, and ch, the latter occurring in two items - in a initial position or in a medial position - totaling thus six complex pseudowords in total. In order to make the cells of the design equivalent we also selected six simple pseudowords.

Reading and spelling tests were administered to Cohort 1 at the beginning and end of Grade 2 and at beginning of Grade 3, and to Cohort 2 at the beginning of Grade 4 and at the end of Grade 4 and 5.

Reading aloud task

Each child was asked to read aloud the best as they could each item when it appeared on a computer monitor. For the pseudowords, children were informed that the words that would appear did not exist but could be read. The items were written in a font type (Arial 48) similar to the one most frequently used in school manuals. Responses were recorded during the test session enabling a posterior analysis of the reading errors. There were three familiarization trials for words and three for pseudowords (presented separately), which could be re-administered if the child failed to understand the instructions. Each item was displayed on the computer screen for a period no longer than 5 s. Two lists were presented: one including a total of 36 words, the other including a total of 12 pseudowords. Within each list, item presentation was random. In the reading task, the word list was presented first (cf. Sprenger-Charolles et al., 1998). The pseudoword list was presented one week after the word list to avoid risk of priming. All items for each task, including those for familiarization, were presented

without any feedback. Stimuli presentation was controlled by E- Prime 1.1 (Schneider, Eschman, & Zuccolotto, 2002a, b) running on a Pentium PC.

Spelling task

Items used in this task were the same as those used in the reading task. Both word and pseudoword lists were presented separately in two different randomized orders.

The word-spelling task was applied one week after the word-reading task to prevent recollection of the words previously read. The pseudoword-spelling task was also applied after the pseudoword-reading task, in this case with at least one- day interval. As in the reading task, there were three familiarization trials for words and three for pseudowords (presented separately), which could be re-administered if the child failed to understand the instructions. Given that pseudowords cannot be presented in a sentence context, we dictated them twice. Words were first read in a sentence context and later dictated in isolation; this was done to avoid the possibility of confusion between homophones.

(d) Orthographic Knowledge.

Two tasks were used, one involving an orthographic choice, the other examining orthographic awareness. Both were administered to Cohort 1 and to Cohort 2 in period 1 at beginning of Grade 2 and 4, respectively.

Orthographic Choice Task.

In the Orthographic Choice Task, children were shown 32 sets of five stimuli (e.g., *braço – brasso – draço – braco – arbço*). Only one member of each set correctly matched a listened target word (e.g., *braço*). The other members corresponded to one pseudo-homophone foil (e.g., *brasso*); a word or pseudoword with a visual similarity in the first syllable (e.g., *draço*); a word or pseudoword with a visual similarity in the last syllable (e.g., *braco*); and a non-word that combined the letters of the target word in an illegal sequence for European Portuguese (e.g., *arbço*). In each set, stimuli were randomly presented in a centred column of an A5 sheet. The task was to select the member of each set that "matched" the heard word.

Orthographic Awareness Task.

In the Orthographic Awareness Task, children were shown 14 pairs of pronounceable pseudowords (e.g., *prula – rulap* and *drulo – srulo*). One member of each pair contained a string that never occurs in European Portuguese in the initial (e.g., *srulo*) or final (e.g., *rinot*) position; the other member of the pair contained an orthographically legal string in the same position. The task was to select the member of each pair that "could be a word" or "looks like a word".

General procedure

The Vocabulary Peabody Picture, Phonemic Awareness, and Reading Aloud tests were administered to each child individually by a trained graduate student. They took place in a quiet setting provided by the school and were conducted in separate sessions. The Raven's Colored Progressive Matrices, the Orthographic Knowledge, and the Spelling tests were administered also in different sessions by a trained graduate student, but to large groups of participants.

Results

Descriptive statistics are presented in Table 1. The means for VPPT are at or slightly above the norms (we used the Spanish population norms; see Dunn, Padilla, Lugo, & Dunn, 1986) according to the test manuals for each age group. For both orthographic tasks, accuracy scores were expressed as proportion of correct responses and as chance-corrected proportion[6] (.50 and .20, respectively, for the Orthographic Choice Task and Orthographic Awareness Task).

A summary of concurrent and longitudinal correlations between measures is presented in Tables 2 (Cohort 1) and 3 (Cohort 2).

Table 1

Means and standard deviations for correct responses in the various tests for each Cohort of students by testing period

	Cohort 1						Cohort 2					
	Grade 2				Grade 3		Grade 4				Grade 5	
	N= 83				N= 83		N= 87				N= 74	
	Beginning		End		Beginning		Beginning		End		End	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Matrices[a]	28.95	4.16					33.08	2.37				
Peabody Vocabulary[b]	125.31	10.62					124.64	11.96				
Phoneme Deletion (accuracy)	.66	.31					.87	.22				
Word Reading Task (accuracy)	.87	.11	.93	.06	.91	.09	.90	.09	.94	.05	.96	.06
Pseudoword Reading Task (accuracy)	.85	.17	.90	.11	.80	.16	.74	.16	.84	.12	.82	.14
Word Spelling Task (accuracy)	.63	.15	.79	.13	.81	.12	.82	.12	.89	.13	.89	.08
Pseudoword Spelling Task (accuracy)	.60	.18	.60	.17	.75	.18	.69	.17	.68	.17	.68	.15
Orthographic Choice Task[c] (accuracy)	.71	.17					.88	.10				
Corrected values	.64	.21					.85	.13				
Orthographic Awareness Task[d] (accuracy)	.76	.16					.78	.15				
Corrected values	.53	.31					.57	.30				

Note. 1) **Beginning** = November-January; **End** = April-June; 2) **accuracy** = mean proportion of correct responses; [a] Mean of correct responses in a total of 36; [b] Standardized results; [c] Chance level for complete test was .20; [d] Chance level for complete test was .50; the means and standard deviations presented in each cell of the table were calculated for all participants who accomplished the task.

[6] The data for each forced-choice task (Orthographic Choice Task and Orthographic Awareness Task) were the proportion of chance-corrected successful detections. The chance level was different for each task (.20 and .50, for Orthographic choice and Orthographic awareness, respectively), and the compensation for chance success was accomplished using the formula $p = (p' - c) / (1 - c)$, where p = the corrected detection proportion; p' = the raw proportion; and c = the probability of being correct by chance (e.g., Clark, Rutschmann, Link, & Brown, 1963).

Table 2

Correlation Matrix for all measures in Cohort 1.

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Matrices	1	.17	.17	.22	.01	.21	.02	.35**	.03	.12	.12	.17	-.01	.19	.07	.26*	-.03
2	Peabody Vocabulary at beginning of Grade 2		1	.04	.11	-.08	.12	-.08	.18	-.06	.23*	.02	.18	.01	.12	.05	.33**	.21
3	Phonemic Awareness accuracy at beginning of Grade 2			1	.35**	.08	.32**	.18	.40**	.23*	.29*	.26*	.44**	.23*	.43**	.14	.45**	.13
4	Orthographic Choice Task at beginning of Grade 2				1	.17	.49**	.14	.63**	.14	.48**	.32**	.61**	.01	.59**	.26*	.52**	.31**
5	Orthographic Awareness Task at beginning of Grade 2					1	.10	.18	.23*	.17	.03	.19	.22*	.04	.09	.08	.12	.37**
6	Word Reading Accuracy at beginning of Grade 2						1	.51**	.49**	.29**	.69**	.32**	.57**	.23*	.65**	.34**	.63**	.12
7	Pseudoword Reading Accuracy at beginning of Grade 2							1	.29**	.06	.36**	.46**	.29**	.24*	.29*	.38**	.42**	.09
8	Word Spelling Accuracy at beginning of Grade 2								1	.39**	.49**	.42**	.67**	-.01	.47**	.34**	.68**	.40**
9	Pseudoword Spelling Accuracy at beginning of Grade 2									1	.24*	.17	.24*	.09	.37**	.16	.41**	.19
10	Word Reading Accuracy at end of Grade 2										1	.42**	.58**	.06	.63**	.35**	.65**	.14
11	Pseudoword Reading Accuracy at end of Grade 2											1	.40**	.21	.49**	.41**	.45**	.26*
12	Word Spelling Accuracy at end of Grade 2												1	.15	.54**	.26*	.71**	.38**
13	Pseudoword Spelling Accuracy at end of Grade 2													1	.15	.10	.05	.06
14	Word Reading Accuracy at beginning of Grade 3													.	1	.42**	.66**	.26*
15	Pseudoword Reading Accuracy at beginning of Grade 3															1	.29*	.21
16	Word Spelling Accuracy at beginning of Grade 3																1	.30**
17	Pseudoword Spelling Accuracy at beginning of Grade 3																	1

* p < .05 ** p < .01

Table 3

Correlation Matrix for all measures in Cohort 2.

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Matrices	1	.26*	.14	.23*	-.07	.07	.16	.18	.20	.01	-.03	.18	-.04	.30**	.29*	.07	.23*
2	Peabody Vocabulary at beginning of Grade 4		1	.15	.20	.01	.30**	.14	.40**	.21	.31**	.13	.26*	.11	.25*	.34**	.13	.36**
3	Phonemic Awareness accuracy at beginning of Grade 4			1	.19	-.04	.23	.17	.24*	-.03	.12	.23	.23*	.21	.01	.09	.14	.16
4	Orthographic Choice Task at beginning of Grade 4				1	.04	.36**	.37**	.56**	.25*	.42**	.03	.56**	.07	.28*	.28*	.59**	.18
5	Orthographic Awareness Task at beginning of Grade 4					1	-.06	.06	.02	.02	-.06	.00	.08	.13	.03	.28*	-.10	.10
6	Word Reading Accuracy at beginning of Grade 4						1	.41**	.63**	.36**	.53**	.21	.59**	.22*	.22	.12	.48**	.30*
7	Pseudoword Reading Accuracy at beginning of Grade 4							1	.33**	.28*	.20	.33**	.36**	.39**	.24*	.29*	.23	.27*
8	Word Spelling Accuracy at beginning of Grade 4								1	.41**	.60**	.18	.81**	.15	.37**	.11	.68**	.43**
9	Pseudoword Spelling Accuracy at beginning of Grade 4									1	.23*	.19	.40**	.25*	.08	.08	.19	.30*
10	Word Reading Accuracy at end of Grade 4										1	.32**	.61**	.14	.21	.20	.58**	.12
11	Pseudoword Reading Accuracy at end of Grade 4											1	.25*	.19	.07	.13	.26*	.02
12	Word Spelling Accuracy at end of Grade 4												1	.29**	.17	.10	.73**	.28*
13	Pseudoword Spelling Accuracy at end of Grade 4													1	-.02	.19	.15	.09
14	Word Reading Accuracy at end of Grade 5														1	.39**	.22	.20
15	Pseudoword Reading Accuracy at end of Grade 5															1	.08	.23
16	Word Spelling Accuracy at end of Grade 5																1	.33**
17	Pseudoword Spelling Accuracy at end of Grade 5																	1

* p < .05 ** p < .01

Sequential Regression Analyses

SRAs are used to model relationships between the present variables and to predict the value of a dependent variable from one or more independent variables, i.e. the predictors. Here, we first specified the set of predictors that make up the model. Next, we specified their order of entry, which reflects our theoretical framework and previous research findings. Then, we tested the relative contribution of each predictor to the dependent variable in a sequential regression model.

For all SRAs reported here, age, nonverbal reasoning, vocabulary and phonemic ability were entered first to control for the contributions of age, general nonverbal and language abilities, and phonemic awareness.

Long-term predictive effects from orthographic knowledge on reading and spelling.

The long-term predictive effects from orthographic knowledge (lexical and sublexical) on reading and spelling abilities were examined by means of cross-lag SRAs. Figure 2 shows a schematic representation of cross-lag SRAs. We evaluated whether cross-lag contributions of the predictor variable (A at Time 1), entered at the fourth step, to an outcome variable (dependent variable B, at Time 2) survived the additional control of B at Time 1, entered in the third step. For example, when the long-term effect of *lexical orthographic knowledge* at the beginning of Grade 2 on *word reading* at the end of Grade 2 was examined, the beginning of Grade 2 *word reading* was entered as a control variable in the third step to examine the contribution of *lexical orthographic knowledge* to the change in *word reading* from the beginning of Grade 2 to the end of Grade 2 or beginning of Grade 3. Subsequently, the same was done to evaluate the long-term effect of *lexical orthographic knowledge* at the beginning of

Grade 2 on *pseudoword reading* at the end of Grade 2 or beginning of Grade 3. This procedure was applied to following pairs of variables in both Cohorts: *lexical orthographic knowledge / word reading; lexical orthographic knowledge / pseudoword reading; sublexical orthographic knowledge / word reading; sublexical orthographic knowledge / pseudoword reading; lexical orthographic knowledge / word spelling; lexical orthographic knowledge / pseudoword spelling; sublexical orthographic knowledge / word spelling; sublexical orthographic knowledge / pseudoword spelling.*

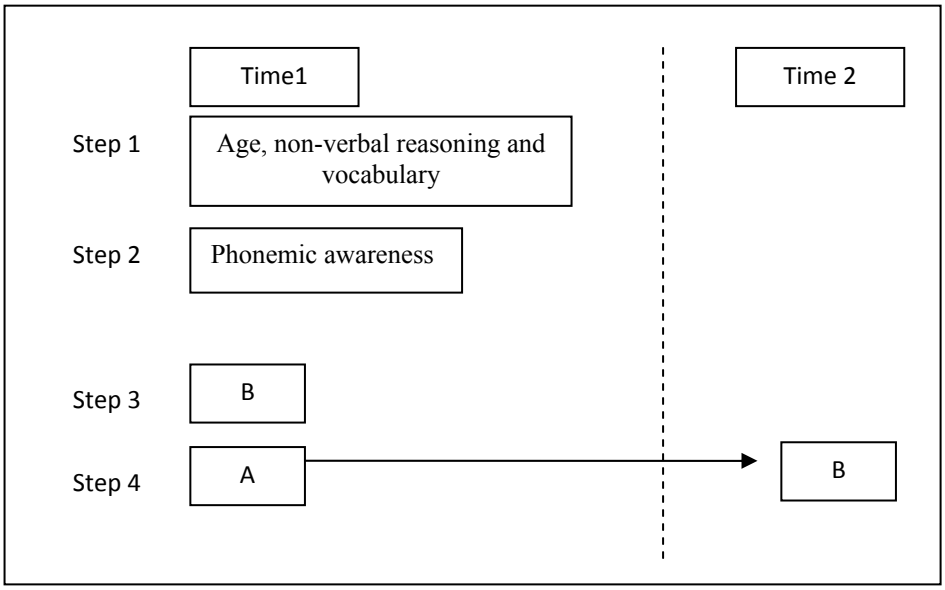

Figure 2. General procedure of the cross-lag SRA.

Relationship between the two components of orthographic knowledge and reading.

The results of the cross-lagged SRAs are presented in Figure 3 for Cohort 1(see Tables A1 to A4 of Appendix) and in Figure 4 for Cohort 2 (see Tables A5 to A8 of Appendix). This set of sequential regressions showed some significant contributions from lexical orthographic knowledge on word and pseudoword reading; and from sublexical orthographic knowledge on pseudoword reading.

In **Cohort 1**, performance on Orthographic Choice Task at the beginning of Grade 2 accounted for significant variance in word and pseudoword reading at the end of Grade 2 (3% and 5%, respectively). These contributions remained significant or almost significant (p=.07) even with a greater time lag: performance on Orthographic Choice Task at the beginning of Grade 2 accounted for significant variance in word and pseudoword reading at the beginning of Grade 3 (9% and 4%, respectively). In a different way, the performance on Orthographic Awareness Task didn't account for any variance in word or pseudoword reading neither with a small time lag (from the beginning of Grade 2 to the end of Grade 2) nor with a greater time lag (from the beginning of Grade 2 to the beginning of Grade 3). In sum, the observed effects occurred only from lexical orthographic knowledge within the same processing levels (on word reading) and also between processing levels (on pseudoword reading).

Some significant predictive effects from orthographic knowledge on word and pseudoword reading were also observed in **Cohort 2** but these predictive effects are observed only within the same processing level. In fact, performance on Orthographic Choice Task at the beginning of Grade 4 has a significant contribution (7%) in word reading at the end of Grade 4, and the performance on Orthographic Awareness Task at the beginning of Grade 4 accounted (9%) for significant variance on pseudoword reading at the end of Grade 5. Contrary, there were no significant cross predictive effects neither from the performance on Orthographic Choice Task on pseudoword

reading (sublexical level) neither from performance on Orthographic Awareness Task on word reading (lexical level).

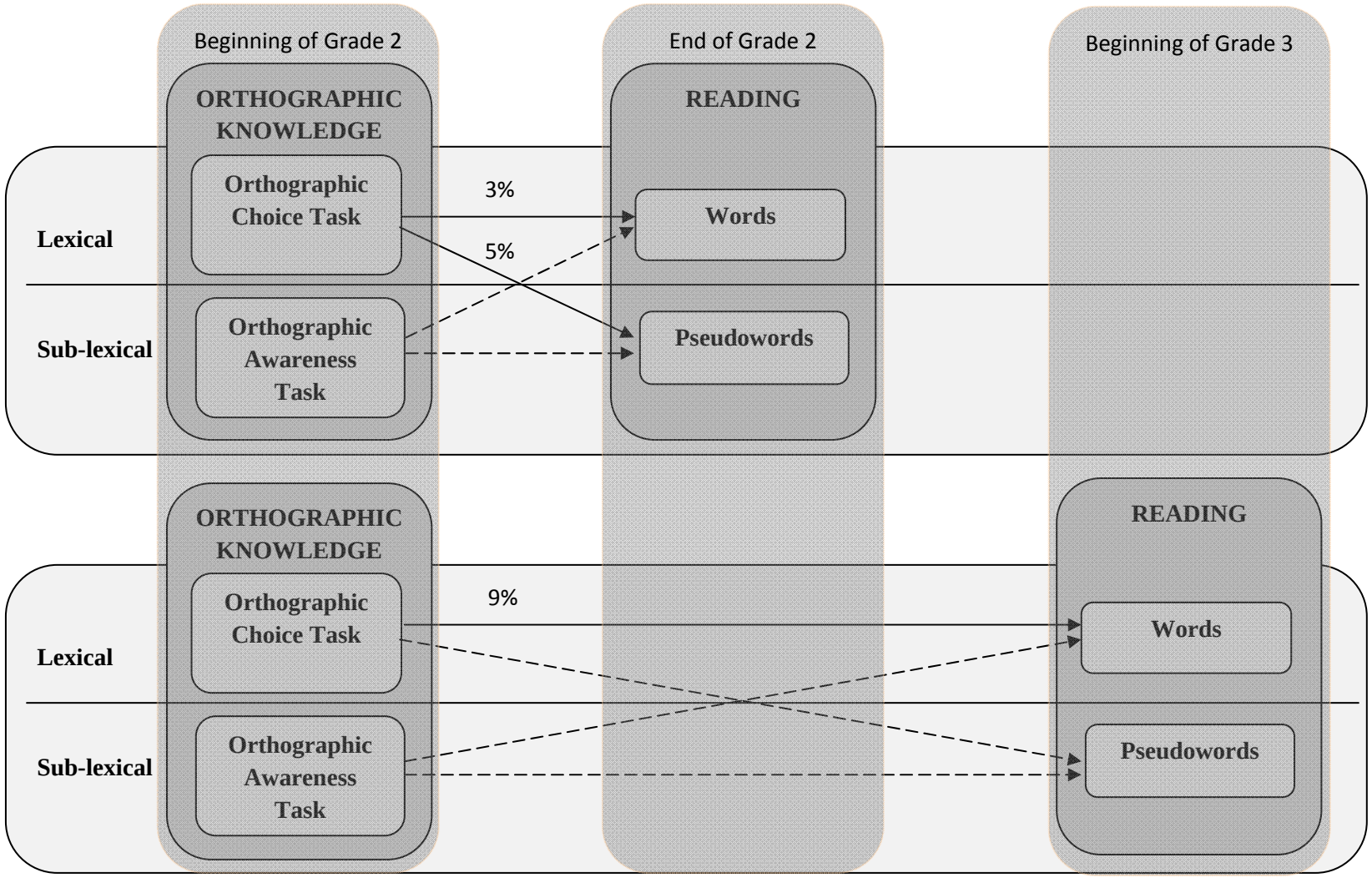

Figure 3. Results of SRA in Cohort 1. Arrows in bold denote a significant relationship from Orthographic Choice and Orthographic Awareness tasks (sublexical or lexical orthographic knowledge) on word or pseudoword reading as tested in the longitudinal regression analysis.

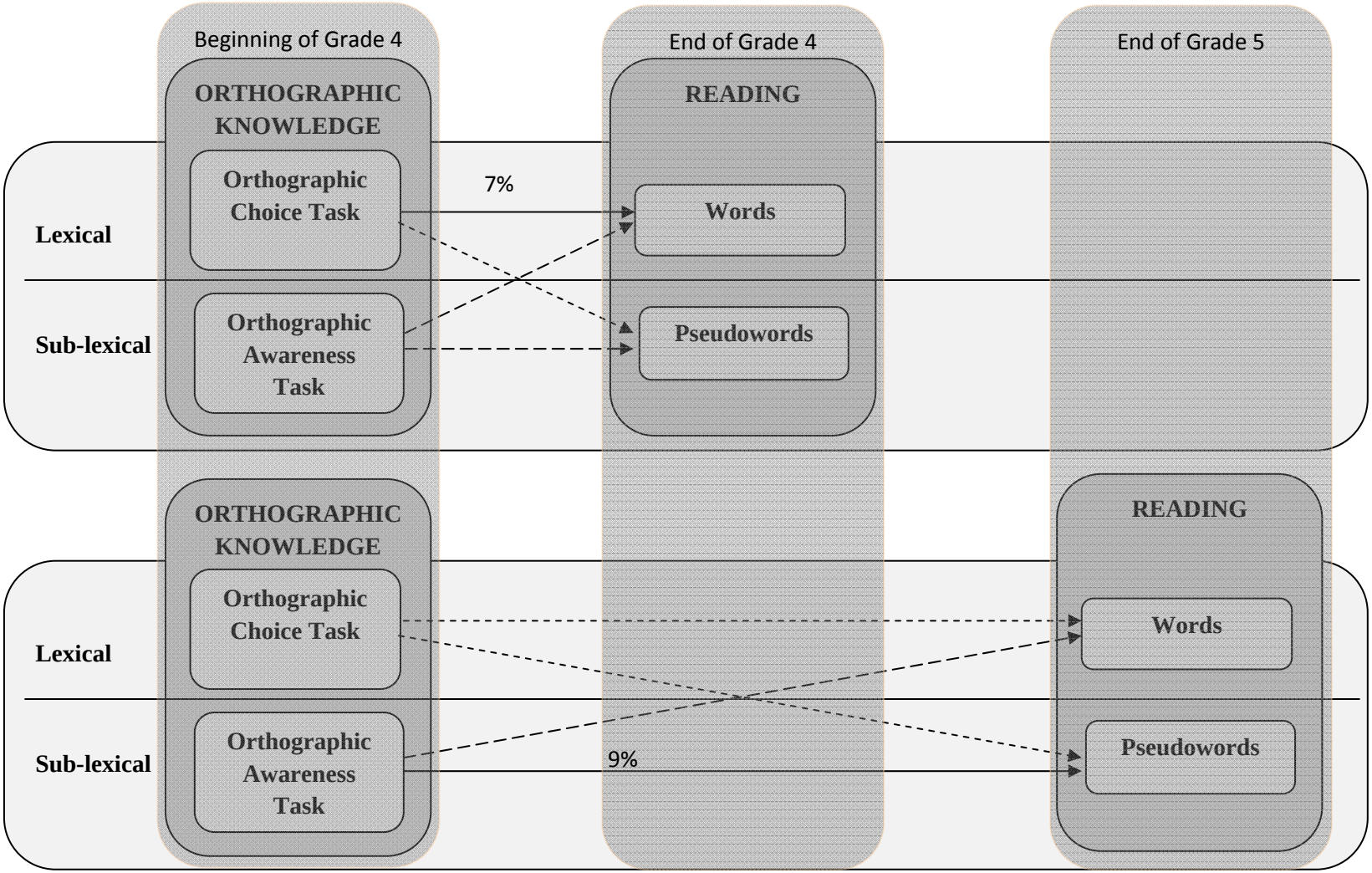

Figure 4. Results of SRA in Cohort 2. Arrows in bold denote a significant relationship from Orthographic Choice and Orthographic Awareness tasks (lexical and sublexical orthographic knowledge) on word or pseudoword reading as tested in the longitudinal regression analysis.

Relationship between the two components of orthographic knowledge and spelling.

The results of the cross-lagged SRAs are presented in Figures 5 and 6 for Cohort 1 and 2, respectively (see Tables A9 to A12 and Tables A13 to A16 of Appendix, respectively for Cohort 1 and 2). This set of sequential regressions showed significant contributions: again, lexical orthographic knowledge accounted for significant variance on word and pseudoword spelling; and sublexical orthographic knowledge significantly predicted pseudoword spelling.

In **Cohort 1**, performance on Orthographic Choice Task at the beginning of Grade 2 made a significant contribution to word spelling at the end of Grade 2 (5%) and to pseudoword spelling at the beginning of Grade 3(8%). Furthermore, performance on Orthographic Awareness Task e at the beginning of Grade 2 accounted for significant variance on pseudoword spelling at the beginning of Grade 3 (12%). As already referred for reading, we didn't observe any significant cross predictive effect from the performance on Orthographic Awareness Task at the beginning of Grade 2 on word spelling both at the end of Grade 2 and at the beginning of Grade 3.

We also observed significant contributions in **Cohort 2,** but only within the lexical level of processing. Indeed, performance on Orthographic Choice Task at the beginning of Grade 4 significantly predicted word spelling at the end of Grade 4 and 5 (4% and 7%, respectively. Contrary, the performance on Orthographic Awareness Task at the beginning of Grade 4 didn't explain significant variance on pseudoword or word spelling both at the end of Grade 4 and 5.

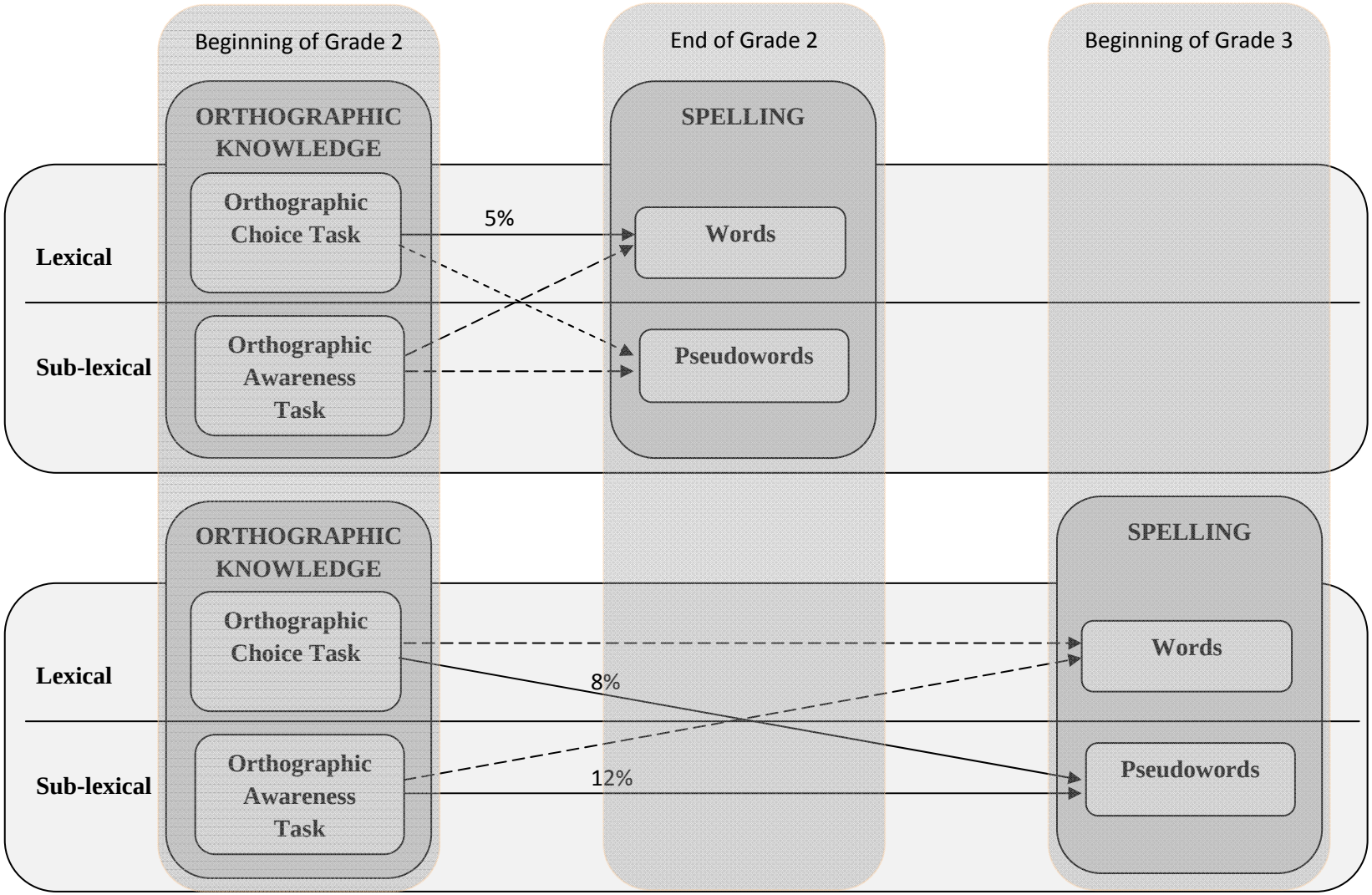

Figure 5. Results of SRA in Cohort 1. Arrows in bold denote a significant relationship from Orthographic Choice and Orthographic Awareness tasks (lexical and sublexical orthographic knowledge) on word or pseudoword spelling as tested in the longitudinal regression analysis.

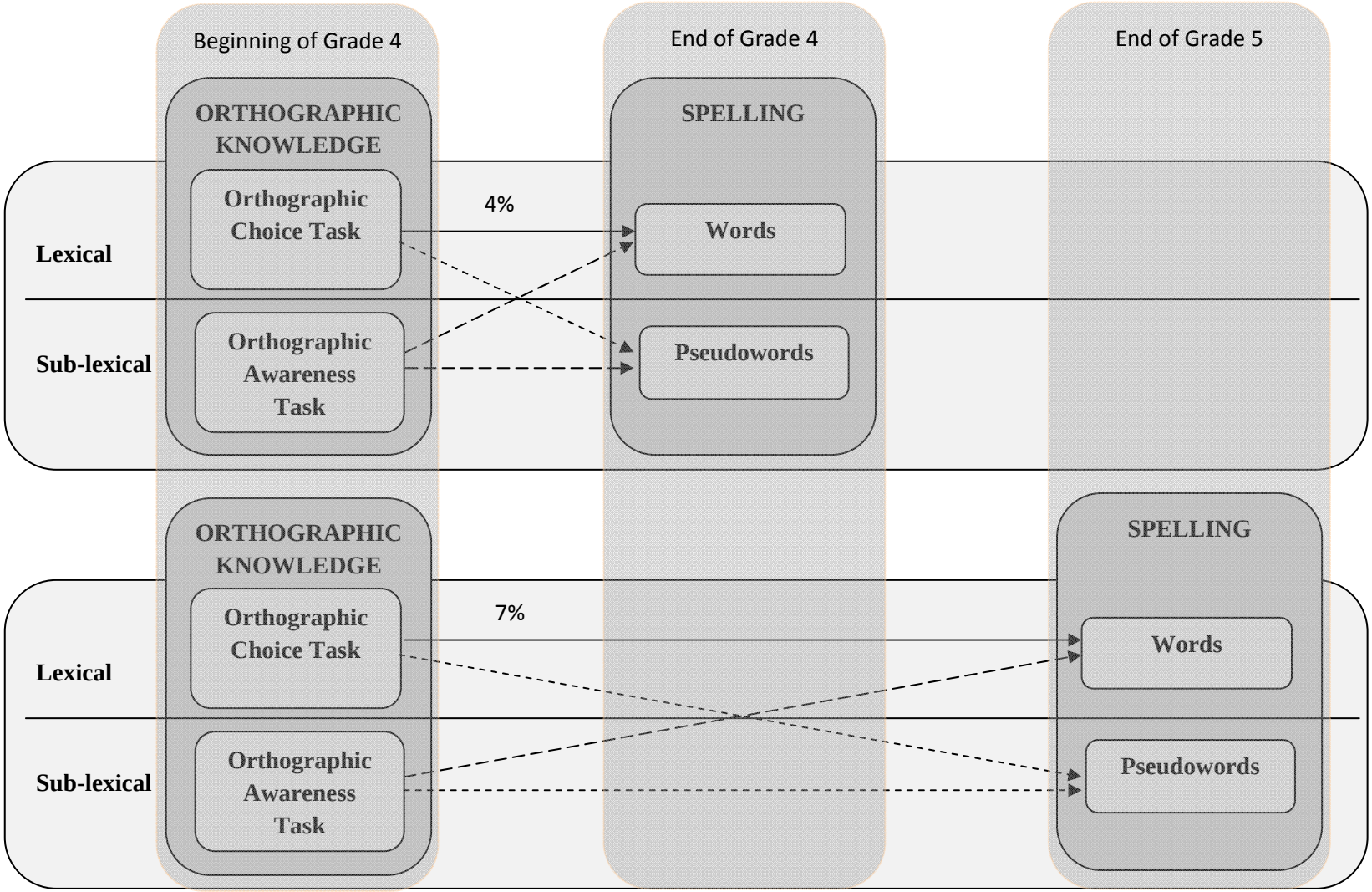

Figure 6. Results of SRA in Cohort 2. Arrows in bold denote a significant relationship from Orthographic Choice and Orthographic Awareness tasks (lexical and sublexical orthographic knowledge) on word or pseudoword spelling as tested in the longitudinal regression analysis.

Discussion

Does orthographic knowledge influence reading and spelling acquisition? The present study aimed to answer this question determining whether there are longitudinal predictive effects from the sublexical and lexical processing levels of orthographic knowledge on the sublexical and lexical processing levels of reading and spelling. We also intend to explore how these relations vary along development.

Theoretical accounts suggested that phonological recoding (i.e., the practice in reading and spelling) leads to the buildup of orthographic knowledge (e.g., Ehri, 1997; Share, 1999). It is also proposed, in Ehri's (2005) phase model of reading acquisition, that orthographic knowledge supports reading and spelling – familiar and unfamiliar word reading and spelling is attained by means of lexical orthographic knowledge using word specific representations stored in memory, or through analogy to stored words, respectively. Furthermore, sublexical orthographic knowledge would provide expectations and constraints useful to read or spell any word, familiar and unfamiliar.

Following this theoretical account we hypothesized that reading and spelling acquisition is supported by orthographic knowledge. Our hypothesis was confirmed in great extent by the findings of the present study.

In line with our expectation, we observed predictive effects between orthographic representations and word reading and spelling, i.e., within the lexical level of processing. Actually, children's performance on orthographic choice task, at beginning of Grade 2, accounted for a significant amount of unique variance in their word reading and spelling performance at end of Grade 2 (3% and 5%, respectively) and at grade 3 (9% for word reading). Similarly, the performance on orthographic choice task from beginning of Grade 4, explained a significant unique variance in word

reading and spelling performance at end of Grade 4 (7% and 4%, respectively) and at the end of Grade 5 (7% for spelling).

We also observed that children's results on the orthographic awareness task uniquely explained variance on pseudoword reading and spelling performance but not in such a systematic way. In fact, its effect was only observed from beginning of Grade 2 on pseudoword spelling at the grade 3 (12%) and from beginning of Grade 4 on pseudoword reading at the end of Grade 5 (9%).

Cross-predictive effects between one level of orthographic knowledge on the other level of processing of reading and spelling were also observed providing support to our hypothesis. These effects were observed only from orthographic choice task (performed at lexical level), at beginning of Grade 2, on pseudoword reading at the end of Grade 2 (5%) and on pseudoword spelling at Grade 3 (8%). In a different way, awareness choice task (performed at sublexical level) didn't explain any variance in subsequent word reading and spelling performance.

Thus, we found that early orthographic processing skill (lexical and sublexical) significantly predicts later reading and spelling in several longitudinal analyses. In fact, sequential regression analyses showed some unique contributions from lexical orthographic knowledge on reading and spelling at both levels of processing, and from sublexical orthographic knowledge on sublexical level of reading and spelling. These results were noteworthy once they arise in longitudinal analyses from beginning of grade 2 to end of grade 2, or even to grade 3.

In a early stage (Cohort 1) of reading acquisition in which decoding / recoding is still predominant, lexical orthographic knowledge predicted either word and pseudoword reading and spelling, while the predictive influence of sublexical orthographic knowledge it's confined to pseudoword reading and spelling. In a more

advanced stage (Cohort 2) the predictive effects occurred only within the same processing levels, i.e. from both lexical orthographic knowledge on word reading and spelling, and from sublexical orthographic knowledge on pseudoword reading.

Our finding that orthographic knowledge contributes to progress in reading and spelling acquisition provides empirical support to Ehri (2005) influential theoretical approach. Our results additionally suggest that orthographic processing ability is not only an outcome of reading and spelling practice. Orthographic representations as well general orthographic knowledge are useful for and are underpinning reading and spelling development at their both levels of processing – lexical and sublexical.

Recent previous concurrently studies with English children have reported a predictive role of orthographic knowledge on both reading and spelling (Conrad et al., 2013; Rothe et al., 2013). This contribution had been examined from one (Rothe et al., 2013) or the two (Conrad et al., 2013) different components of the orthographic knowledge on just one level of processing of reading or spelling (lexical level). In this way, their results suggest that orthographic knowledge at a sublexical level, i.e. sensitivity to orthographic regularities, is important for the development of reading and spelling skills in the very beginning (end of first Grade) of reading and spelling instruction (Rothe et al., 2013). Moreover, both levels of orthographic knowledge – sublexical and lexical – seem to be useful beyond the early grade of instruction. In fact, in school-aged children ranging from seven to nine years old, both types of orthographic knowledge have made a unique contribution to both reading and spelling (Conrad et al., 2013), confirming their importance to developing literacy. These evidences showed the online importance of orthographic knowledge in the acquisition of reading and spelling, i.e. at the same moment of development.

Our results observed in cross-lag analyses, also suggest that the predictive role of orthographic knowledge on reading and spelling acquisition persists during a long time period, from the beginning of literacy instruction until later stages of learning to read and spell. Such predictive role was observed between two moments of the Grade 2, between the Grade 2 and the Grade 3 and between the Grade 4 and Grade 5.

The predictive effects from orthographic knowledge on reading and spelling abilities were observed along several grades and after stringent controls (e.g., phonological ability, auto-regressive control, etc….). These results highlight the crucial role of orthographic knowledge assigning it a similar role as phonological awareness has on reading and spelling acquisition. Thus, they suggest that orthographic knowledge must be considered behind the well established skills (e.g., phonological awareness or letter knowledge), as a predictor of reading and spelling acquisition, at least in a semi transparent orthography as was the case of European Portuguese. Moreover, it is important to note that there seems to be a differential role of the components of orthographic knowledge on reading and spelling. Lexical orthographic knowledge proves to be useful (Cohort 1) either for later word and pseudoword reading and spelling. In turn, it appears that, sublexical orthographic knowledge only has an influential role on later pseudoword reading and spelling. However, the fact that we didn't observe, in the present study, a significant predictive effect from sublexical orthographic knowledge on reading and spelling of familiar words, doesn't mean that this type of knowledge wasn't useful for that purpose. The predictive effect of sublexical orthographic knowledge could eventually arise in a concurrent design or with a smaller interval of time between variables than that used in our study. Thus, lexical orthographic knowledge seems to have a long lasting and widespread influence on the ability to read and spell familiar and non familiar words. Otherwise, sublexical

orthographic knowledge appears to be beneficial uniquely for the ability of read and spell unknown words.

To our knowledge, no longitudinal findings, to date, point in this direction. In fact, and contrarily to our results, Ise and colleagues (Ise et al., 2014) and Deacon and colleagues (Deacon et al., 2012) studies suggest that the orthographic knowledge is not related to later reading and spelling performance. Those results suggest an influence of the orthographic knowledge on reading and spelling development that is time restricted and not long lasting, contrarily to what is expectable accordingly to Ehri's (2005) theoretical approach. Furthermore, they do not answer the question concerning the relationships between sublexical and lexical levels of orthographic knowledge and the correspondent levels on reading and spelling. In fact, these previous longitudinal studies (Ise et al., 2012 and Deacon et al., 2012) have only considered restricted relationships between orthographic knowledge and reading or spelling. They have focused on the relation between just one level of orthographic knowledge (sublexical) and reading/spelling (Ise et al., 2013) or on the relation between the two levels (sublexical and lexical) of orthographic knowledge and reading but not spelling (Deacon et al., 2012). Both of them considered only the lexical level of processing in reading and/or spelling.

Our study considered orthographic knowledge as one ability that is compounded by two specific components, each of them acting in a different level of processing, i.e., lexical and sublexical and explored their predictive role on the same levels of reading and spelling ability, in a language semitransparent as that of Portuguese.

The discrepancy between those results (Ise et al., 2012 and Deacon et al., 2012) and ours may have several explanations. Firstly, participants might not present the same level literacy instruction, and consequently the same level of decoding ability. As we

have already reported previously (Querido, Fernandes, Verhaeghe, Carvalho, & Morais, 2015) the relationship between decoding and orthographic knowledge depends on decoding ability. Secondly, the relationship between orthographic knowledge and reading and spelling may also depend on the characteristics of the orthographic code, particularly, its degree of transparency and, on the type and size of the orthographic patterns that are used for English (Deacon et al., 2012), German (Ise et al., 2014) and Portuguese.

In conclusion, our hypothesis was supported to a large extent. The results of the present study highlight the predictive role of lexical and sublexical orthographic knowledge on reading and spelling ability. In school aged children ranged from Grade 2 to Grade 5 early specific orthographic knowledge have a predictive effect on the later ability to read or spell familiar as well unknown words. Moreover, pattern orthographic knowledge, albeit more restrict, has also a predictive effect in the ability to read and spell unknown words.

Interestingly, these predictive effects are in accordance with Ehri's (2005) theoretical proposal – the use of word specific representations stored in memory allows children to read and spell familiar and unknown words respectively. Moreover, unknown words could also be read and spelled with the help of sublexical orthographic knowledge that gives the expectations and constrains (Ehri, 2005) about how a word could be read or spelled accordingly with knowledge of recurring letter patterns.

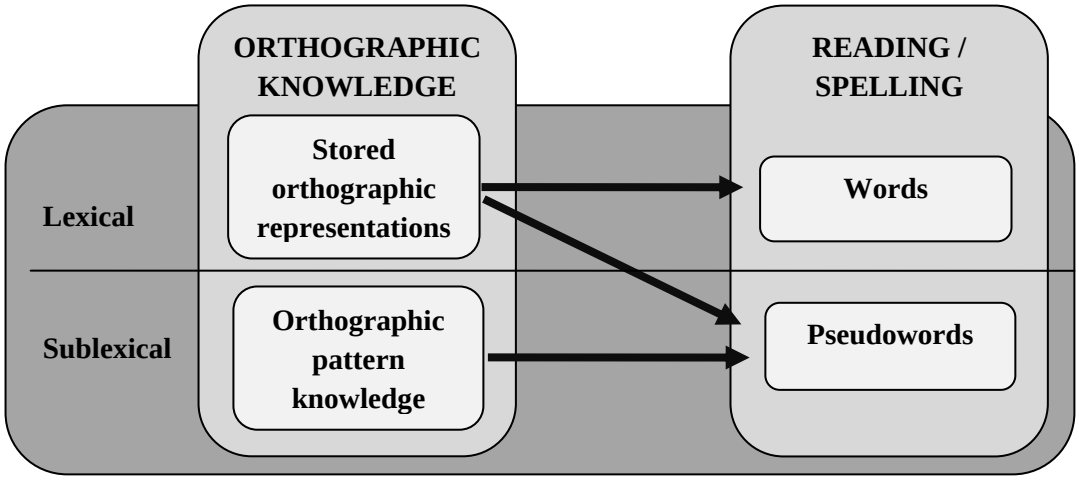

Figure 7. Schematic representation of results highlighting relationships between orthographic knowledge and reading and spelling.

References

Anthony, J. L., & Francis, D. J. (2005). Development of phonological awareness. *Current Directions in Psychological Science*, *14*(5), 255-259. doi: 10.1111/j.0963-7214.2005.00376.x

Apel, K. (2011). What is orthographic knowledge? *Language, Speech, and Hearing Services in Schools*, *42*(4), 592-603. doi: 10.1044/0161-1461(2011/10-0085)

Conners, F. A., Loveall, S. J., Moore, M. S., Hume, L. E., & Maddox, C. D. (2011). An individual differences analysis of the self-teaching hypothesis. *Journal of Experimental Child Psychology, 108* (2), 402-410. doi:10.1016/j.jecp.2010.09.009

Conrad, N. J., Harris, N., & Williams, J. (2013). Individual differences in children's literacy development: The contribution of orthographic knowledge. *Reading and Writing*, *26*(8), 1223-1239. doi: 10.1007/s11145-012-9415-2

Deacon, S. H., Benere, J., & Castles, A. (2012). Chicken or egg? Untangling the relationship between orthographic processing skill and reading accuracy. *Cognition*, *122*(1), 110-117. doi: 10.1016/j.cognition.2011.09.003

Dunn, L. M., Padilla, E. R., Lugo, D. E., & Dunn, L. M. (1986). *Manual Del Examinador para el Test de Vocabulário en Imágenes Peabody*. Circle Pines: American Guidance Service.

Ehri, L. C. (1997). Learning to read and learning to spell are one and the same, almost. In C. Perfetti, L. Rieben & M. Fayol (Eds.), *Learning to spell: Research, theory, and practice across languages* (pp. 237-268). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Ehri, L. C. (2005). Learning to read words: Theory, findings, and issues. *Scientific Studies of Reading*, *9*(2), 167-188. doi: 10.1207/s1532799xssr0902_4

Fernandes, S., Ventura, P., Querido, L., & Morais, J. (2008). Reading and spelling acquisition in European Portuguese: A preliminary study. *Reading and Writing*, *21*(8), 805-821. doi: 10.1007/s11145-007-9093-7

Frith, U. (1980). Unexpected spelling problems. In U. Frith (Ed.), *Cognitive processes in spelling* (pp.495-515). London: Academic Press.

Ise, E., Arnoldi, C. J., & Schulte-Körne, G. (2014). Development of orthographic knowledge in German-speaking children: a 2-year longitudinal study. *Journal of Research in Reading*, *37*(3), 233-249. doi: 10.1111/j.1467-9817.2012.01535.x

Kenny, D. A. (1975). Cross-lagged panel correlation: A test for spuriousness. *Psychological Bulletin*, *82*(6), 887-903. doi: 10.1037/0033-2909.82.6.887

Loveall, S. J., Channell, M. M., Phillips, B. A., & Conners, F. A. (2013). Phonological recoding, rapid automatized naming, and orthographic knowledge. *Journal of Experimental Child Psychology*, *116*(3), 738-746. doi: 10.1016/j.jecp.2013.05.009

Morais, J., Alegria, J., & Content, A. (1987). The relationships between segmental analysis and alphabetic literacy: an interactive view. *Cahiers de Psychologie Cognitive*, 7, 415-443. Retrieved from http://psycnet.apa.org/psycinfo/1988-35331-001

Nation, K., & Hulme, C. (1997). Phonemic segmentation, not onset-rime segmentation, predicts early reading and spelling skills. *Reading Research Quarterly*, *32*(2), 154-167. doi: 10.1598/RRQ.32.2.2

National Reading Panel (US), National Institute of Child Health, & Human Development (US). (2000). *Report of the national reading panel: Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction: Reports of the subgroups*. National Institute of Child Health and Human Development, National Institutes of Health.

Olson, R. K., Forsberg, H., Wise, B., & Rack, J. (1994). Measurement of word recognition, orthographic, and phonological skills. In G. R. Lyon (Ed.), *Frames of reference for the assessment of learning disabilities: New views on measurement issues* (pp. 243–277). Baltimore, MD: Brookes.

Ouellette G., & Sénéchal, M. (2008). Pathways to literacy: a study of invented spelling and its role in learning to read. *Child Development, 79*, 899–913. doi: 10.1111/j.1467-8624.2008.01166.x

Querido, L., Fernandes, S., Verhaeghe, A., Carvalho, C., & Morais, J. (2015). *Relationships between lexical and sublexical components of orthographic knowledge during learning to read.* Manuscript in preparation.

Rothe, J., Schulte-Körne, G., & Ise, E. (2014). Does sensitivity to orthographic regularities influence reading and spelling acquisition? A 1-year prospective study. *Reading and Writing*, *27*(7), 1141-1161. doi: 10.1007/s11145-013-9479-7

Schneider, W., Eschman, A., & Zuccolotto, A. (2002a). *E-Prime: User's guide*. Psychology Software Incorporated.

Schneider, W., Eschman, A., & Zuccolotto, A. (2002b). *E-prime computer software and manual.* Pittsburgh, PA: Psychology Software Tools Inc.

Share, D. L. (1995). Phonological recoding and self-teaching: sine qua non of reading acquisition. *Cognition*, *55*(2), 151-218. doi: 10.1016/0010-0277(94)00645-2

Share, D. L. (1999). Phonological recoding and orthographic learning: A direct test of the self-teaching hypothesis. *Journal of Experimental Child Psychology*, *72*(2), 95-129. doi: 10.1006/jecp.1998.2481

Simões, M. R. (1994). *Investigações no âmbito da aferição nacional do teste das Matrizes Progressivas Coloridas de Raven (M.P.C.R.)*. Dissertação de Doutoramento. Coimbra: Universidade de Coimbra.

Sprenger-Charolles, L., Siegel, L. S., Béchennec, D., & Serniclaes, W. (2003). Development of phonological and orthographic processing in reading aloud, in silent reading, and in spelling: A four-year longitudinal study. *Journal of Experimental Child Psychology*, *84*(3), 194-217. doi:10.1016/S0022-0965(03)00024-9

Stanovich, K. E., & Siegel, L. S. (1994). Phenotypic performance profile of children with reading disabilities: A regression-based test of the phonological-core variable-difference model. *Journal of Educational Psychology*, *86*(1), 24-53. doi: 10.1037/0022-0663.86.1.24

Stanovich, K. E., West, R. F., & Cunningham, A. E. (1991). Beyond phonological processes: Print exposure and orthographic processing. In S. Brady & D. Shankweiler (Eds.), *Phonological processes in literacy: A tribute to Isabelle Y. Liberman* (pp. 219-235). England: Lawrence Erlbaum Associates.

Treiman, R. (1993). *Beginning to spell: A study of first-grade children*. New York: Oxford University Press.

Appendix

Appendix - Summary of Sequential Regression Analysis (SRA) effects.

Table A1

Summary of Sequential Regression Analysis (SRA) for the study of long-term effect of lexical orthographic knowledge (LOK) on word reading (WR) in cohort 1

		Summary of statistics from LOK at beginning of Grade 2 to WR at end of Grade 2 as dependent variable						Summary of statistics from LOK at beginning of Grade 2 to WR at beginning of Grade 3 as dependent variable			
		R^2	Δ R^2	ΔF	β			R^2	Δ R^2	ΔF	β
Step	**IV**					**Step**	**IV**				
1	M				-.02	1	M				-.04
	V	.06	.06	2.17	.14		V	.02	.02	.84	.04
2	PA	.13	.07	5.95*	.04	2	PA	.20	.18	14.88***	.20
3	WR	.50	.37	51.12***	.56	3	WR	.44	.23	26.94***	.37
4	LOK	.53	.03	4.77*	.21	4	LOK	.53	.09	12.70**	.36

Note. IV = Independent variables; M = Matrices; V = Vocabulary; PA = Phonemic Awareness; LOK= Lexical Orthographic Knowledge; WR = Word Reading.

* p ≤ .05; ; ** p ≤ .01; *** p ≤ .001

Table A2

Summary of Sequential Regression Analysis (SRA) for the study of long-term effect of lexical orthographic knowledge (LOK) on Pseudoword Reading (PWR) in cohort 1

		Summary of statistics from LOK at beginning of Grade 2 to PWR at end of Grade 2 As dependent variable						Summary of statistics from LOK at beginning of Grade 2 to PWR at beginning of Grade 3 as dependent variable			
		R^2	Δ R^2	ΔF	β			R^2	Δ R^2	ΔF	β
Step	**IV**					**Step**	**IV**				
1	M				.03	1	M				.07
	V	.01	.01	.38	.03		V	.02	.02	.51	.05
2	PA	.07	.06	4.27*	.10	2	PA	.03	.02	1.19	.00
3	PWR	.22	.16	13.82***	.38	3	PWR	.18	.15	11.92**	.38
4	LOK	.28	.05	5.05*	.25	4	LOK	.23	.04	3.49	.22

Note. IV = Independent variables; M = Matrices; V = Vocabulary; PA = Phonemic Awareness; LOK= Lexical Orthographic Knowledge; PWR = PseudoWord Reading.

* p ≤ .05; ; ** p ≤ .01; *** p ≤ .001

Table A3

Summary of Sequential Regression Analysis (SRA) for the study of long-term effect of sublexical orthographic knowledge (SubLOK) on word reading (WR) in cohort 1

		Summary of statistics from SubLOK at beginning of Grade 2 to WR at end of Grade 2 as dependent variable						Summary of statistics from SubLOK at beginning of Grade 2 to WR at beginning of Grade 3 as dependent variable			
		R^2	ΔR^2	ΔF	β			R^2	ΔR^2	ΔF	β
Step	**IV**					**Step**	**IV**				
1	M				-.01	1	M				-.01
	V	.07	.07	2.64	.15		V	.03	.03	1.16	.07
2	PA	.14	.07	5.52*	.08	2	PA	.20	.16	13.71***	.26
3	WR	.51	.37	53.04***	.66	3	WR	.44	.24	28.54***	.53
4	SubLOK	.51	.00	.08	-.02	4	SubLOK	.44	.00	.00	.00

Note. IV = Independent variables; M = Matrices; V = Vocabulary; PA = Phonemic Awareness; LOK= Lexical Orthographic Knowledge; WR = Word Reading.

* p ≤ .05; ; ** p ≤ .01; *** p ≤ .001

Table A4

Summary of Sequential Regression Analysis (SRA) for the study of long-term effect of sublexical orthographic knowledge (SubLOK) on Pseudoword Reading (PWR) in cohort 1

		Summary of statistics from SubLOK at beginning of Grade 2 to PWR at end of Grade 2 As dependent variable						Summary of statistics from SubLOK at beginning of Grade 2 to PWR at beginning of Grade 3 as dependent variable			
		R^2	ΔR^2	ΔF	β			R^2	ΔR^2	ΔF	β
Step	**IV**					**Step**	**IV**				
1	M				.07	1	M				.11
	V	.01	.01	.39	.06		V	.02	.02	.53	.06
2	PA	.07	.06	4.28*	.17	2	PA	.03	.02	1.20	.07
3	PWR	.22	.16	14.04***	.38	3	PWR	.19	.15	12.12**	.39
4	SubLOK	.23	.01	.76	.09	4	SubLOK	.19	.00	.17	.05

Note. IV = Independent variables; M = Matrices; V = Vocabulary; PA = Phonemic Awareness; SubLOK = Sublexical Orthographic Knowledge; PWR = PseudoWord Reading.

* p ≤ .05; ; ** p ≤ .01; *** p ≤ .001

Table A5

Summary of Sequential Regression Analysis (SRA) for the study of long-term effect of lexical orthographic knowledge (LOK) on word reading (WR) in cohort 2

		Summary of statistics from LOK at beginning of Grade 4 to WR at end of Grade 4 as dependent variable						Summary of statistics from LOK at beginning of Grade 4 to WR at end of Grade 5 as dependent variable			
		R^2	Δ R^2	ΔF	β			R^2	Δ R^2	ΔF	β
Step	**IV**					**Step**	**IV**				
1	M				-.12	1	M				.19
	V	.08	.08	2.84	.13		V	.13	.13	5.07**	.18
2	PA	.08	.01	.37	-.03	2	PA	.13	.00	.29	-.11
3	WR	.28	.20	18.20***	.41	3	WR	.16	.02	1.80	.11
4	LOK	.35	.07	7.13*	.29	4	LOK	.20	.04	3.28	.22

Note. IV = Independent variables; M = Matrices; V = Vocabulary; PA = Phonemic Awareness; LOK= Lexical Orthographic Knowledge; WR = Word Reading.

* p ≤ .05; ; ** p ≤ .01; *** p ≤ .001

Table A6

Summary of Sequential Regression Analysis (SRA) for the study of long-term effect of lexical orthographic knowledge (LOK) on Pseudoword Reading (PWR) in cohort 2

		Summary of statistics from LOK at beginning of Grade 4 to PWR at end of Grade 4 as dependent variable						Summary of statistics from LOK at beginning of Grade 4 to PWR at end of Grade 5 as dependent variable			
		R^2	Δ R^2	ΔF	β			R^2	Δ R^2	ΔF	β
Step	**IV**					**Step**	**IV**				
1	M				-.11	1	M				.14
	V	.03	.03	1.15	.13		V	.17	.17	6.83**	.28
2	PA	.08	.05	3.43	.18	2	PA	.17	.00	.02	-.03
3	PWR	.17	.09	7.34**	.34	3	PWR	.22	.04	3.56	.15
4	LOK	.18	.01	.51	-.09	4	LOK	.25	.03	2.80	.20

Note. IV = Independent variables; M = Matrices; V = Vocabulary; PA = Phonemic Awareness; LOK= Lexical Orthographic Knowledge; PWR = PseudoWord Reading.

* p ≤ .05; ; ** p ≤ .01; *** p ≤ .001

Table A7

Summary of Sequential Regression Analysis (SRA) for the study of long-term effect of sublexical orthographic knowledge (SubLOK) on word reading (WR) in cohort 2

		Summary of statistics from SubLOK at beginning of Grade 4 to WR at end of Grade 4 as dependent variable						Summary of statistics from SubLOK at beginning of Grade 4 to WR at end of Grade 5 as dependent variable			
		R^2	Δ R^2	ΔF	β			R^2	Δ R^2	ΔF	β
Step	**IV**					**Step**	**IV**				
1	M				-.06	1	M				.25
	V	.06	.06	2.13	.06		V	.12	.12	4.46*	.13
2	PA	.06	.00	.25	-.03	2	PA	.12	.00	.35	-.10
3	WR	.30	.24	22.08***	.53	3	WR	.15	.03	2.07	.19
4	SubLOK	.30	.00	.00	-.01	4	SubLOK	. 15	.00	.31	.07

Note. IV = Independent variables; M = Matrices; V = Vocabulary; PA = Phonemic Awareness; SubLOK = Sublexical Orthographic Knowledge; WR = Word Reading.

* p ≤ .05; ; ** p ≤ .01; *** p ≤ .001

Table A8

Summary of Sequential Regression Analysis (SRA) for the study of long-term effect of sublexical orthographic knowledge (SubLOK) on Pseudoword Reading (PWR) in cohort 2

		Summary of statistics from SubLOK at beginning of Grade 4 to PWR at end of Grade 4 as dependent variable						Summary of statistics from SubLOK at beginning of Grade 4 to PWR at end of Grade 5 as dependent variable			
		R^2	Δ R^2	ΔF	β			R^2	Δ R^2	ΔF	β
Step	**IV**					**Step**	**IV**				
1	M				-.13	1	M				.21
	V	.03	.03	1.01	.12		V	.16	.16	6.23**	.25
2	PA	.08	.05	3.30	.17	2	PA	.16	.00	.01	.00
3	PWR	.17	.09	7.21**	.31	3	PWR	.20	.04	3.49	.21
4	SubLOK	.17	.00	.01	-.01	4	SubLOK	.30	.09	8.10**	.30

Note. IV = Independent variables; M = Matrices; V = Vocabulary; PA = Phonemic Awareness; SubLOK = Sublexical Orthographic Knowledge; PWR = PseudoWord Reading.

* p ≤ .05; ; ** p ≤ .01; *** p ≤ .001

Table A9

Summary of Sequential Regression Analysis (SRA) for the study of long-term effect of lexical orthographic knowledge (LOK) on word spelling (WS) in cohort 1

		Summary of statistics from LOK at beginning of Grade 2 to WS at end of Grade 2 as dependent variable					Summary of statistics from LOK at beginning of Grade 2 to WS at beginning of Grade 3 as dependent variable			
		R^2	Δ R^2	ΔF	β		R^2	Δ R^2	ΔF	β
Step	**IV**					**Step**	**IV**				
1	M				-.07	1	M				.01
	V	.04	.04	1.26	.04		V	.15	.15	5.87**	.21
2	PA	.23	.20	17.38***	.21	2	PA	.32	.18	17.54***	.19
3	WS	.48	.24	30.87***	.41	3	WS	.58	.26	42.12***	.47
4	LOK	.53	.05	6.70*	.28	4	LOK	.61	.02	3.79	.19

Note. IV = Independent variables; M = Matrices; V = Vocabulary; PA = Phonemic Awareness; LOK= Lexical Orthographic Knowledge; WS = Word Spelling.

* p ≤ .05; ; ** p ≤ .01; *** p ≤ .001

Table A10

Summary of Sequential Regression Analysis (SRA) for the study of long-term effect of lexical orthographic knowledge (LOK) on Pseudoword Spelling (PWS) in cohort 1

		Summary of statistics from LOK at beginning of Grade 2 to PWS at end of Grade 2 As dependent variable					Summary of statistics from LOK at beginning of Grade 2 to PWS at beginning of Grade 3 as dependent variable			
		R^2	Δ R^2	ΔF	β		R^2	Δ R^2	ΔF	β
Step	**IV**					**Step**	**IV**				
1	M				.00	1	M				-.11
	V	.00	.00	.01	-.01		V	.03	.03	1.20	.17
2	PA	.04	.04	2.91	.22	2	PA	.05	.02	1.37	.02
3	PWS	.04	.00	.04	.03	3	PWS	.08	.02	1.68	.11
4	LOK	.05	.00	.31	-.07	4	LOK	.15	.08	5.78*	.30

Note. IV = Independent variables; M = Matrices; V = Vocabulary; PA = Phonemic Awareness; LOK= Lexical Orthographic Knowledge; PWS = PseudoWord Spelling.

* p ≤ .05; ; ** p ≤ .01; *** p ≤ .001

Table A11

Summary of Sequential Regression Analysis (SRA) for the study of long-term effect of sublexical orthographic knowledge (SubLOK) on word spelling (WS) in cohort 1

		Summary of statistics from SubLOK at beginning of Grade 2 to WS at end of Grade 2 as dependent variable						Summary of statistics from SubLOK at beginning of Grade 2 to WS at beginning of Grade 3 as dependent variable			
		R^2	Δ R^2	ΔF	β			R^2	Δ R^2	ΔF	β
Step	**IV**					**Step**	**IV**				
1	M				-.05	1	M				.01
	V	.05	.05	1.69	.07		V	.16	.16	6.47*	.21
2	PA	.23	.18	15.91***	.22	2	PA	.32	.17	17.20***	.21
3	WS	.48	.25	31.80***	.55	3	WS	.59	.26	43.29***	.60
4	SubLOK	.48	.01	.67	.08	4	SubLOK	.59	.00	.46	-.06

Note. IV = Independent variables; M = Matrices; V = Vocabulary; PA = Phonemic Awareness; SubLOK = Sublexical Orthographic Knowledge; WS = Word Spelling.

* p ≤ .05; ; ** p ≤ .01; *** p ≤ .001

Table A12

Summary of Sequential Regression Analysis (SRA) for the study of long-term effect of sublexical orthographic knowledge (SubLOK) on Pseudoword Spelling (PWS) in cohort 1

		Summary of statistics from SubLOK at beginning of Grade 2 to PWS at end of Grade 2 As dependent variable						Summary of statistics from SubLOK at beginning of Grade 2 to PWS at beginning of Grade 3 as dependent variable			
		R^2	Δ R^2	ΔF	β			R^2	Δ R^2	ΔF	β
Step	**IV**					**Step**	**IV**				
1	M				-.01	1	M				-.07
	V	.00	.00	.01	-.01		V	.03	.03	1.17	.21
2	PA	.04	.04	2.97	.20	2	PA	.05	.02	1.45	.09
3	PWS	.04	.00	.04	.02	3	PWS	.08	.02	1.73	.08
4	SubLOK	.04	.00	.03	.02	4	SubLOK	.19	.12	9.45**	.35

Note. IV = Independent variables; M = Matrices; V = Vocabulary; PA = Phonemic Awareness; SubLOK = Sublexical Orthographic Knowledge; PWS = PseudoWord Spelling.

* p ≤ .05; ; ** p ≤ .01; *** p ≤ .001

Table A13

Summary of Sequential Regression Analysis (SRA) for the study of long-term effect of lexical orthographic knowledge (LOK) on word spelling (WS) in cohort 2

		Summary of statistics from LOK at beginning of Grade 4 to WS at end of Grade 4 as dependent variable						Summary of statistics from LOK at beginning of Grade 4 to WS at end of Grade 5 as dependent variable			
		R^2	Δ R^2	ΔF	β			R^2	Δ R^2	ΔF	β
Step	**IV**					**Step**	**IV**				
	M				.00		M				-.05
1	V	.05	.05	1.61	-.10	1	V	.01	.01	.42	-.10
2	PA	.08	.04	2.56	.04	2	PA	.02	.01	.45	-.09
3	WS	.59	.51	80.62***	.67	3	WS	.44	.42	42.84***	.57
4	LOK	.63	.04	6.90*	.23	4	LOK	.50	.07	7.56**	.30

Note. IV = Independent variables; M = Matrices; V = Vocabulary; PA = Phonemic Awareness; LOK= Lexical Orthographic Knowledge; WS = Word Spelling.

* p ≤ .05; ; ** p ≤ .01; *** p ≤ .001

Table A14

Summary of Sequential Regression Analysis (SRA) for the study of long-term effect of lexical orthographic knowledge (LOK) on Pseudoword Spelling (PWS) in cohort 2

		Summary of statistics from LOK at beginning of Grade 4 to PWS at end of Grade 4 as dependent variable						Summary of statistics from LOK at beginning of Grade 4 to PWS at end of Grade 5 as dependent variable			
		R^2	Δ R^2	ΔF	β			R^2	Δ R^2	ΔF	β
Step	**IV**					**Step**	**IV**				
1	M				-.20	1	M				.18
	V	.04	.04	1.24	.11		V	.20	.20	7.78**	.31
2	PA	.08	.04	3.16	.23	2	PA	.21	.01	.39	.07
3	PWS	.09	.01	.69	.11	3	PWS	.21	.01	.61	.09
4	LOK	.10	.01	.50	-.09	4	LOK	.22	.00	.21	.06

Note. IV = Independent variables; M = Matrices; V = Vocabulary; PA = Phonemic Awareness; LOK= Lexical Orthographic Knowledge; PWS = PseudoWord Spelling.

* p ≤ .05; ; ** p ≤ .01; *** p ≤ .001

Table A15

Summary of Sequential Regression Analysis (SRA) for the study of long-term effect of sublexical orthographic knowledge (SubLOK) on word spelling (WS) in cohort 2

		Summary of statistics from SubLOK at beginning of Grade 4 to WS at end of Grade 4 as dependent variable						Summary of statistics from SubLOK at beginning of Grade 4 to WS at end of Grade 5 as dependent variable			
		R^2	Δ R^2	ΔF	β			R^2	Δ R^2	ΔF	β
Step	**IV**					**Step**	**IV**				
1	M				.04	1	M				-.03
	V	.04	.04	1.34	-.12		V	.01	.01	.18	-.13
2	PA	.07	.03	2.40	.05	2	PA	.01	.01	.34	-.10
3	WS	.59	.52	79.10***	.78	3	WS	.42	.40	39.47***	.69
4	SubLOK	.59	.00	.02	.01	4	SubLOK	.42	.00	.42	-.07

Note. IV = Independent variables; M = Matrices; V = Vocabulary; PA = Phonemic Awareness; SubLOK = Sublexical Orthographic Knowledge; WS = Word Spelling.

* p ≤ .05; ; ** p ≤ .01; *** p ≤ .001

Table A16

Summary of Sequential Regression Analysis (SRA) for the study of long-term effect of sublexical orthographic knowledge (SubLOK) on Pseudoword Spelling (PWS) in cohort 2

		Summary of statistics from SubLOK at beginning of Grade 4 to PWS at end of Grade 4 as dependent variable						Summary of statistics from SubLOK at beginning of Grade 4 to PWS at end of Grade 5 as dependent variable			
		R^2	Δ R^2	ΔF	β			R^2	Δ R^2	ΔF	β
Step	**IV**					**Step**	**IV**				
1	M				-.21	1	M				.19
	V	.04	.04	1.22	.10		V	.21	.21	7.93**	.31
2	PA	.08	.04	3.13	.23	2	PA	.21	.01	.43	.09
3	PWS	.09	.01	.67	.11	3	PWS	.22	.01	.51	.09
4	SubLOK	.10	.00	.31	.07	4	SubLOK	.22	.00	.28	.06

Note. IV = Independent variables; M = Matrices; V = Vocabulary; PA = Phonemic Awareness; SubLOK = Sublexical Orthographic Knowledge; PWS = PseudoWord Spelling.

* p ≤ .05; ; ** p ≤ .01; *** p ≤ .001

CAPÍTULO 4

The influence of orthographic knowledge on writing composition: A longitudinal path analysis.

The influence of orthographic knowledge on writing composition: A longitudinal path analysis [7].

Abstract

Recent literature suggests that both lexical and sublexical orthographic knowledge have an important role in spelling that, in turn, is an important skill that influences the written production. The current study examines the direct and mediated role of both components of orthographic knowledge on the composition process. A longitudinal cohort of 83 children from Grade 2 to 3 completed tests of lexical and sublexical knowledge, word spelling and written composition. The contribution of orthographic knowledge on written composition was both direct and mediated. In fact, the lexical component of orthographic knowledge presents a direct effect on written composition, whereas the sublexical component of orthographic knowledge presents a contribution mediated by word spelling. This contribution is only observed within Grade 2, and not at a more advanced level. Therefore, this evidence is in agreement with the role attributable to transcription skills in the Not-so Simple View of Writing, i.e., a higher reliance of novice writers than skilled writers in transcription skills, in this case, the orthographic knowledge. Furthermore, our results support the key role of orthographic knowledge as predictor of written composition. The accommodation of orthographic knowledge in the Simple View of Writing, as a foundational ability of spelling transcription skill is, thus, reinforced. Additionally, it opens a high way for the inclusion of different processes underpinning the proposed transcription skills as contributors to writing skill, enhancing the complexity of the Simple View of Writing.

[7] Manuscrito em preparação.

Keywords: lexical orthographic knowledge, sublexical orthographic knowledge, Simple View of Writing, written composition, transcription skills.

Introduction

W*R*iting was the neglected "R" (National Commission of Writing, 2003) for several decades during which *R*eading and a*R*ithmetic were the focus of researchers. However, during the last two decades writing research has taken off over and the gap is beginning to close (Wagner, Puranik, Foormen, Foster, Wilson, Tschinkel, & Kantor, 2011).

As the report of National Commission on Writing (2003) states: "Although many models of effective ways to teach writing exist, both the teaching and learning of writing are increasingly short changed throughout the school and college years ..." (pp. 3). In fact, the Nation's Report Card: Writing (2002) found only 28%, 31% and 24% of tested 4^{th}, 8^{th} and 12^{th} graders, respectively, as having a "proficient" or "advanced" level of writing. About ten years later, there was no improvement: only "twenty-four percent of students at both grades 8 and 12 performed at the Proficient level in writing" (Nation's Report Card: Writing, 2012, pp. 1), i.e., the largest percentage of students still performing at the Basic level or below. In European Portuguese there are no research data about writing performance along the literacy process and, unfortunately, there are no reasons to believe that our students perform at a better level. In fact, in 2015, only 21410 (22,64%) and 3235 (3,42%) from a total of 94579 students attained the scores 4 and 5 (0 – 5 scale), respectively, in the national ministry of education final examination of Portuguese lecture at Grade 9 (Instituto de Avaliação Educativa, 2015).

Considering the complexity of writing, the above data are not completely surprising. There are several possible reasons for difficulties in the production of legible, accurate and coherent text, namely, specific difficulties inherent of child writer, and environmental constraints (e.g., inadequate teaching, lack of practice of producing texts). Therefore, it is clear that research on the normal writing acquisition process is

necessary to develop and test theoretical models of writing aiming to help children struggling with writing, and also to inform instruction related to writing. For this purpose, research should focus on the relation between writing composition and their underlying processes.

Writing a connected text (i.e., written composition) is a highly complex task that depends on multiple processes (Kim, Otaiba, Sidler, & Gruelich, 2014) such as oral language skills, transcription skills, and memory (both long-term and working memory; Berninger, Abbott, Graham, & Richards, 2002; Berninger & Swanson, 1994; McCutchen, 2006; Shanahan, MacArthur, Graham, & Fitzgerald, 2006).

Hayes and Flower (1980; Hayes, 1996) were pioneers in conceiving a model that provided us an understanding of the writing process. In this model skilled adult writer is conceptualised as using three main cognitive processes to produce a text: translating, planning and reviewing/revising. Their model also incorporated working memory, long-term memory as well as motivation for writing (Hayes, 1996). Moreover, the model was derived on think-aloud protocols of adults, and hence does not address the development of writing skills. Even so, it served as a framework for developmental models of writing in young children (Berninger, Winn, MacArthur, Graham, & Fitzgerald, 2006).

The Simple View of Writing was modeled as an analogy to the Simple View of Reading (Juel, Griffith, & Gough, 1986) and based on the Hayes and Flower (1980) and Hayes (1996) theories of writing. In its first conceptualization, writing is accounted by ideation and spelling (Juel, Griffith, & Gough, 1986). Ideation refers to the ability to generate and organize ideas. Spelling is accomplished by the orthographic cipher – the knowledge of spelling-sound correspondence rules – and by lexical orthographic knowledge – knowledge of specific items in the lexicon, about which rules do apply (or do not) to specific words. The combination of both types of knowledge – spelling-sound correspondence rules and lexical orthographic knowledge – provides the required

information for spelling, that in turn together with ideation enables text generation (Juel, Griffith, & Gough, 1986).

A revised Simple View of Writing (Berninger, Vaughan, Abbott, Begay, Byrd, & Curtin, 2002) conceptualizes that transcription and executive functions are the foundational bases that contribute to text generation at different levels of language (words, sentences and text). Afterwards, Berninger and colleagues (2006) expanded the model to the Not so- Simple View of Writing in order to incorporate the relations between working memory and long-term memory and emphasized the supervisory role of attention concerning executive functions.

These theoretical developmental accounts of writing (Berninger et al., 2002) assume that several cognitive and linguistic factors are necessary for writing development, being composed of low-level and high-level processes. The later ones concern to executive functions and include planning, revision and translation, i.e., ideation. Transcription is posited to be the lower level skill and consists of handwriting (Berninger et al., 2002) and spelling (Juel, Griffith, & Gough, 1986; Berninger et al., 2002). Additionally, it is argued that composing requires an efficient online coordination of both low-level and high-level processes (Fayol, 2012).

The role of the low-level and high-level processes on written text/composing changes along development. At beginning of learning novice writers rely on the low-level skills, i.e. transcription skills such as handwriting and spelling. At very beginning of learning, these skills need to be taught and practiced over and over until they achieve automaticity. Automaticity frees up resources that will feed up more cognitive demanding and complex processes (e.g., Connelly, Dockrell, & Barnett, 2012). Older expert writers with more automatic transcription skills have a stronger planning and reviewing/revising because they need to focus minimally on transcription skills. Thus, transcription processes would explain most of individual differences in writing skill in

novice writers whereas for skilled writers planning and reviewing are the strategic processes that explain those individual differences.

In the present study our goal is to examine in children the role of transcription processes and their contribution to text generation. Despite its importance, we will not explore the influence of executive functions on writing composition.

As already mentioned, handwriting and spelling are the key components of transcription skill in writing. Research about children writing development shows that these two transcription skills account for a large part of variance in writing composition quality scores (see Berninger, 1999, for a review).

Several studies (e.g., Berninger & Swanson, 1994; Graham, Berninger, Abbott, Abbott, & Whitaker, 1997) with typically developing children shown that handwriting fluency is a strong predictor of writing composition scored as length and quality. More recently, Wagner and colleagues (Wagner et al., 2011) found that handwriting fluency is moderately (at first grade) and highly (at fourth grade) correlated with several factors of writing composition (e.g., macro organization, complexity and productivity), particularly having the strongest relation with productivity (total number of words and number of different words produced).

Spelling, the second key component of transcription, have also been observed as having an influence on writing composition in children with dyslexia (e.g., Berninger, Nielson, Abbott, Wijsman, & Raskind, 2008) and in typical developing children (e.g., Abbott, Berninger, & Fayol, 2010). Berninger, and colleagues (Berninger et al., 2008) examined 122 children (ranging from 7 to 14 years old) with dyslexia and found that word spelling was a key predictor of overall quality of writing composition. In another study, a longitudinal one (with overlapping cohorts), word spelling was found to explain remarkable variance of written composition from the first through seventh grades (Abbott et al., 2010). The authors advance one interpretation for this robust longitudinal

relationship: “children with stronger spelling skills are more likely than those who have weaker spelling skills to translate ideas into written words and combine written words to generate written text” (pp. 294). Furthermore, accordingly to the authors, spelling skills were the most stable of all writing skills across the 5 years.

Beyond these constituent skills of the transcription process, it’s theoretically plausible (Juel et al., 1986; Juel, 1988) that other abilities underpinning them can also make a specific contribution to the development of written composition skills. We believe that this is the case of the orthographic knowledge, a foundational skill of spelling acquisition.

In fact, orthographic knowledge was recently considered as one of the factors that predict spelling acquisition (e.g., Conrad, Harris, & Williams, 2013; Rothe, Schulte-Korne, & Ise, 2013; Querido, Fernandes, Verhaeghe, Carvalho, & Morais, 2015). Orthographic knowledge has been designated as mental representations of the words’ spelling in long term memory (e.g., Frith, 1980; Treiman, 1993). It encompasses two components (e.g., Apel 2011, Deacon et al., 2012): orthographic representations and orthographic pattern knowledge. The former acts at a lexical level whereas the later at a sublexical level.

Conrad and colleagues (Conrad et al., 2013) observed a contribution (15%) of orthographic knowledge – as a multidimensional construct (consisting of both lexical and sublexical orthographic knowledge) – on spelling skill, in English-speaking children aged between seven and eight years old, in a concurrent study. Additionally, both types of orthographic knowledge have a unique and separate contribution for word spelling (β=.32 and β=.29, for lexical and sublexical orthographic knowledge, respectively).

Accordingly, Rothe and colleagues (Rothe et al., 2013) also found an influence of orthographic pattern knowledge, at sublexical level, on spelling. The authors

observed that at the end of the first grade, German-speaking children's sensitivity to orthographic regularities – sublexical orthographic knowledge – explains a significant amount of variance in word spelling performance (7%).

More recently, in a longitudinal study, Querido and colleagues (Querido et al., 2015), found that in Portuguese-speaking children, early orthographic processing skill (lexical and sublexical) significantly predicts later spelling performance. Actually, sequential regression analyses showed that children's lexical orthographic knowledge accounted for a significant amount of unique variance in their word spelling performance (i.e. 5% between the beginning of Grade 2 and end of Grade 2; and 4% and 7% respectively, between the beginning of Grade 4 and the end of Grade 4 or the end of Grade 5). They also observed a contribution of sublexical orthographic knowledge (12%) at beginning of Grade 3, on pseudoword spelling performance at Grade 3. Cross-predictive effects between one level of orthographic knowledge and the other level of processing of spelling were also observed: lexical orthographic knowledge, at beginning of Grade 2, on pseudoword spelling performance at Grade 3 (8%). Contrarily, sublexical orthographic knowledge did not explain any variance in subsequent word spelling performance.

From this set of studies it is clear that both lexical and sublexical orthographic knowledge have an important role in spelling not only in English (Conrad et al., 2013) and German (Rothe et al., 2013) but also in Portuguese (Querido et al., 2015).

As already mentioned, spelling is an important skill that influences the written production (e.g., Abbott, Berninger, & Faiol, 2010). Since spelling suffers the influence from the two components of orthographic knowledge, and the former have a direct influence on written composition, we first hypothesized (H1) that both components of orthographic knowledge have a direct and/or mediated role on the composition process. The purpose of present study was to explore this issue.

It follows from this reasoning that children with stronger orthographic knowledge might acquire greater spelling skills over time. Additionally, if stronger orthographic knowledge enables greater word spelling skills it should be found that orthographic knowledge influences written composition through its influence on word spelling skill. If so, the relationship between orthographic knowledge and written composition should be statistically mediated by word spelling skill. This mediation could occur in two ways. First, mediation could be full – the relation between orthographic knowledge and written composition would be completely explained by the influence of orthographic knowledge on word spelling skill. Second, the relation could be partially mediated, and in this case orthographic knowledge links directly to written composition additionally to the indirect link through word spelling skill. Finally, the relation between orthographic knowledge and written composition could be not mediated by word spelling and instead orthographic knowledge links directly to written composition and would provide evidence against the idea that orthographic knowledge supports word spelling skill. Thus, in the current study we will contrast three different models of the relation between orthographic knowledge and written composition: *direct* i.e. with direct independent contributions of both components of orthographic knowledge to written composition; *full mediation* and *partial mediation* (see Figure. 1).

We also expected (Hypothesis 2) that lexical orthographic knowledge would have a higher or exclusive impact, direct or mediated, on written composition relatively to sublexical orthographic knowledge. This prediction was based on Querido et al., (2015) study where it was observed an influence of lexical orthographic knowledge on word spelling skill but not from sublexical orthographic knowledge.

To accomplish our goals, we used two measures of orthographic processing skill – the Orthographic Choice Task and the Orthographic Awareness Task – each at a different level of processing – lexical and sublexical, respectively. We assessed spelling

skill, a key part of the transcription process, through a set of Word Spelling Task (similar to those used in Querido et al., 2015). Finally, a measure of written composition was administered and scored as lexical diversity, an important predictor of compositional quality of writing (Beard, 1984).

The study focused on a cohort of children on Grades 2 and 3 because in these early Grades, the development of children's orthographic knowledge would have an impact on their word spelling skills. Children were tested at the beginning of Grade 2, and at the end of Grade 2 and Grade 3.

Method

Participants

A total of 83 children (of whom 37 girls) attending one cohort, from two public schools in the Lisbon district participated in the study. There were three testing periods: (i) in the initial three months of the school year in one grade; (ii) in the final three months of that same school year; (iii) in the last three months of the subsequent grade. Children's were tested in Grades 2 and 3.

Students came from two different classrooms per grade in each school. They were all native speakers of European Portuguese and had an average or above average cognitive functioning – 25th percentile or higher on the Raven's Coloured Progressive Matrices (Simões, 1994). Children flagged by their parents or teachers as having learning, emotional, or sensory disabilities were not included in the sample. These screening criteria determined the ineligibility of 15 from the initial sample.

Tests[8]

(a) Nonverbal abilities.

Raven's Colored Progressive Matrices.

The Portuguese adaptation of the Raven's Colored Progressive Matrices (Simões, 1994) was used to measure general nonverbal intellectual ability. It was administered at beginning of Grade 2.

[8] All of the tests considered in this study were developed and administered to the participants as part of the project "Developmental benchmarks of reading and writing in European Portuguese from the 1st to 6th grades" (2008-2010), which was conducted under the auspices of the National Reading Plan.

(b) Word spelling task.

Three word categories were used: simple regular (n = 12), complex regular (n = 12), and irregular words (n = 12). Each category contained 6 high frequency words and 6 low frequency words. Words were selected from Portulex, a lexical and frequency database for European Portuguese (Teixeira & Castro, 2007). High and low frequency words were roughly matched on number of syllables in oral pronunciation, more precisely, for high frequency words there were six disyllabic words and twelve trisyllabic words; and for low frequency words there were five disyllabic words and thirteen trisyllabic.

A word was defined as regular when its letter sequence was in accordance with the rules of Portuguese grapheme–phoneme and phoneme–grapheme correspondences. A word was defined as irregular when its letter sequence was not completely in accordance with these rules. Following Sprenger-Charolles et al.'s (1998) and Fernandes al.'s (2008) criteria, the irregular words chosen contained either a grapheme whose phonetic realization is unusual (for example, in "trânsito" the "s" is pronounced /z/ in only 25 words out of 125, according to the Portuguese database "Porlex" (Gomes & Castro, 2003), or a silent grapheme in a non-terminal position (e.g., "h" in hora).

An item was considered simple when each of its graphemes corresponded to one letter only (e.g., fita). It was considered complex if one of its graphemes contained more than one letter. Two types of digraphs were used: a vocalic digraph ou and four consonantal digraphs, nh, lh, ch and rr. These digraphs were selected because (i) either alternative spelling, although less frequent, exists for them (as is the case of ou and ch), or (ii) there is no alternative spelling (as is the case of nh and lh). Other than this, these digraphs pose no more difficulties in spelling than in reading.

The test was administered at the beginning and at the end of Grade 2.

There were three familiarization trials which could be re-administered if the child failed to understand the instructions. Words were first read in a sentence context and later dictated in isolation; this was done to avoid the possibility of confusion between homophones.

(c) Orthographic Knowledge.

Two tasks were used, one involving an orthographic choice, the other examining orthographic awareness. Both were administered at beginning and at the end of Grade 2.

Ortographic Choice Task.

In the Orthographic Choice Task, children were shown 32 sets of five stimuli (e.g., *braço – brasso – draço – braco – arbço*). Only one member of each set correctly matched a listened target word (e.g., *braço*). The other members corresponded to one pseudo-homophone foil (e.g., *brasso*); a word or pseudoword with a visual similarity in the first syllable (e.g., *draço*); a word or pseudoword with a visual similarity in the last syllable (e.g., *braco*); and a non-word that combined the letters of the target word in an illegal sequence for European Portuguese (e.g., *arbço*). In each set, stimuli were randomly presented in a centred column of an A5 sheet. The task was to select the member of each set that "matched" the heard word.

Orthographic Awareness Task.

In the Orthographic Awareness Task, children were shown 14 pairs of pronounceable pseudowords (e.g., *trino – rinot* and *drulo – srulo*). One member of each pair contained a string that never occurs in European Portuguese in the initial (e.g., *srulo*) or final (e.g., *rinot*) position; the other member of the pair contained an

orthographically legal string in the same position. The task was to select the member of each pair that "could be a word" or "looks like a word".

(c) Written composition task

Pairs of trained graduate students administered this task to children while their classroom teachers were present in classrooms. Testing occurred at the end of Grade 2 and 3. The writing prompt was designed to be similar to statewide curriculum-based writing assessments. Children's were asked to compose a text about a specific topic (e.g., summer holidays). Children had 30 minutes to complete the task. Some students stopped before the end and were not forced to continue. This task was scored as lexical diversity – number of different spelled words correctly.

General Procedure

The tests (Raven's Colored Progressive Matrices, the Orthographic Knowledge, Spelling, and Written Composition) were administered in different sessions by a trained graduate student, to large groups of participants.

Statistical Analysis: Path Analysis

Path analysis was used to test the hypotheses and to validate the proposed models (Figure 1) since this approach can examine complex relationships between multiple measures (Pedhazur, 1997). The statistical software AMOS 19.0 (Arbuckle, 2010) was used, and the maximum likelihood estimation method was adopted jointly with the percentile and bias-corrected bootstrap procedures to provide the confidence intervals of the indirect effects (Preacher & Hayes, 2008). The bootstrap procedures were used to create 2000 bootstrap samples. The existence of outliers was assessed by

the squared Mahalanobis distance, and the normality of the variables was assessed by the coefficients of skewness and univariate and multivariate kurtosis.

Path analysis enables researchers to specify and test structural models that reflect hypothesized relationships concerning direct or indirect causal effects among observed variables based on their correlation structure. With path analysis, we can determine the quantity of unique variance that one measure accounts for in another. This unique variance is represented by a path coefficient. Path analysis enables a more robust test of the relationships between measures because an estimate of measurement error for each measure is included using an estimate of the reliability of that measure.

Bootstrapping is a method of assigning measures of accuracy to sample estimates (Efron & Tibshirani, 1993). This technique enables the estimation of the sampling distribution of statistics by repeatedly sampling from the dataset and consequently allows to inference of path coefficients. Similarly to the traditional bootstrap, the percentile and the bias-corrected bootstrap procedures are used to estimate the indirect effect in each resampled dataset and, therefore, to allow the significance analysis of the specific and total indirect effects in the mediator models (Preacher & Hayes, 2008).

Three models are used to test structural hypotheses concerning the relationships between each of the two components of orthographic knowledge (lexical and sublexical), word spelling, and written composition. In model 1, lexical and sublexical orthographic knowledge were proposed to be direct predictors of the written composition measure (Figure 1 – Model 1). In model 2, we test a full mediated contribution of word spelling, i.e. lexical and sublexical orthographic knowledge were expected to be predictors of written composition with a complete mediation of word spelling (Figure 1 – Model 2). Model 2 intends to test the full mediation. However, the mediation role of word spelling could be partial, instead of complete. Therefore, another

model, the model 3 or the partial mediation model is estimated. This latter model tests direct paths from lexical and sublexical orthographic knowledge on written composition and the mediated effect of word spelling between orthographic knowledge (lexical e sublexical) and written composition (Figure 1 – Model 3).

As above mentioned, the proposal models use variables measured in three different moments - at the beginning of the Grade 2, at the end of Grade 2 and at the end of Grade 3 –, in two distinct ways: (1) Independent variables measured in the beginning of Grade 2 and the outcome variable at the end of Grade 2 (Set 1), and (2) independent variables measured in the end of Grade 2 and the outcome variable at the end of Grade 3 (Set 2).

For each specified relationship, a path coefficient was obtained and examined for significance using a t test. The t statistic was used to determine if the path coefficient was significantly different from zero.

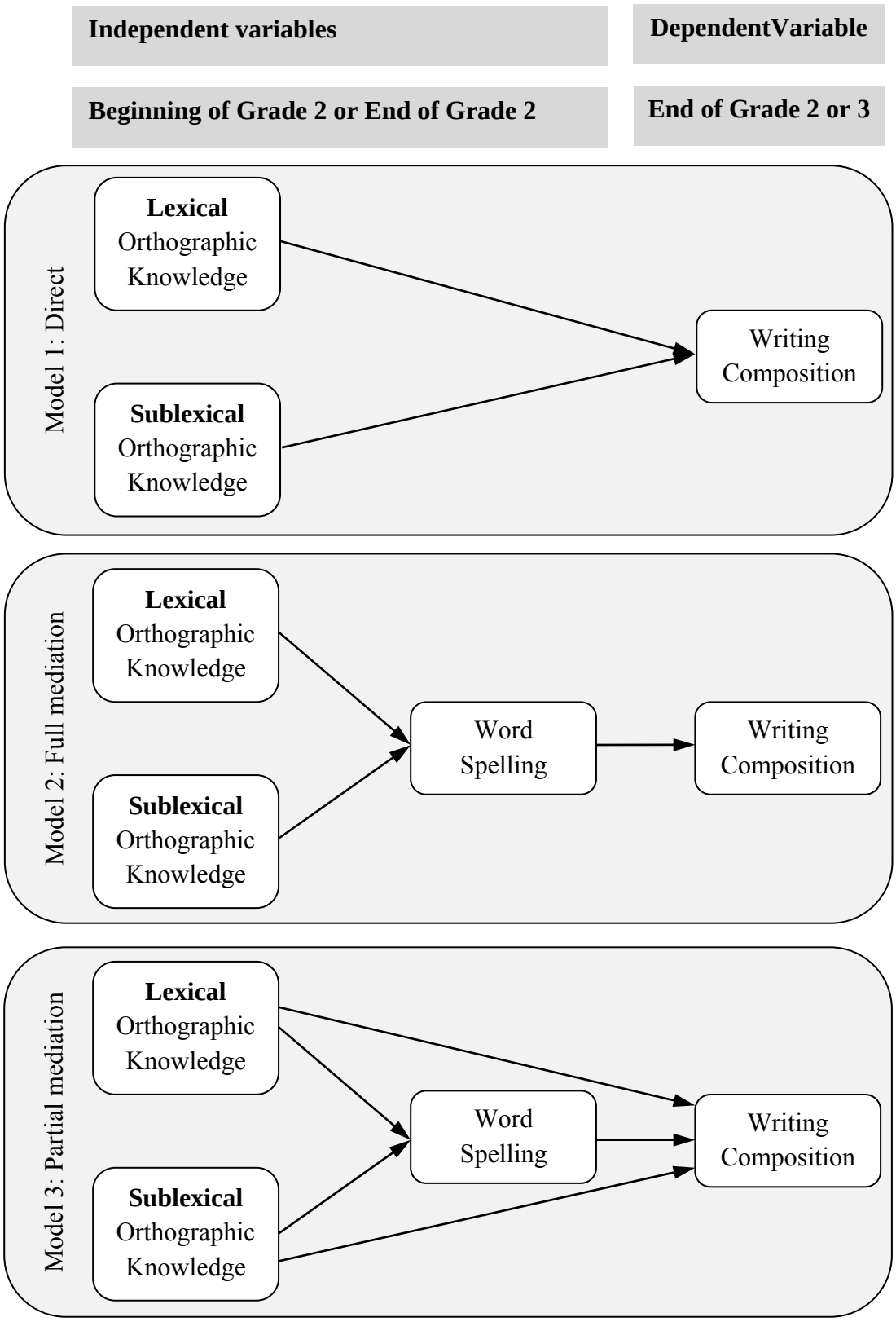

Figure 1. Path diagrams of the three proposal models

Results

Table 1 shows means and standard deviations for accuracy in the Orthographic Choice Task, Orthographic Awareness Task, and Word Spelling; and for number of different spelled words on Written Composition. For both orthographic tasks, accuracy scores were expressed as proportion of correct responses and as chance-corrected proportion[9] (.20 and .50, respectively, for the Orthographic Choice Task and Orthographic Awareness Task).

The correlations among all variables are shown in Table 2.

Table 1

Means and standard deviations for correct responses and response times in the various tests for each cohort of students by testing period.

	Grade 2				Grade 3	
	Beginning		End		End	
	M	SD	M	SD	M	SD
Orthographic Choice Task* (accuracy)	.72	.16	.81	.12		
Corrected values	.64	.20	.76	.15		
Orthographic Awareness Task** (accuracy)	.76	.16	.83	.14		
Corrected values	.52	.30	.67	.27		
Word Spelling Task	.64	.13	.79	.12		
Written Composition Task						
Number of different words			65.89	23.45	57.90	17.02

Note. 1) Beginning = November-January; End = April-June; 2) accuracy = mean proportion of correct responses; * Chance level for complete test was .50; ** Chance level for complete test was .20; the means and standard deviations presented in each cell of the table were calculated without the outliers (N= 80).

[9] The data for each forced-choice task (Orthographic Choice Task and Orthographic Awareness Task) were the proportion of chance-corrected successful detections. The chance level was different for each task (.50 and .20, for Orthographic choice and Orthographic awareness, respectively), and the compensation for chance success was accomplished using the formula $p = (p' - c) / (1 - c)$, where p = the corrected detection proportion; p' = the raw proportion; and c = the probability of being correct by chance (e.g., Clark, Rutschmann, Link, & Brown, 1963).

Table 2

Correlation Matrix for all measures.

	Variable	1	2	3	4	5	6	7	8
1	Orthographic Choice Task at **beginning of Grade 2**	1	.27*	.63**	.62**	.21	.59**	.38**	.14
2	Orthographic Awareness Task at **beginning of Grade 2**		1	.38**	.39**	.23*	.29*	.23*	.01
3	Word Spelling Task at **beginning of Grade 2**			1	.60**	.16	.72**	.34**	.08
4	Orthographic Choice Task at **end of Grade 2**				1	.09	.66**	.27*	.14
5	Orthographic Awareness Task at **end of Grade 2**					1	.23*	.11	-.06
6	Word Spelling Task at **end of Grade 2**						1	.35**	.13
7	Written Composition Task at **end of Grade 2**							1	.28*
8	Written Composition Task at **end of Grade 3**								1

* p < .05 ** p < .01

Model estimation results

The three hypothesized models above mentioned tested the contribution[10] of the two components of orthographic knowledge on written composition. Figure 2 and 3 presents the path diagrams for the estimated models for Set 1 and Set 2, respectively. Relationships with non-significant path coefficient estimates were represented by a dotted line in the models.

A fourth model is estimated in the case of Set 1 (independent variables measured in the beginning of Grade 2 and the outcome variable at the end of Grade 2) as a result of removing the non-significant paths founded in Model 3 (Model 3.1). This procedure was only carried out for Set 1, because the Model 3 - Set 2 (independent variables measured in the end of Grade 2 and the outcome variable at the end of Grade 3) did not present any significant path coefficient estimates between the independent variables (lexical and sublexical orthographic knowledge and word spelling) and the outcome variable (writing composition).

[10] We are conscious that path analysis relies on the association of variables represented by correlational values. Therefore, the inferred causal relationships were only based on our interpretation of path coefficients accordingly with theoretical literature revision.

None of the variables exhibited values that indicated that the data have non-normal distribution. There were few outliers, which were removed before the model estimations were performed.

A summary of model fit is presented in Tables 3 and 4. The estimated models exhibited a good fit to the data. The model fit was assessed using the minimum fit function chi-square statistic (Bollen, 1989; Joreskog & Sorbom, 2003), the Comparative Fit Index (CFI) (Bentler, 1990) and the Root Mean Square Error of Approximation (RMSEA) (Browne & Cudeck, 1993). Our final models (Figure 2) have a chi-square range value between 0 and 5.34 with p-value >.05. The CFI value was good in all of the models (1 or near 1, which indicates perfect fit), and the RMSEA value was within the range that would be associated with an acceptable fit. Overall, these statistics indicate that the models have a good fit. Thus, the data did not significantly deviate from the proposed model for each grade (Joreskog & Sorbom, 2003, Hair, Black, Babin, Anderson, & Tatham, 2005).

Table 3

Model fit indices with independent variables measured in the beginning of Grade 2 and the outcome variable at the end of Grade 2 (Set 1).

Model	X^2	d*f*	*p*	CFI	RMSEA(a)
1 – Direct	0.00	0	saturated model		
2 – Total mediation	5.34	2	.07	.95	.15 [.00; .30]
3 – Partial mediation	0.00	0	saturated model		
3.1 – Partial mediation	2.61	2	.27	.99	.06 [.00; .24]

(a) Confidence intervals at 90% for RMSEA; * if the p-value of the test H0: RMSEA≤0.05 is inferior to 0.05. In this test we aim to non reject the null hypothesis; The RMSEA value is bolded in case of p>0.5 meaning good fit..

Table 4

Model fit indices with independent variables measured in the end of Grade 2 and the outcome variable at the end of Grade 3 (Set 2).

Model	**χ^2**	**d*f***	***p***	**CFI**	**RMSEA (a)**
1 – Direct	0.00	0		**saturated model**	
2 – Total mediation	1.09	2	.58	1.00	**.00** [.00; .19]
3 – Partial mediation	0.00	0		**saturated model**	

(a) Confidence intervals at 90% for RMSEA; * if the p-value of the test H0: RMSEA≤0.05 is inferior to 0.05. In this test we aim to non reject the null hypothesis; The RMSEA value is bolded in case of p>0.5 meaning good fit..

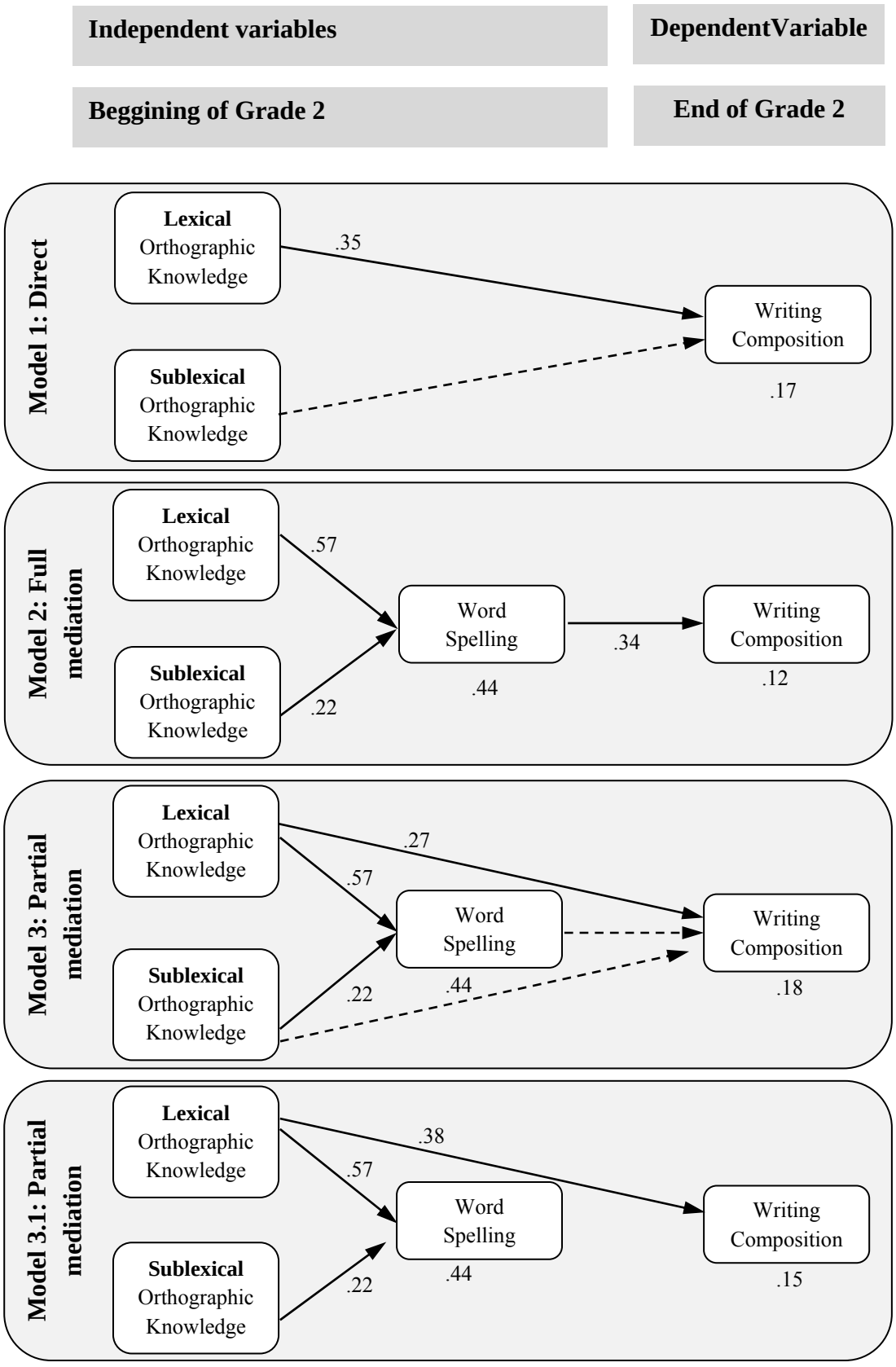

Figure 2. Path diagram of proposed models depicting relationships with significant path coefficient estimates for Set 1.

The squared multiple correlations (R^2) for writing composition and for word spelling are significant for the two sets of models with the exception of writing composition in Model 3 (Set 2) which presents a non significant squared multiple correlation (R^2=.03, p>.10) (Table 5).

Table 5

Squared multiple correlations of endogenous variables for each grade/model.

	Set 1- Independent variables measured in the beginning of Grade 2 and the outcome	Set 2 - Independent variables measured in the end of Grade 2 and the outcome variable at the
Model 1	R^2	R^2
Writing Composition	.17*	.03**
Model 2	R^2	R^2
Word Spelling	.44**	.46**
Writing Composition	.12*	.02*
Model 3	R^2	R^2
Word Spelling	.44**	.46**
Writing Composition	.18**	.03
Model 3.1	R2	
Word Spelling	.44**	
Writing Composition	.15*	

* p<.01; ** p<.05

Tables 6 and 7 contain the standardized path coefficients and its bootstrapped confidence intervals at 90% (obtained by the Bias-corrected bootstrap procedure) for all effects of Orthographic Knowledge on the writing composition, for Set 1 and 2 respectively.

Results of the three estimated models, of the Set 1, can be summarized as follows:

(1) In Model 1, only the lexical component of the Orthographic Knowledge directly influences the writing composition (coefficient estimate of 0.35; $p<0.01$).

(2) Analyzing the models 1, 2, and 3, it can be observed that Word Spelling does not mediate the relationship between Lexical Orthographic Knowledge and Writing Composition. The model 2 shows a significant indirect effect through Word Spelling (coef. estimate of 0.195, $p<0.01$); however the model 3 shows that the magnitude of direct effect decreases from 0.35 (model 1) to 0.27, meaning that the mediation effect of Word Spelling is very weak. Indeed the indirect effect in the model 3 has a non-significant estimated coefficient of 0.074 ($p=0.26$); therefore, the hypothesis concerning the mediation is not verified when the lexical component of the Orthographic Knowledge is taken into account.

(3) When the paths with non-significant coefficients from Model 3 are removed, there is a slightly higher direct influence (coefficient estimate of 0,38; $p<0.01$) from Lexical Orthographic Knowledge on the Writing Composition.

(4) Regarding the Sublexical component of the Orthographic Knowledge, it does not directly influence the Writing Composition (models 1 and 3); however there is a weak indirect effect on this variable through word spelling (coefficient estimate of 0,077; $p<0.01$) (see model 2), meaning that this latter variable may be considered a full mediator of the Sublexical Orthographic Knowledge- Writing Composition relationship. Thus, Sublexical Orthographic Knowledge weakly influences the Writing Composition through mediation of Word Spelling.

For the Set 2 there are not any significant path coefficients, either directly or mediated from the two components of Orthographic knowledge on Writing Composition. In addition, Word Spelling does not have a significant effect on Writing

Composition. Therefore, the Writing Composition of children at the end of Grade 3 is not influenced by their Orthographic knowledge at the end of Grade 2.

Finally it is important to underline that in both sets of models, Orthographic Knowledge was able to explain an high and significant amount of variance in word spelling (44% for the Set 1 with Independent variables measured in the beginning of Grade 2 and the outcome variable at the end of Grade 2; and 46% for the Set 2 with Independent variables measured in the end of Grade 2 and the outcome variable at the end of Grade 3). In the Set 1, the lexical component of orthographic knowledge has a strong significant effect on word spelling (coefficient estimate of .57; $p < .01$) while the sublexical component exhibits an effect of .22 ($p < .01$). Additionally, in the set 2, in a more advanced moment of children development, only the lexical component of orthographic knowledge shows a significant effect on word spelling (coefficient estimate of 0.63; $p<0.01$), assuming an exclusive important role.

Table 6

Effects of Orthographic Knowledge on Writing Composition for Set 1 (independent variables measured in the beginning of Grade 2 and the outcome variable at the end of Grade 2)

		St. Est.	90%CI for St. Est.	P
Lexical				
Model 1 - without mediation	Direct effect	0.35	] 0.15; 0.52[	0.00
Model 2 – full mediation	Indirect effect	0.20	] 0.10; 0.30[	0.00
Model 3 – partial mediation	Direct effect	0.27	]0.05; 0.49[	0.06
	Indirect effect	0.07	]-0.04; 0.19 [	0.26
	Total effect	0.35	]0.15; 0.52 [	0.00
SubLexical				
Model 1 - without mediation	Direct effect	0.14	] -0.06; 0.31[	0.27
Model 2 – full mediation	Indirect effect	0.08	] 0.02; 0.15[	0.01
Model 3 – partial mediation	Direct effect	0.11	]-0.09; 0.28[	0.37
	Indirect effect	0.03	]-0.01; 0.09 [	0.24
	Total effect	0.14	]-0.06; 0.31[	0.27

Table 7

Effects of Orthographic Knowledge on Writing Composition for Set 2 (independent variables measured in the end of Grade 2 and the outcome variable at the end of Grade 3)

		St. Est.	90%CI for St. Est.	P
Lexical				
Model 1 - without mediation	Direct effect	0.15	] -0.03; 0.33[	0.19
Model 2 – full mediation	Indirect effect	0.08	]-0.04; 0.21[	0.27
Model 3 – partial mediation	Direct effect	0.10	]-0.11; 0.31[	0.41
	Indirect effect	0.05	]-0.08; 0.19 [	0.51
	Total effect	0.15	]-0.03; 0.33 [	0.19
SubLexical				
Model 1 - without mediation	Direct effect	-0.07	]-0.24; 0.09[	0.50
Model 2 – full mediation	Indirect effect	0.02	]-0.01; 0.07[	0.19
Model 3 – partial mediation	Direct effect	-0.09	]-0.27; 0.09[	0.47
	Indirect effect	0.01	]-0.02; 0.07 [	0.36
	Total effect	-0.07	]-0.24; 0.09[	0.48

Discussion

In the present study we intended to examine whether the written composition process benefits from the long lasting contribution of lexical and sublexical components of orthographic knowledge among a cohort of Portuguese children from the beginning of grade 2 to the end of grade 3. We also intend to highlight whether this possible influence occurred directly, or is partially mediated, or otherwise totally mediated by word spelling.

According to the not so simple view of writing (Berninger et al., 2006), spelling is a key transcription skill posited to promote text generation. It is also postulated that among novice writers, this low level skill – transcription skills – would be more important to writing composition than higher level skills.

Regarding spelling, the theoretical account of Ehri (2005) suggested that the development of efficient word spelling is supported by overall orthographic knowledge. Ehri's (2005) phase model proposed that familiar and unfamiliar word spelling could be accomplished through both lexical and sublexical orthographic knowledge: either using word specific representations stored in memory or by analogy to stored words through; furthermore, sublexical orthographic knowledge would furnish beneficial expectations and constraints to spell any word.

Accordingly with these theoretical accounts we first hypothesized that orthographic knowledge, an underpinning ability of word spelling, have an effect on written composition skill. This influence could occur in three ways: 1) the establishment of strong orthographic knowledge will enable the acquisition of efficient word spelling that in turn influences written composition – a full indirect or mediated contribution of orthographic knowledge, through word spelling on written composition; 2) behind this indirect link, orthographic knowledge would also directly influence written composition

– partially mediated contribution; and 3) it may be the case that the contribution of orthographic knowledge on written composition occurs only directly, without any mediation.

Based on previous empirical data (Querido et al., 2015) our second hypothesis concerns the possible different weight contribution of lexical and sublexical components of orthographic knowledge on written composition. Thus, we expected that written composition benefits more or exclusively from the influence of the lexical orthographic knowledge, comparatively to sublexical orthographic knowledge.

These hypotheses were tested contrasting three different path models. Results suggest that indeed, there is an effective contribution of orthographic knowledge on written composition, confirming our first hypothesis. We found that early orthographic knowledge (lexical and sublexical) significantly predicts later written skills, explaining between 12% and 18% of individual variance in writing composition in our path models. In fact, results of path analysis shown that lexical orthographic knowledge, at the beginning of Grade 2, contributes directly (without mediation by word spelling) to written composition at the end of Grade 2 (β=.38). Concerning the sublexical component of orthographic knowledge, although weak, it also has a predictive effect on written composition, but in that case it was fully mediated by word spelling. That is, sublexical orthographic knowledge, at the beginning of Grade 2, has an indirect contribution on written composition at the end of Grade 2, through word spelling (β=.08). Moreover, as predicted, the influence of sublexical orthographic knowledge on written composition was weaker comparatively to the influence of lexical orthographic knowledge, supporting our second hypothesis.

It is with noting that the influence of orthographic knowledge on written composition either directly (lexical component) or mediated (sublexical component)

only occurs at a very early stage of reading acquisition – within Grade 2, and not at a more advanced level – from the end of Grade 2 to the end of Grade 3. Therefore, the observed role of orthographic knowledge on written composition is in agreement with the conception that low level processes are more relevant at the beginning of literacy. Theoretical approaches (Berninger et al., 2002; Berninger et al., 2006; Juel et al., 1986; Juel, 1988) consider spelling and hence orthographic knowledge a low level ability. They also suggest that at the beginning of literacy, novice writers rely more on this lower level abilities, and only when its mastery and automaticity is attained, they will free resources for a greater intervention of high level processes.

Corroborating a main finding reported in Querido et al (2015), orthographic knowledge plays a crucial role during the process of learning to read and spell as a source of individual differences in the ability to correctly spell words. In fact, early orthographic knowledge (at the beginning and at the end of Grade 2) explains a significant amount of variance in later ability (44% and 46% at the end of Grade 2 and 3, respectively) to spell words. Additionally, and in line with Querido et al (2015), we observed that the influence of lexical orthographic knowledge on word spelling was higher ($\beta = .57$ from the beginning to the end of Grade 2) or exclusive ($\beta = .63$ from the end of Grade 2 to the end of Grade 3) in comparison to the one attributable to sublexical orthographic knowledge ($\beta = .22$ from the beginning to the end of Grade 2 and non significant from the end of Grade 2 to the end of Grade 3). Thus, despite the observed influence of sublexical orthographic knowledge, lexical orthographic knowledge seems to have a stronger and long-lasting influence on the ability to spell familiar words. The observed effects are in agreement with the Ehri's theory that proposes that the use of lexical as well as sublexical knowledge allows children to spell words correctly, either

by given them access to word specific representations or expectations and constrains about how a word could be spelled.

Orthographic knowledge is an underpinning ability of word spelling development that, in turn, was postulated as a key predictor of written composition (e.g., Berninger et al., 2008 and Abbott et al., 2010). Thus, our results are in agreement with the original conception of *Simple View of Writing* (Juel et al., 1986; Juel, 1999) where orthographic knowledge is conceived as part of spelling ability, and suggest that foundational abilities of transcription skills could also, by their own, make a specific contribution to the written composition skills. Consequently, the *Not So Simple View of Writing* model (Berninger et al., 2006) should accommodate the specific role of orthographic knowledge as well as from other foundational abilities (e.g., decoding) underlying the postulated transcription skills. It should be noted that word spelling, in our more complex model (Model 3) does not make a significant contribution to written composition. Therefore, this result suggests that when their foundational abilities are included in the model, word spelling loses their predictive effect on written composition. This result is not fully in agreement with prior evidences (e.g., Abbott et al., 2010) that suggest that spelling is a crucial predictor of writing composing. Presumably with the inclusion of the two components of the orthographic knowledge, our study has highlighted their specific contribution removing predictive power to the word spelling skill. However, we believe that word spelling itself has an important role, on writing composition. Perhaps, if we used a quality measure of written composition, or in a language with a more opaque orthography, this influence arises. Nonetheless, it seems essential to include the two components of the orthographic knowledge in future studies exploring the writing composition predictors. In fact, and as it is known (Kim et al., 2014), writing a connected text depends on multiple processes and is a highly

complex task. It is possible that in a different stage of development other foundational abilities of transcription skills would be more influent to written composition process. We believe that phonological recoding, a subjacent ability of orthographic knowledge and word spelling, in an earlier stage of development, should assume a direct or mediated role on written composition, more important than those of orthographic knowledge itself. More research would be needed to clarify this issue.

It is worth noting that the relationship between orthographic knowledge and reading and spelling may also depend on the characteristics of the orthographic code, particularly, its degree of transparency and, on the type and size of the orthographic patterns used in English (Deacon et al., 2012), German (Ise et al., 2014) and Portuguese. Consequently, the influence of orthographic knowledge on writing skills may also depend from these language characteristics.

The difficulty in spelling would differ between orthographic systems accordingly with the consistency of phoneme-grapheme correspondences (Bonin, Collay, & Fayol, 2008). European Portuguese is a less transparent language than Finnish, Dutch or Turkish but not as inconsistent as English (see Fernandes, Ventura, Querido, & Morais, 2008, and Sucena, Castro, & Seymour, 2009 for a characterization of the orthography). In the case of European Portuguese orthography there is no complete one-to-one phoneme-grapheme or grapheme-phoneme mapping. This inconsistency is more remarkable for spelling than it is for reading (Morais, 1997). Consequently, Portuguese children have a higher degree of difficulty in spelling. Under these circumstances, to achieve a correct spelling it is necessary to build-up and use both lexical and sublexical orthographic knowledge. Although few, some studies have examined the role of these two components of orthographic knowledge on reading and spelling acquisition in other languages than English (e.g. Babayigit & Stainthorp, 2010).

However, research examining writing skills, in typically developing children is restricted or few in number in English but even fewer in writing systems with other consistency (Babayigit & Stainthorp, 2010). In this way our study could be considered as a contribuition to the growth body of knowledge about the component processes of spelling and writing in languages other than English. Besides, our findings are the first empirical evidence of the influence of orthographic knowledge on written composition and are worthy of attention since they arise from stringent longitudinal analysis. This raises an important issue that needs additional investigation in different orthographic systems and with different writing measures.

Conclusion

The present study aimed to contribute to the area of research on writing providing additional evidence to the role of lexical and sublexical components of orthographic knowledge on word spelling, but also showing that their role could be extended to more distant and general skills such as written composition. Importantly, we found that in addition to spelling and handwriting, orthographic knowledge also plays an important role in writing skills development in a semi-transparent orthography such as European Portuguese. Therefore, the present findings suggest that different processes underpinning the proposed transcription skills should be considered as contributors to writing skill development.

References

Abbott, R. D., Berninger, V. W., & Fayol, M. (2010). Longitudinal relationships of levels of language in writing and between writing and reading in grades 1 to 7. *Journal of Educational Psychology*, *102*(2), 281-298. doi: 10.1037/a0019318

Apel, K. (2011). What is orthographic knowledge?. *Language, Speech, and Hearing Services in Schools*, *42*(4), 592-603. doi: 10.1044/0161-1461(2011/10-0085)

Beard, R. (1984). *Children's writing in the primary school*. Seven Oaks: Hodder and Stoughton.

Berninger, V., & Swanson, H. L. (1994). Modifying Hayes and Flower's model of skilled writing to explain beginning and developing writing. In E. Butterfield (Ed.), *Children's writing: Toward a process theory of development of skilled writing* (pp. 57–81). Greenwich, CT: JAI Press.

Berninger, V., Winn, W., MacArthur, C. A., Graham, S., & Fitzgerald, J. (2006). Implications of advancements in brain research and technology for writing development, writing instruction, and educational evolution. In C. MacArthur, S. Graham, & J. Fitzgeral, (Eds.), *Handbook of writing research (pp.* 96-114). New York: Guilford Press.

Berninger, V. W. (1999). Coordinating transcription and text generation in working memory during composing: Automatic and constructive processes. *Learning Disability Quarterly*, *22*(2), 99-112. doi: 10.2307/1511269

Berninger, V. W., Abbott, R. D., Abbott, S. P., Graham, S., & Richards, T. (2002). Writing and reading connections between language by hand and language by eye. *Journal of Learning Disabilities*, *35*(1), 39-56. doi: 10.1177/002221940203500104

Berninger, V. W., Nielsen, K. H., Abbott, R. D., Wijsman, E., & Raskind, W. (2008). Writing problems in developmental dyslexia: Under-recognized and under-treated. *Journal of School Psychology*, *46*(1), 1-21. doi:10.1016/j.jsp.2006.11.008

Berninger, V., Vaughan, K., Abbott, R., Begay, K., Byrd, K., Curtain, G., & Graham, S. (2002). Teaching spelling and composition alone and together: Implications for the simple view of writing. *Journal of Educational Psychology*, *94*, 291-304. doi: 10.1037/0022-0663.94.2.291

Bonin, P., Collay, S., & Fayol, M. (2008). La consistance orthographique en production verbale écrite: une brève synthèse. *L'Année Psychologique*, *108*(4), 517-546. Retrieved from http://leadserv.u-bourgogne.fr/files/publications/000154-la-consistance-orthographique-en-production-verbale-ecrite-une-breve-synthese.pdf

Connelly, V., Dockrell, J. E., Barnett, A. L., & Lane, G. (2012). Children challenged by writing due to language and motor difficulties. In V. Berninger (Ed.), *Past, present, and future contributions of cognitive writing research to cognitive psychology* (pp. 217–245). New York: Psychology Press/Taylor Francis Group.

Conrad, N. J., Harris, N., & Williams, J. (2013). Individual differences in children's literacy development: The contribution of orthographic knowledge. *Reading and Writing*, *26*(8), 1223-1239. doi: 10.1007/s11145-012-9415-2

Deacon, S. H., Benere, J., & Castles, A. (2012). Chicken or egg? Untangling the relationship between orthographic processing skill and reading accuracy. *Cognition*, *122*(1), 110-117. doi: 10.1016/j.cognition.2011.09.003

Dunn, L. M., Padilla, E. R., Lugo, D. E., & Dunn, L. M. (1986). *Manual Del Examinador para el Test de Vocabulário en Imágenes Peabody*. Circle Pines: American Guidance Service.

Fayol, M. (2012). Cognitive Processes of Children and Adults in Translating Thought Into Written Language in Real Time Perspectives From 30 Years of Programmatic Cognitive Psychology. In V. Berninger (Ed.), *Past, present, and future contributions of cognitive writing research to cognitive psychology* (pp. 27–59). New York: Psychology Press/Taylor Francis Group.

Fernandes, S., Ventura, P., Querido, L., & Morais, J. (2008). Reading and spelling acquisition in European Portuguese: A preliminary study. *Reading and Writing*, *21*(8), 805-821. doi: 10.1007/s11145-007-9093-7

Frith, U. (1980). Unexpected spelling problems. In U. Frith (Ed.), *Cognitive processes in spelling* (pp.495-515). London: Academic Press.

Graham, S., Berninger, V. W., Abbott, R. D., Abbott, S. P., & Whitaker, D. (1997). Role of mechanics in composing of elementary school students: A new methodological approach. *Journal of Educational Psychology*, *89*(1), 170-182. doi: 10.1037/0022-0663.89.1.170

Hayes, J. R. (1996). A new model of cognition and affect in writing. In M. Levy, & S. Ransdell (Eds.). *The science of writing*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Hayes, J. R., & Flower, L. S. (1980). Identifying the organization of writing processes. In I. Gregg & E. Steinberg (Eds.), *Cognitive Processes in Writing* (pp. 3-30). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Instituto de avaliação educativa, I.P. (2015). Provas do 3.º CEB - distribuições de classificações. Retrieved from http://iave.pt/np4/file/225/Resultados_3._ceb_distribui__o.pdf

Ise, E., Arnoldi, C. J., & Schulte-Körne, G. (2014). Development of orthographic knowledge in German-speaking children: a 2-year longitudinal study. *Journal of Research in Reading*, *37*(3), 233-249. doi: 10.1111/j.1467-9817.2012.01535.x

Juel, C., Griffith, P. L., & Gough, P. B. (1986). Acquisition of literacy: A longitudinal study of children in first and second grade. *Journal of Educational Psychology*, *78*(4), 243-255. doi: 10.1037/0022-0663.78.4.243

Kenny, D. A. (1975). Cross-lagged panel correlation: A test for spuriousness. *Psychological Bulletin*, *82*(6), 887-903. doi: 10.1037/0033-2909.82.6.887

Kim, Y. S., Al Otaiba, S., Sidler, J. F., & Gruelich, L. (2013). Language, literacy, attentional behaviors, and instructional quality predictors of written composition for first graders. *Early Childhood Research Quarterly*, *28*(3), 461-469. doi:10.1016/j.ecresq.2013.01.001

McCutchen, D. (2006). Cognitive factors in the development of children's writing. In C. MacAuthur, S. Graham, & J. Fitzgerald (Eds.), *Handbook of writing research* (pp. 115–130). New York: Guilford.

Morais, J. (1997): A arte de ler : psicologia cognitiva da leitura. Lisboa: Edições Cosmos.

National Center for Education Statistics (2002). The Nation's Report Card: Writing Highlights 2002. Institute of Education Sciences, U.S. Department of Education, Washington, D.C. Retrieved from http://files.eric.ed.gov/fulltext/ED476189.pdf

National Center for Education Statistics (2012). The Nation's Report Card: Writing 2011. Institute of Education Sciences, U.S. Department of Education, Washington, D.C. Retrieved from http://www2.ed.gov/pubs/edpubs.html.

National Commission on Writing. (2003). The neglected R: The need for a writing revolution. Retrieved from http://www.collegeboard.com

Querido, L., Fernandes, S., Verhaeghe, A., Carvalho, C., & Morais, J. (2015). *Does orthographic knowledge influence reading and spelling acquisition? A longitudinal study.* Manuscript in preparation.

Rothe, J., Schulte-Körne, G., & Ise, E. (2014). Does sensitivity to orthographic regularities influence reading and spelling acquisition? A 1-year prospective study. *Reading and Writing*, *27*(7), 1141-1161. doi: 10.1007/s11145-013-9479-7

Shanahan, T., MacArthur, C. A., Graham, S., & Fitzgerald, J. (2006). Relations among oral language, reading, and writing development. In C. MacAuthur, S. Graham, & J. Fitzgerald (Eds.), *Handbook of writing research* (pp. 171-183). New York: Guilford.

Simões, M. R. (1994). *Investigações no âmbito da aferição nacional do teste das Matrizes Progressivas Coloridas de Raven (M.P.C.R.)*. Dissertação de Doutoramento. Coimbra: Universidade de Coimbra.

Sucena, A., Castro, S. L., & Seymour, P. (2009). Developmental dyslexia in an orthography of intermediate depth: the case of European Portuguese. *Reading and Writing*, *22*(7), 791-810. doi: 10.1007/s11145-008-9156-4

Treiman, R. (1993). *Beginning to spell: A study of first-grade children*. New York: Oxford University Press.

Wagner, R. K., Puranik, C. S., Foorman, B., Foster, E., Wilson, L. G., Tschinkel, E., & Kantor, P. T. (2011). Modeling the development of written language. *Reading and Writing*, *24*(2), 203-220. doi: 10.1007/s11145-010-9266-7

PARTE III
Conclusão Geral

CAPÍTULO 5

Discussão integrada dos principais resultados e considerações finais

Discussão integrada dos principais resultados dos três estudos experimentais

A presente dissertação engloba três estudos empíricos longitudinais nos quais participaram crianças portuguesas do 2º ao 5º ano de escolaridade de duas escolas públicas de Lisboa, constituindo duas coortes experimentais.

Estes três estudos pretendem responder ao objetivo geral enunciado na Introdução: examinar as relações entre os componentes, lexical e sublexical, do conhecimento ortográfico, o seu papel na leitura, na escrita e no processo de produção escrita de texto ao longo do desenvolvimento da literacia.

Os resultados específicos de cada estudo estão descritos e discutidos nos capítulos que lhes foram atribuídos (respetivamente; Capítulos 2, 3 e 4).

Com esta secção entendemos retomar os principais resultados obtidos, analisando-os de forma integrada e conclusiva.

Assim, no primeiro estudo empírico da presente dissertação – Capítulo 2 – sugerimos e testámos um modelo sobre o desenvolvimento dos dois componentes do conhecimento ortográfico – lexical e sublexical – e sobre a direção da sua relação durante a aquisição da leitura. Estudámos, assim, o contributo longitudinal de cada um destes componentes para o outro, e como a intensidade deste contributo variava ao longo do desenvolvimento.

No segundo estudo – Capítulo 3 – examinámos se os níveis de processamento lexical e sublexical da leitura e da escrita beneficiavam da influência longitudinal dos componentes lexical e sublexical do conhecimento ortográfico, e de que modo esta influência variava ao longo do desenvolvimento.

Os objetivos destes dois primeiros estudos foram examinados com crianças Portuguesas do 2º ao 5º ano de escolaridade, recorrendo a análises de regressão com controlo auto regressivo, como referido na introdução do presente trabalho.

Finalmente, no terceiro estudo – Capítulo 4 – com análises *path*, uma metodologia mais sofisticada, verificámos se o processo de composição escrita beneficiava de um contributo longitudinal dos componentes lexical e sublexical do conhecimento ortográfico e se este contributo seria ou não mediado pela habilidade escrita de palavras, numa coorte de crianças Portuguesas do início do 2º ao final do 3º ano.

Deste modo, começámos por testar um modelo, consistente com as teorias de aquisição da leitura (e.g., Ehri, 1992; Share, 1999), que propunha uma associação entre o conhecimento ortográfico e a recodificação fonológica eficiente. Assumimos que a recodificação fonológica eficiente seria crucial para o desenvolvimento dos dois componentes do conhecimento ortográfico e, em particular, para o desenvolvimento de representações ortográficas lexicais (e.g., Share, 2004) que, por sua vez, permitiriam à criança extrair padrões ou sequências ortográficas relevantes, i.e., conhecimento ortográfico sublexical (Conrad, 2008).

Observámos que, no início e no final do 2º ano de escolaridade, as crianças com melhor eficiência de recodificação fonológica apresentavam um melhor nível de conhecimento ortográfico (lexical e sublexical) do que as crianças com baixo nível nesta habilidade. Do 3º ano em diante, o nível de conhecimento ortográfico, lexical e sublexical, não foi significativamente diferente entre os dois grupos.

Esta evidência sugere, como esperado teoricamente (e.g., Share, 1999; Ehri, 1992), que a recodificação fonológica está associada de forma preponderante ao conhecimento ortográfico, lexical e sublexical, em anos iniciais da aquisição da leitura.

Em anos mais avançados do desenvolvimento, esta associação deixa de se manifestar – o conhecimento ortográfico dissocia-se da recodificação fonológica. Assim, a recodificação fonológica parece ser essencial para o estabelecimento do conhecimento ortográfico, lexical e sublexical, no início da aquisição da leitura. Contudo, assim que a criança atinge um nível relativamente eficiente na habilidade de leitura, deixa de o ser para o desenvolvimento continuado do conhecimento ortográfico, a qualquer nível, lexical ou sublexical.

Os resultados obtidos com as análises de regressão sequencial mostraram ainda que o conhecimento ortográfico lexical, no início do 2º ano, contribui significativamente para o desenvolvimento do conhecimento ortográfico sublexical (8%), no final do 2º ano. Para além disso, apesar de mais fraco (3%), verificou-se também um contributo na direção inversa (do conhecimento ortográfico sublexical para o lexical). Estas evidências são concordantes com as perspetivas teóricas de Ehri (1997) e Share (1995) que sugerem que, através da recodificação fonológica, se desenvolvem primeiramente as representações ortográficas lexicais. Assim, a partir desta suposição entendemos que seriam estas representações lexicais que estariam na base do estabelecimento do conhecimento ortográfico sublexical. De facto, os nossos resultados apontam neste sentido e estão de acordo também com propostas teóricas mais recentes (Conrad, 2008), que sugerem que o estabelecimento de representações ortográficas lexicais, no início da escolaridade, beneficia a extração de padrões ortográficos relevantes ao nível sublexical. No entanto, as nossas evidências parecem ir além desta suposição (Ehri, 1997; Share, 1999), pois sugerem também um contributo no sentido inverso. Deste modo, os nossos resultados parecem dar suporte empírico à perspetiva avançada por Deacon e colaboradores (Deacon et al., 2009) de que o conhecimento de

padrões ortográficos pode contribuir, embora em menor grau, para o desenvolvimento de representações ortográficas lexicais de confiança.

Em suma, estes primeiros resultados, numa fase inicial da aquisição da leitura: 1) corroboram a ideia de que a recodificação fonológica tem um papel fundamental no desenvolvimento de ambos os componentes do conhecimento ortográfico; e 2) sugerem que a relação entre estes componentes não se restringe apenas a um contributo unidirecional, mas sim a uma relação bidirecional assimétrica entre eles.

Os nossos resultados, acima descritos, apoiam a visão proposta na literatura (e.g., Ehri, 1997; Share, 1999), de que a recodificação fonológica (i.e., que se torna eficiente pela prática na leitura e na escrita) leva ao estabelecimento do conhecimento ortográfico. A relação inversa, i.e., de que o conhecimento ortográfico apoia a leitura e a escrita, é também proposta teoricamente por Ehri (2005). Examinámos com detalhe esta última proposta no *Estudo 2*. Verificámos que o conhecimento ortográfico (lexical e sublexical) inicial contribui para a leitura e escrita ulterior. As análises de regressão revelaram que o conhecimento ortográfico lexical contribui para as habilidades de leitura e escrita quer de palavras quer de pseudopalavras. No entanto, o conhecimento ortográfico sublexical revelou uma influência mais restrita, contribuindo apenas para a leitura e a escrita de pseudopalavras.

As nossas evidências, de que o conhecimento ortográfico é preditor da habilidade posterior de leitura e de escrita, fornecem apoio empírico à abordagem teórica de Ehri (2005), sugerindo que a habilidade de conhecimento ortográfico não é apenas uma consequência: as representações ortográficas (lexicais), bem como o conhecimento de padrões ortográficos (sublexical) são úteis para, e estão subjacentes ao desenvolvimento bem-sucedido da leitura e da escrita de palavras e de pseudopalavras.

Estudos recentes, com crianças inglesas (Rothe et al., 2012; Conrad et al., 2013), tinham referido um efeito preditivo semelhante, mas com um desenho experimental concorrente (no mesmo momento de teste). Com um desenho longitudinal, Deacon e colaboradores (Deacon et al., 2012) não observaram qualquer contributo do processamento ortográfico lexical e sublexical para a leitura. As nossas evidências resultam também de análises longitudinais e, contrariamente aos resultados de Deacon e colaboradores (Deacon et al., 2012), apontam para um papel importante e duradouro do conhecimento ortográfico na aquisição quer da leitura quer da escrita (i.e., do 2º ao 5º ano de escolaridade). Além disso, estes efeitos longitudinais foram obtidos entre vários anos de escolaridade e sujeitos a controlos rigorosos (e.g., habilidade fonológica e controlo autorregressivo), realçando o papel crucial do conhecimento ortográfico, atribuindo-lhe uma importância semelhante à da consciência fonológica na leitura e na escrita, pelo menos numa língua semitransparente como o Português Europeu.

Note-se que há fatores que diferem entre o nosso estudo e o estudo de Deacon e colaboradores (Deacon et al., 2012), tais como, a opacidade da língua em que os estudos foram levados a cabo (Inglês e Português), os anos de escolaridade em estudo (2º ao 3º vs. 2º ao 5º). Além destes fatores, é de sublinhar que no estudo de Deacon e colaboradores (Deacon et al., 2012) foi examinado o contributo dos dois componentes do conhecimento ortográfico para a habilidade de leitura de palavras, enquanto no nosso estudo considerámos, além da leitura de palavras (de nível lexical), uma medida de leitura de pseudopalavras (de nível sublexical), bem como medidas de escrita (de palavras e de pseudopalavras).

Deste modo foi possível diferenciar o papel de cada um dos componentes do conhecimento ortográfico para as habilidades de leitura e escrita, cujas evidências devemos destacar: o conhecimento ortográfico lexical parece ter uma influência mais

ampla e duradoura do que o conhecimento ortográfico sublexical, na habilidade de ler e escrever, quer palavras familiares, quer palavras não familiares. De forma diferente, o conhecimento ortográfico sublexical parece ser útil particularmente para a habilidade de ler e escrever palavras desconhecidas. Do nosso conhecimento, estas são as primeiras evidências empíricas longitudinais a apontar neste sentido.

Estas evidências apoiam, em grande medida, a proposta de Ehri (2005) que sugere que, quer o conhecimento ortográfico lexical quer o sublexical, podem ajudar a leitura e a escrita de palavras conhecidas (nível lexical) e desconhecidas (nível sublexical). No entanto, não observámos, nos nossos resultados, um papel do conhecimento ortográfico sublexical na habilidade de leitura e de escrita de palavras conhecidas. Não colocamos de parte a possibilidade desta influência ocorrer no desenvolvimento. Recordamos que as nossas evidências resultam de análises longitudinais, onde os efeitos observados têm um intervalo temporal superior a 6 meses. Talvez numa análise concorrente (não longitudinal), ou numa análise longitudinal com um intervalo temporal mais reduzido esta influência se manifestasse. O nível intermédio de opacidade que caracteriza o Português Europeu, língua em estudo, pode também ter contribuído para que esta influência não se observasse. Em línguas com uma ortografia mais opaca, é possível que a necessidade, nas crianças aprendizes, de maior apoio no conhecimento ortográfico lexical e sublexical fizesse sobressair a utilidade do conhecimento ortográfico sublexical para a leitura e escrita de palavras conhecidas.

As evidências empíricas anteriormente descritas e a proposta de Ehri (2005) sugerem que o desenvolvimento eficiente da escrita de palavras é apoiado pelo conhecimento ortográfico. Segundo a *Simple View of Writing* (Juel, Griffith, & Gough, 1986; Juel, 1988) e a *Not-so-simple view of Wrinting* (Berninger & Winn, 2006), a escrita de palavras é uma habilidade de transcrição crucial para a promoção da produção

de texto, sobretudo em escritores aprendizes. Assim, sugerimos e examinámos, através de análises *path,* a ideia de que o conhecimento ortográfico teria um efeito, direto ou mediado pela escrita de palavras, na habilidade de composição escrita. Verificámos que o conhecimento ortográfico (lexical e sublexical) explica até 18% da variância individual da habilidade de produção escrita de texto. Esta influência ocorre quer diretamente quer de forma mediada e apenas numa fase inicial da aprendizagem da leitura – ao longo do 2º ano de escolaridade. De facto, o conhecimento ortográfico lexical inicial (início do 2º ano) apresentou um contributo exclusivo direto para a habilidade de composição escrita posterior (final do 2º ano). Por outro lado, o contributo do conhecimento ortográfico sublexical inicial para a composição escrita posterior foi totalmente mediado pela escrita de palavras. Além disso, esta influência foi mais fraca do que a do componente lexical do conhecimento ortográfico.

O conhecimento ortográfico é portanto uma habilidade subjacente ao desenvolvimento da escrita de palavras e esta última, tem sido apontada, teórica (e.g., Juel, Griffith, & Gough, 1986; Juel, 1988; Berninger & Winn, 2006) e empiricamente (e.g., Berninger et al., 2008; Abbott et al., 2010) como uma habilidade crucial para a composição escrita. Os nossos resultados vêm indicar que as habilidades subjacentes aos componentes da transcrição da *Not-so-simple View of Writing* podem por si só ter um papel direto ou mediado na produção escrita de texto. Este resultado está de acordo com a conceção original da *Simple View of Writing* (Juel, Griffith, & Gough, 1986; Juel, 1988) que contempla o conhecimento ortográfico como parte integrante da escrita de palavras (do original: *spelling*). Além disso, está também de acordo com a conceção de que os processos de nível inferior são mais importantes no início da aprendizagem. Quaisquer destas perspetivas (Berninger et al., 2002; Juel et al., 1986; Juel, 1988) considera a escrita de palavras, e portanto o conhecimento ortográfico, como uma

habilidade de nível inferior. Sugerem também que no início da aprendizagem, os escritores aprendizes se apoiam mais nestas habilidades de nível inferior, e apenas quando a sua automaticidade é atingida, se libertarão recursos para uma maior participação de processos cognitivos de nível superior. De facto, e de forma coerente com esta posição, apenas observámos um contributo do conhecimento ortográfico para a composição escrita dentro do 2º ano de escolaridade (do início para o final do ano) e não entre o 2º e o 3º ano (final de cada ano).

Por outro lado, é de sublinhar que no nosso modelo mais complexo (ver Figura 1 – Modelo 3 do Capítulo 4), no qual incluímos os dois componentes do conhecimento ortográfico e a habilidade de escrita de palavras como preditores da composição escrita, esta última habilidade deixa de ter qualquer contributo para o processo de composição escrita. Este nosso último resultado não vai de encontro a evidências anteriores que sugeriam que a escrita de palavras era um preditor importante da composição escrita (e.g., Abbott et al., 2010). Supostamente, a inclusão dos dois componentes do conhecimento ortográfico, no nosso estudo, fez sobressair o seu contributo específico retirando poder preditivo à habilidade de escrita de palavras. No entanto, acreditamos que a escrita de palavras tenha um papel importante, por si só, na composição escrita. Talvez com outra medida de avaliação da composição escrita, ou numa língua com uma ortografia mais opaca se manifeste esta influência. Contudo, parece-nos imprescindível a inclusão dos dois componentes do conhecimento ortográfico em estudos futuros que explorem os preditores da composição escrita.

Do nosso conhecimento, estes resultados que decorrem de análises longitudinais, constituem, até à data, a primeira evidência de que o conhecimento ortográfico influencia a produção escrita de texto..

Em suma, os resultados dos três estudos mostram que as habilidades básicas contribuem e estão subjacentes às habilidades que lhes são subsequentes ao longo da aprendizagem da leitura e da escrita. Este é o caso da recodificação fonológica para o conhecimento ortográfico e deste para a leitura, a escrita e a produção de texto.

As nossas evidências clarificam e sublinham a importância da recodificação fonológica, manifestada na associação entre o seu nível de eficiência e o nível de conhecimento ortográfico, quer lexical, quer sublexical (de acordo com as teorias do desenvolvimento da leitura, e.g., Ehri, 1997; Share, 1999). A importância do nível de conhecimento ortográfico lexical inicial para a promoção e o desenvolvimento do conhecimento ortográfico sublexical foi também notória nos nossos resultados. A influência no sentido inverso (do conhecimento ortográfico sublexical para o lexical) também se verificou, mas como menor intensidade.

Indo de encontro, neste caso, à proposta teórica de Ehri (2005), os nossos resultados mostram que o uso de representações específicas da palavra na memória contribui para que a criança leia e escreva corretamente, quer palavras familiares, quer desconhecidas. Além disso, a leitura e a escrita das palavras desconhecidas também pode ser obtida com recurso ao conhecimento ortográfico sublexical, fazendo uso do conhecimento de padrões recorrentes de letras. Estas evidências sublinham o importante papel do conhecimento ortográfico lexical e sublexical para o sucesso na leitura e na escrita de palavras conhecidas e desconhecidas.

Foi também nosso objetivo examinar se o contributo do conhecimento ortográfico se estendia à produção de texto. As análises *path* com intervalo temporal, revelaram que, para além da escrita de palavras e da escrita manual, o conhecimento ortográfico desempenha um importante papel preditivo da habilidade da produção escrita de texto. Estas evidências sugerem que tal como o conhecimento ortográfico,

outras habilidades subjacentes ao componente de transcrição da *Not-so-simple View of Writing,* poderão ter também um papel preponderante no desenvolvimento da habilidade de composição escrita.

Para finalizar, não podemos deixar de sublinhar a importância dos dois componentes do conhecimento ortográfico, lexical e sublexical, para o processo de literacia, quer para o desenvolvimento de habilidades que lhe são próximas (i.e., leitura e escrita) quer para habilidades que lhe são mais distantes e complexas (e.g., composição escrita). No entanto, não podemos negligenciar o papel fundamental que a recodificação fonológica desempenha no desenvolvimento do conhecimento ortográfico, no início da aprendizagem e, portanto, para o desenvolvimento de todas as outras habilidades que dele beneficiam direta ou indiretamente.

Contributos

Os três estudos empíricos aqui desenvolvidos pretendem contribuir em vários aspetos para a literatura acerca do desenvolvimento do conhecimento ortográfico e do seu papel no processo de literacia.

O primeiro aspeto, de caráter mais geral, que destacamos refere-se ao *design* experimental. Os três estudos foram levados a cabo com uma (*Estudo 3*) ou duas coortes de crianças (*Estudos 1* e *2*) testadas longitudinalmente, em dois momentos da aprendizagem. Estudos tão abrangentes, com uma diversidade de anos de escolaridade e que envolvam um período tão longo de análise são raros na literatura. É de realçar que os anos em estudo (2º ao 5º ano de escolaridade) abarcam um período de desenvolvimento que vai do início da aquisição das habilidades de leitura e escrita até ao início do seu estabelecimento.

O segundo aspeto relevante refere-se ao estudo de processos básicos da aprendizagem numa língua não dominante na literatura. A maior parte das evidências neste âmbito surge de estudos na língua inglesa, uma língua com características particulares, distintas do Português Europeu (ver, e.g., Fernandes et al., 2008, para uma caraterização desta ortografia).

Uma terceira contribuição, ainda de caráter geral, diz respeito à utilização, nos dois primeiros estudos, de uma metodologia de análise de regressão sequencial com controlo autorregressivo. Este controlo confere maior robustez aos resultados observados pois permite verificar o contributo único de uma variável num momento inicial para uma outra num momento posterior, subtraindo o efeito imediato entre ambas no momento inicial. Além disso, esta metodologia tem sido usada na literatura (e.g.,

Deacon et al., 2012) de modo a examinar efeitos bidirecionais entre variáveis tal como foi nosso objetivo do *Estudo 1*.

Ao controlo autorregressivo acima referido, adicionámos outras variáveis controlo (e.g., idade, inteligência não-verbal) de modo a evitar qualquer efeito espúrio. Neste conjunto de variáveis, foi de particular relevância a inclusão da consciência fonémica como controlo aquando das análises de regressão. Estas análises tinham por objetivo verificar o contributo único de um dos componentes (e.g., lexical) do conhecimento ortográfico para o outro componente (e.g., sublexical), ou para uma outra variável (e.g., leitura de palavras). Deste modo, controlou-se o efeito da habilidade fonológica aquando da determinação destes efeitos.

Embora existissem já evidências na literatura de que os componentes lexical e sublexical do conhecimento ortográfico se começam a desenvolver cedo, do nosso conhecimento, não existe qualquer estudo que examine como estes dois componentes se relacionam entre si e como a sua relação varia ao longo deste desenvolvimento. O nosso *Estudo 1* vem clarificar esta questão.

Estudos empíricos e propostas teóricas anteriores apontam para que o estabelecimento do conhecimento ortográfico lexical e sublexical assenta na habilidade de recodificação fonológica. No entanto, a análise do contributo do conhecimento ortográfico para os níveis de processamento lexical e sublexical da leitura e da escrita (*Estudo 2*), até então não explorado, contribuiu para o conhecimento mais específico do papel desta habilidade no desenvolvimento da leitura e da escrita.

Do nosso conhecimento, não existe nenhum estudo na literatura que considere os dois componentes do conhecimento ortográfico como preditores da composição escrita (*Estudo 3*). Para estudar estes efeitos preditivos foi de particular relevância a possibilidade da utilização de análises *path*, uma metodologia mais rigorosa e

sofisticada do que as análises de regressão sequencial. Esta possibilidade surgiu, por um lado, do número de relações em estudo e, por outro lado, e em particular, do objetivo subjacente ao estudo: o exame de relações diretas e mediadas.

Esta metodologia é, de facto, considerada a que melhor permite examinar os efeitos diretos do conhecimento ortográfico, bem como os efeitos indiretos na habilidade de composição escrita, considerando a escrita de palavras como mediador.

Depois destas considerações, vemos o presente trabalho como um contributo para a compreensão do conhecimento ortográfico como medida multidimensional (i.e., lexical e sublexical) e como um promotor do desenvolvimento das habilidades de leitura e de escrita.

Limitações e indicações para estudos futuros

São de referir quatro limitações do presente trabalho.

Em **primeiro lugar**, devido ao tamanho das amostras em estudo, e à origem geograficamente restrita destas amostras, os resultados devem ser interpretados com alguma precaução. Estudos com amostras de maior dimensão e com maior representatividade serão necessárias para a replicação destas evidências. Para além disso, amostras mais extensas são passíveis de ser estudadas com recurso a metodologias mais sofisticadas, como as análises *path*, que conseguimos usar apenas no *Estudo 3*.

Em **segundo lugar**, cada um dos componentes do conhecimento ortográfico foi avaliado com recurso a uma tarefa apenas, embora tenhamos optado pelas tarefas mais tradicionalmente usadas na literatura. Estudos futuros deverão contemplar mais do que uma tarefa de forma a possibilitar, por exemplo, a constituição de variáveis latentes representativas de cada um dos componentes do conhecimento ortográfico.

Um **terceiro aspeto** que poderia trazer maior robustez aos resultados obtidos, está relacionado com o tipo de medida das tarefas que avaliam o conhecimento ortográfico. Nas tarefas utilizadas avaliámos a precisão das respostas. Em investigações futuras, o recurso a uma medida adicional que contemple a velocidade de resposta, de particular relevância em anos mais avançados, permitirá uma melhor distinção entre os dois componentes do conhecimento ortográfico e do papel de cada um.

Por último, avaliámos a composição escrita através da chamada diversidade lexical (i.e., número de palavras diferentes escritas no texto). Esta é uma das medidas que se tem revelado como um preditor importante da qualidade da composição escrita (e.g., Beard, 1984; Conelly et al., 2012). No entanto, em estudos futuros a utilização de

outras medidas complementares como, por exemplo, uma medida holística que incluísse dimensões como o uso de vocabulário, ideias, desenvolvimento, gramática e pontuação seria de considerar, pois enriqueceria os resultados obtidos nos nossos estudos. É de referir que para este tipo de medidas existem protocolos estandandizados como por exemplo a Subescala de Expressão Escrita de Wechsler Objective Language Dimensions (Rust, 1996). Contudo, a utilização destas medidas exige a avaliação de mais do que um juiz, um processo moroso e dispendioso. De qualquer forma, este tipo de protocolo não está ainda disponível para a língua portuguesa e, como tal, teria que ser previamente adaptado ou, preferencialmente, aferido.

Implicações práticas e pedagógicas

Apesar das limitações anteriormente apontadas, podemos retirar deste trabalho implicações importantes para as práticas de instrução.

A *Simple View of Writing*, que impulsionou a realização do nosso *Estudo 3,* identifica componentes chave para o desenvolvimento da habilidade de escrita. Segundo esta teoria, a transcrição e a autorregulação, em conjunto, e a par da memória de trabalho, permitem a produção escrita eficiente de texto. É defendido (e.g., Berninger et al., 2002) que o treino da escrita de palavras e da habilidade de composição escrita de texto levam ao desenvolvimento destes dois componentes. Neste nosso último estudo examinámos e identificámos o papel de um subcomponente do processo de transcrição – o conhecimento ortográfico, numa coorte de crianças do 2º ao 3º ano de escolaridade. É de sublinhar que o conhecimento ortográfico teve um papel significativo ao longo do 2º ano e não além disso. De acordo com estes resultados, o treino desta habilidade promotora da escrita eficiente de palavras, e da habilidade de composição escrita é de particular relevância no início da aprendizagem da escrita. A partir do 3º ano, é importante que se continuem a ensinar habilidades de transcrição, ou seja, se insista em estratégias que desenvolvam o conhecimento ortográfico específico da palavra e o conhecimento de padrões ortográficos, bem como a escrita de palavras conhecidas e desconhecidas. No entanto, e apesar de se poderem introduzir antes, é também neste período da aprendizagem que se deve insistir na incorporação da instrução explícita da composição escrita, englobando estratégias de autorregulação (e.g., estratégias para delinear planos e revisão do texto produzido). Realçamos que este terceiro estudo reforça a relevância de um processo básico – o conhecimento ortográfico, para a produção de texto.

De facto, o conhecimento ortográfico revelou-se não apenas como um resultado do processo de aprendizagem da leitura e da escrita, mas também como um importante promotor destas duas habilidades.

Os resultados do nosso *Estudo 2* clarificam a importância de um bom desenvolvimento do conhecimento ortográfico, quer lexical, quer sublexical: o conhecimento ortográfico específico da palavra é útil para a leitura e a escrita de palavras conhecidas e desconhecidas, enquanto o conhecimento de padrões ortográficos é útil para a habilidade de ler e escrever, em particular palavras desconhecidas. Esta utilidade verificou-se ao longo de todos os anos em estudo, i.e., do 2º ao 5º ano de escolaridade, reforçando a sua importância. Neste sentido, o desenvolvimento de medidas de avaliação educativas destas habilidades torna-se premente. Uma vez que o contributo do conhecimento ortográfico é crucial para o desenvolvimento da literacia, psicólogos e educadores devem ter em consideração a necessidade da avaliação dos dois componentes do conhecimento ortográfico, no contexto clínico e educacional, com o fim de melhor delinearem planos de intervenção e instrução.

O estabelecimento deste conhecimento ortográfico está associado, como proposto pelas teorias do desenvolvimento da leitura e da escrita (e.g., Ehri, 1997, Share, 1999), e como observado no nosso *Estudo 1*, à eficiência da recodificação fonológica. A eficiência do uso deste mecanismo é fundamental para que seja atingida a identificação correta e automática de palavras, através do acesso a representações lexicais. O conhecimento de padrões ortográficos é também importante para esta identificação. Assim, e uma vez que o desenvolvimento do conhecimento ortográfico em geral, depende da habilidade de recodificação fonológica, esta também não pode ser descurada no processo de literacia.

As nossas evidências sugerem que o conhecimento ortográfico, um processo diferente, relativamente aos habitualmente considerados (e.g., consciência fonológica e morfológica) está subjacente, não só à habilidade de leitura, mas, em particular à habilidade de escrita. Como tal, os programas educativos devem considerar e integrar desde logo o conhecimento ortográfico como uma competência a desenvolver de modo a garantir que as crianças cedo beneficiarão do seu importante papel na aprendizagem. Estas descobertas sublinham, assim, a importância da introdução de múltiplas fontes de conhecimento metalinguístico (e.g., consciência fonológica, morfológica e ortográfica) aquando da instrução da leitura.

Estas evidências, a par das obtidas em outros estudos (e.g., Deacon et al., 2012) sugerem que a relação entre a leitura e o conhecimento ortográfico é recíproca, cada uma destas habilidades promovendo a outra, de modo semelhante ao que acontece entre a leitura e a habilidade fonológica.

Tendo em consideração que o conhecimento ortográfico é importante quer para a leitura, quer para a escrita (ver *Estudo 2*), e que estas habilidades partilham muitas representações (e.g., Ehri, 1997, 2005; Perfetti, 1997), não é surpreendente que estas habilidades se ajudem mutuamente (e.g., Conrad, 2008; Morais et al., 2012). Na realidade é sugerido (Ehri, 1997; Perfetti, 1997) que o que é aprendido através de uma habilidade deva beneficiar a outra habilidade, embora não no mesmo grau.

A escrita é mais difícil do que a leitura e requer uma maior qualidade da representação (e.g., Morais et al., 2012; Perfetti, 1992). Os nossos resultados (em particular do *Estudo 2*) apontam, de facto, para um maior recurso ao conhecimento ortográfico aquando da escrita do que aquando da leitura, i.e., observámos uma maior percentagem de variância única explicada na habilidade de escrita do que na habilidade de leitura, na maioria das análises de regressão. Na verdade, para ler uma palavra (e.g.,

gafanhoto) não precisamos conhecer todas as correspondências letra-som ou ter uma representação exata (e.g., todos nós leitores reconhecemos gafa*oto), mas para escrever corretamente precisamos do conhecimento completo da ortografia da palavra (Morais et al., 2012; Perfetti, 1997) sendo necessária uma atenção completa a todas as letras que a constituem.

A prática do ato motor, envolvido na escrita, também pode fornecer uma pista adicional que é incorporada na representação em memória (Hulme, 1981), ajudando a consolidar a representação ortográfica (Morais et al., 2012).

Esta perfeição exigida na escrita pode produzir representações mais completas do que as estabelecidas apenas pela leitura (Conrad, 2008).

Assim, terminamos frisando a importância do treino da escrita, no contexto educativo: "O treino da escrita generaliza-se à leitura e o treino da leitura generaliza-se à escrita (…). A generalização da escrita à leitura é completa ou quase, o que não é o caso da generalização da leitura à escrita. Isto é uma razão muito forte para que o ensino da leitura dê um lugar muito importante ao ensino da escrita" (Morais et al., 2012, p. 78).

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Referências – Parte I e Parte III

Abbott, R. D., Berninger, V. W., & Fayol, M. (2010). Longitudinal relationships of levels of language in writing and between writing and reading in grades 1 to 7. *Journal of Educational Psychology*, *102*(2), 281-298. doi: 10.1037/a0019318

Anthony, J. L., & Francis, D. J. (2005). Development of phonological awareness. *Current Directions in Psychological Science*, *14*(5), 255-259. doi: 10.1111/j.0963-7214.2005.00376.x

Apel, K. (2010). Kindergarten children's initial spoken and written word learning in a storybook context. *Scientific Studies in Reading, 14*(5), 440 - 463. doi:10.1080/10888431003623496

Apel, K. (2011). What is orthographic knowledge?. *Language, Speech, and Hearing Services in Schools*, *42*(4), 592-603. doi: 10.1044/0161-1461(2011/10-0085)

Apel, K., & Masterson, J. J. (2001). Theory-guided spelling assessment and intervention: A case study. *Language, Speech, and Hearing Services in the Schools, 32,* 182-195. doi:10.1044/0161-1461(2001/017)

Apel, K., Thomas-Tate, S., Wilson-Fowler, E. B., & Brimo, D. (2012). Acquisition of initial mental graphemic representations by children at risk for literacy development. *Applied Psycholinguistics*, *33*(2), 365-391. doi: 10.1017/S0142716411000403

Apel, K., Wolter, J.A., & Masterson, J.J. (2006). Effects of phonotactic and orthotactic probabilities during fast-mapping on five year-olds' learning to spell. *Developmental Neuropsychology, 29*(1), 21-42. doi: 10.1207/s15326942dn2901_3

Badian, N. A. (2001). Phonological and orthographic processing: Their roles in reading prediction. *Annals of Dyslexia*, *51*(1), 177-202. doi: 10.1007/s11881-001-0010-5

Barker, T. A., Torgesen, J. K., & Wagner, R. K. (1992). The role of orthographic processing skills on five different reading tasks. *Reading Research Quarterly*, *27*(4), 335-345. doi: 10.2307/747673

Bear, D. R., & Templeton, S. (1998). Foundations for learning and teaching phonics. *The Reading Teacher*, *52*(3), 222-242. Retrieved from http://www.elearningsolutions.us/msde/reading2/phases/docs/BearTempletonSpelling.pdf

Beard, R. (1984). *Children's writing in the primary school*. Seven Oaks: Hodder and Stoughton.

Berninger, V. W. (1999). Coordinating transcription and text generation in working memory during composing: Automatic and constructive processes. *Learning Disability Quarterly*, *22*(2), 99-112. doi: 10.2307/1511269

Berninger, V. W., & Swanson, H. L. (1994). Modifying Hayes and Flower's model of skilled writing to explain beginning and developing writing. In Carlson, J. S. (series ed.) and Butterfield, E. C. (vol. ed.), *Advances in Cognition and Educational Practice, Vol. 2: Children's Writing: Toward a Process Theory of the Development of Skilled Writing* (pp. 57-81), JAI Press, Greenwich, CT.

Berninger, V. W., Abbott, R. D., Abbott, S. P., Graham, S., & Richards, T. (2002). Writing and reading connections between language by hand and language by eye. *Journal of Learning Disabilities*, *35*(1), 39-56. doi: 10.1177/002221940203500104

Berninger, V. W., Abbott, R. D., Nagy, W., & Carlisle, J. (2010). Growth in phonological, orthographic, and morphological awareness in grades 1 to 6. *Journal of Psycholinguistic Research*, *39*(2), 141-163. doi: 10.1007/s10936-009-9130-6

Berninger, V. W., Nielsen, K. H., Abbott, R. D., Wijsman, E., & Raskind, W. (2008). Writing problems in developmental dyslexia: Under-recognized and under-treated. *Journal of School Psychology*, *46*(1), 1-21. doi:10.1016/j.jsp.2006.11.008

Berninger, V. W., Winn, W., MacArthur, C. A., Graham, S., & Fitzgerald, J. (2006). Implications of advancements in brain research and technology for writing development, writing instruction, and educational evolution. In C. MacArthur, S. Graham, & J. Fitzgerald (Eds.), *Handbook of writing research* (pp. 96-114). New York: Guilford.

Berninger, V., Vaughan, K., Abbott, R., Begay, K., Byrd, K., & Curtain, G. & Graham, S. (2002). Teaching spelling and composition alone and together: Implications for the simple view of writing. *Journal of Educational Psychology*, *94*, 291-304. doi: 10.1037/0022-0663.94.2.291

Bertelson, P., Morais, J., Alegria, J., & Content, A. (1985). Phonetic analysis capacity and learning to read. *Nature*, *313* (3), 73-74.

Bonin, P., Collay, S., & Fayol, M. (2008). La consistance orthographique en production verbale écrite: une brève synthèse. *L''Année Psychologique*, *108*(4), 517-546. doi: 10.4074/S0003503308003059

Bowers, P. G., & Newby-Clark, E. (2002). The role of naming speed within a model of reading acquisition. *Reading and Writing*, *15*(1-2), 109-126. doi: 0.1023/A:1013820421199

Bowers, P. G., & Wolf, M. (1993). Theoretical links among naming speed, precise timing mechanisms and orthographic skill in dyslexia. *Reading and Writing*, *5*(1), 69-85. doi: 10.1007/BF01026919

Bowey, J. A., & Muller, D. (2005). Phonological recoding and rapid orthographic learning in third-graders' silent reading: A critical test of the self-teaching hypothesis. *Journal of Experimental Child Psychology*, *92*(3), 203-219. doi:10.1016/j.jecp.2005.06.005

Burt, J. S. (2006). What is orthographic processing skill and how does it relate to word identification in reading? *Journal of Research in Reading*, *29*(4), 400-417. doi: 10.1111/j.1467-9817.2006.00315.x

Carlisle J. (1995) Morphological awareness and early reading achievement. In: Feldman L. B. (Eds) *Morphological aspects of language processing* (pp 189–209). Lawrence Erlbaum, Hillsdale, NJ.

Carlisle, J. F. (2003). Morphology matters in learning to read: A commentary. *Reading Psychology*, *24*(3-4), 291-322. doi: 10.1080/02702710390227369

Carlisle, J. F., & Stone, C. (2005). Exploring the role of morphemes in word reading. *Reading Research Quarterly*, *40*(4), 428-449 doi: 10.1598/RRQ.40.4.3

Cassar, M., & Treiman, R. (1997). The beginnings of orthographic knowledge: Children's knowledge of double letters in words. *Journal of Educational Psychology*, *89*(4), 631-644. doi: 10.1037/0022-0663.89.4.631

Castles, A., & Coltheart, M. (1993). Varieties of developmental dyslexia.*Cognition*, *47*(2), 149-180. doi:10.1016/0010-0277(93)90003-E

Chenoweth, N. A., & Hayes, J. R. (2001). Fluency in writing generating text in L1 and L2. *Written Communication*, *18*(1), 80-98. doi: 10.1177/0741088301018001004

Connelly, V., Campbell, S., MacLean, M., & Barnes, J. (2006) Contribution of Lower Order Skills to the Written Composition of College Students With and Without Dyslexia. *Developmental Neuropsychology*, *29*(1), 175-196. doi: 10.1207/s15326942dn2901_9

Connelly, V., Dockrell, J. E., Barnett, A. L., & Lane, G. (2012). Children challenged by writing due to language and motor difficulties. In V. Berninger (Ed.), *Past, present, and future contributions of cognitive writing research to cognitive* psychology (pp. 217–245). New York: Psychology Press/Taylor Francis Group.

Conners, F. A., Loveall, S. J., Moore, M. S., Hume, L. E., & Maddox, C. D. (2011). An individual differences analysis of the self-teaching hypothesis. *Journal of Experimental Child Psychology, 108*(2), 402-410. doi:10.1016/j.jecp.2010.09.009

Conrad, N. J. (2008). From reading to spelling and spelling to reading: transfer goes both ways. *Journal of Educational Psychology*, *100*(4), 869-878. doi: 10.1037/a0012544

Conrad, N. J., Harris, N., & Williams, J. (2013). Individual differences in children's literacy development: The contribution of orthographic knowledge. *Reading and Writing*, *26*(8), 1223-1239. doi: 10.1007/s11145-012-9415-2

Cunningham, A. E. (2006). Accounting for children's orthographic learning while reading text: Do children self-teach? *Journal of Experimental Child Psychology*, *95*(1), 56-77. doi:10.1016/j.jecp.2006.03.008

Cunningham, A. E., & Stanovich, K. E. (1993). Children's literacy environments and early word recognition subskills. *Reading and Writing*, *5*(2), 193-204. doi: 10.1007/BF01027484

Cunningham, A. E., Perry, K. E., & Stanovich, K. E. (2001). Converging evidence for the concept of orthographic processing. *Reading and Writing*, *14*(5-6), 549-568. doi: 10.1023/A:1011100226798

Cunningham, A. E., Perry, K. E., Stanovich, K. E., & Share, D. L. (2002). Orthographic learning during reading: Examining the role of self-teaching. *Journal of Experimental Child Psychology*, *82*(3), 185-199. doi:10.1016/S0022-0965(02)00008-5

Deacon, S. H., & Kirby, J. R. (2004). Morphological awareness: Just "more phonological"? The roles of morphological and phonological awareness in reading development. *Applied Psycholinguistics*, *25*(2), 223-238. doi: 10.1017/S0142716404001110

Deacon, S. H., Benere, J., & Castles, A. (2012). Chicken or egg? Untangling the relationship between orthographic processing skill and reading accuracy. *Cognition*, *122*(1), 110-117. doi: 10.1016/j.cognition.2011.09.003

Deacon, S. H., Conrad, N., & Pacton, S. (2008). A statistical learning perspective on children's learning about graphotactic and morphological regularities in spelling. *Canadian Psychology/Psychologie Canadienne*, *49*(2), 118-124. doi: 10.1037/0708-5591.49.2.118

Deacon, S. H., Wade-Woolley, L., & Kirby, J. R. (2009). Flexibility in young second-language learners: examining the language specificity of orthographic processing. *Journal of Research in Reading*, *32*(2), 215-229. 0.1111/j.1467-9817.2009.01392.x

Denckla, M. B., & Rudel, R. G. (1976). Rapid 'automatized'naming (RAN): Dyslexia differentiated from other learning disabilities. *Neuropsychologia*, *14*(4), 471-479. doi:10.1016/0028-3932(76)90075-0

Efron, B., & Tibshirani, R. J. (1994). *An introduction to the bootstrap*. CRC Press.

Ehri, L. C. (1980). The development of orthographic images. In U. Frith (Ed.), *Cognitive processes in spelling* (pp.311-338). London: Academic.

Ehri, L. C. (1992). Reconceptualizing the development of sight word reading and its relationship to recoding. In P. Gough (Ed.), *Reading acquisition* (pp.107-143). Hillsdale, NJ: Erlbaum.

Ehri, L. C. (1997). Learning to read and learning to spell are one and the same, almost. In C. Perfetti, L. Rieben, & M. Fayol (Eds.). *Learning to spell: Research, theory, and practice across languages* (pp. 237-268). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Ehri, L. C. (2005). Learning to read words: Theory, findings, and issues. *Scientific Studies of Reading*, *9*(2), 167-188. doi: 10.1207/s1532799xssr0902_4

Ehri, L. C., & McCormick, S. (1998). Phases of word learning: Implications for instruction with delayed and disabled readers. *Reading & Writing Quarterly: Overcoming Learning Difficulties*, *14*(2), 135-163. doi:10.1080/1057356980140202

Ehri, L. C., & Rosenthal, J. (2007). Spellings of words: A neglected facilitator of vocabulary learning. *Journal of Literacy Research, 39*(4), 389-409. doi: 10.1007/978-1-4419-0834-6_10

Fayol, M. (2012). Cognitive Processes of Children and Adults in Translating Thought Into Written Language in Real Time Perspectives From 30 Years of Programmatic Cognitive Psychology. In V. Berninger (Ed.), *Past, present, and future contributions of cognitive writing research to cognitive psychology* (pp. 27–59). New York: Psychology Press/Taylor Francis Group.

Fernandes, S. (2013). Aprendizagem da leitura no português europeu: relações entre fluência na leitura oral, vocabulário e compreensão em leitura (Dissertação de doutoramento). Retirada de http://repositorio.ul.pt/handle/10451/9179

Fernandes, S., Ventura, P., Querido, L., & Morais, J. (2008). Reading and spelling acquisition in European Portuguese: A preliminary study. *Reading and Writing*, *21*(8), 805-821. doi: 10.1007/s11145-007-9093-7

Friend, A., & Olson, R. K. (2008). Phonological spelling and reading deficits in children with spelling disabilities. *Scientific Studies of Reading*, *12*(1), 90-105. doi:10.1080/10888430701773876

Frith, U. (1980). Unexpected spelling problems. In U. Frith (Ed.), *Cognitive processes in spelling* (pp.495-515). London: Academic Press.

Furnes, B., & Samuelsson, S. (2009). Preschool cognitive and language skills predicting Kindergarten and Grade 1 reading and spelling: a cross-linguistic comparison. *Journal of Research in Reading*, *32*(3), 275-292. doi: 10.1111/j.1467-9817.2009.01393.x

Georgiou, G. K., Parrila, R., & Kirby, J. R. (2009). RAN components and reading development from Grade 3 to Grade 5: What underlies their relationship? *Scientific Studies of Reading*, *13*(6), 508-534. doi:10.1080/10888430903034796

Graham, S., Berninger, V. W., Abbott, R. D., Abbott, S. P., & Whitaker, D. (1997). Role of mechanics in composing of elementary school students: A new methodological approach. *Journal of Educational Psychology*, *89*(1), 170-182. doi:10.1080/10888430903034796

Hagiliassis, N., Pratt, C., & Johnston, M. (2006). Orthographic and phonological processes in reading. *Reading and Writing*, *19*(3), 235-263. doi: 10.1007/s11145-005-4123-9

Hayes, H., Treiman, R., & Kessler, B. (2006). Children use vowels to help them spell consonants. *Journal of Experimental Child Psychology*, *94*(1), 27-42. doi: 10.1016/j.jecp.2005.11.001

Hayes, J. R. (1996). A new model of cognition and affect in writing. In M. Levy, & S. Ransdell (Eds.). *The science of writing.* Hillsdale, N.J.: Lawrence Erlbaum Associates.

Hayes, J. R. (2004). What triggers revision?. In L. Allal, L. Chanquoy, & P. Largy (Eds.), *Revision Cognitive and Instructional Processes* (pp. 9-20). Boston/Dordrecht, Netherlands/New York: Kluwer.

Hayes, J. R., & Flower, L. S. (1980). Identifying the organization of writing processes. In I. Gregg & E. Steinberg (Eds.), *Cognitive Processes in Writing* (pp. 3-30). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Hilte, M., & Reitsma, P. (2008). What type of computer-assisted exercise supports young less skilled spellers in resolving problems in open and closed syllable words? *Annals of Dyslexia*, *58*(2), 97-114. doi: 10.1007/s11881-008-0019-0

Hulme, C. (1981). The effects of manual tracing on memory in normal and retarded readers: Some implications for multi-sensory teaching. *Psychological Research*, *43*(2), 179-191. doi: 10.1007/BF00309828

Instituto de avaliação educativa, I.P. (n.d.). Provas do 3.º CEB - distribuições de classificações. Retrieved from http://iave.pt/np4/file/225/Resultados_3._ceb_distribui__o.pdf

Ise, E., Arnoldi, C. J., & Schulte-Körne, G. (2014). Development of orthographic knowledge in German-speaking children: a 2-year longitudinal study. *Journal of Research in Reading*, *37*(3), 233-249. doi: 10.1111/j.1467-9817.2012.01535.x

Jongejan, W., Verhoeven, L., & Siegel, L. S. (2007). Predictors of reading and spelling abilities in first-and second-language learners. *Journal of Educational Psychology*, *99*(4), 835-851. doi: 10.1037/0022-0663.99.4.835

Juel, C. (1988). Learning to read and write: A longitudinal study of 54 children from first through fourth grades. *Journal of Educational Psychology*, *80*(4), 437-447. doi: 10.1037/0022-0663.80.4.437

Juel, C., Griffith, P. L., & Gough, P. B. (1986). Acquisition of literacy: A longitudinal study of children in first and second grade. *Journal of Educational Psychology*, *78*(4), 243-255. doi: 10.1037/0022-0663.78.4.243

Kim, Y. S., Al Otaiba, S., Sidler, J. F., & Gruelich, L. (2013). Language, literacy, attentional behaviors, and instructional quality predictors of written composition for first graders. *Early Childhood Research Quarterly*, *28*(3), 461-469. doi:10.1016/j.ecresq.2013.01.001

Kirby, J. R., Deacon, S. H., Bowers, P. N., Izenberg, L., Wade-Woolley, L., & Parrila, R. (2012). Children's morphological awareness and reading ability. *Reading and Writing*, *25*(2), 389-410. doi: 10.1007/s11145-010-9276-5

Kuo, L. J., & Anderson, R. C. (2006). Morphological awareness and learning to read: A cross-language perspective. *Educational Psychologist*, *41*(3), 161-180. doi: 10.1207/s15326985ep4103_3

Landerl, K., & Wimmer, H. (2008). Development of word reading fluency and spelling in a consistent orthography: An 8-year follow-up. *Journal of Educational Psychology*, *100*(1), 150-161. doi.org/10.1037/0022-0663.100.1.150

Loveall, S. J., Channell, M. M., Phillips, B. A., & Conners, F. A. (2013). Phonological recoding, rapid automatized naming, and orthographic knowledge. *Journal of Experimental Child Psychology*, *116*(3), 738-746. doi: 10.1016/j.jecp.2013.05.009

Martinet, C., Valdois, S., & Fayol, M. (2004). Lexical orthographic knowledge develops from the beginning of literacy acquisition. *Cognition*, *91*(2), B11-B22. doi:10.1016/j.cognition.2003.09.002

McCutchen, D. (2006). Cognitive factors in the development of children's writing. In C. MacAuthur, S. Graham, & J. Fitzgerald (Eds.), *Handbook of writing research* (pp. 115–130). New York: Guilford.

Moats, L. C. (2000). *Speech to print: Language essentials for teachers*. Paul H. Brookes Publishing Co., PO Box 10624, Baltimore, MD 21285-0624.

Moll, K., Ramus, F., Bartling, J., Bruder, J., Kunze, S., Neuhoff, N., … & Landerl, K. (2014). Cognitive mechanisms underlying reading and spelling development in five European orthographies. *Learning and Instruction*, *29*, 65-77. doi:10.1016/j.learninstruc.2013.09.003.

Morais, J., Alegria, J., & Content, A. (1987). The relationships between segmental analysis and alphabetic literacy: an interactive view. *Cahiers de Psychologie Cognitive*, 7, 415-443.

Morais, J., Araújo, L., Leite, I., Carvalho, C., Fernandes, S., & Querido, L. (2012). *Criar leitores.* Porto: Livpsic

Muter, V., & Diethelm, K. (2001). The contribution of phonological skills and letter knowledge to early reading development in a multilingual population. *Language Learning*, *51*(2), 187-219. doi: 10.1111/1467-9922.00153

Nagy, W., Berninger, V. W., & Abbott, R. D. (2006). Contributions of morphology beyond phonology to literacy outcomes of upper elementary and middle-school students. *Journal of Educational Psychology*, *98*(1), 134-147. doi: 10.1037/0022-0663.98.1.134

Nation, K., & Hulme, C. (1997). Phonemic segmentation, not onset-rime segmentation, predicts early reading and spelling skills. *Reading Research Quarterly*, *32*(2), 154-167. doi: 10.1598/RRQ.32.2.2

Nation, K., & Snowling, M. J. (2004). Beyond phonological skills: Broader language skills contribute to the development of reading. *Journal of Research in Reading*, *27*(4), 342-356. doi: 10.1111/j.1467-9817.2004.00238.x

National Center for Education Statistics (2002). *The Nation's Report Card: Writing Highlights 2002*. Washington, D.C., U.S.: Institute of Education Sciences, Department of Education.

National Center for Education Statistics (2012). *The Nation's Report Card: Writing 2011*. Washington, D.C., U.S.: Institute of Education Sciences, Department of Education.

National Commission on Writing. (2003, April). *The neglected R: The need for a writing revolution*. Retrieved from https://collegeboard.com

National Reading Panel (US), National Institute of Child Health, & Human Development (US). (2000). *Report of the national reading panel: Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction: Reports of the subgroups*. National Institute of Child Health and Human Development, National Institutes of Health.

Olson, R. K., Forsberg, H., & Wise, B. (1994). Genes, environment, and the development of orthographic skills. In V W. Berginger (Ed.), *The varieties of orthographic knowledge I: Theoretical and developmental issues* (pp. 27-71). Springer Netherlands.

Olson, R. K., Forsberg, H., Wise, B., & Rack, J. (1994). Measurement of word recognition, orthographic, and phonological skills. In G. R. Lyon (Ed.), *Frames of reference for the assessment of learning disabilities: New views on measurement issues* (pp. 243–277). Baltimore, MD: Brookes.

Ouellette G., & Sénéchal M. (2008). Pathways to literacy: a study of invented spelling and its role in learning to read. *Child Development, 79*, 899–913. doi: 10.1111/j.1467-8624.2008.01166.x

Pacton, S., Sobaco, A., Fayol, M., & Treiman, R. (2013). How does graphotactic knowledge influence children's learning of new spellings? *Frontiers in Psychology*, *4*, 1-10. doi: 10.3389/fpsyg.2013.00701

Pae, H. K., Sevcik, R. A., & Morris, R. D. (2010). Cross-language correlates in phonological awareness and naming speed: evidence from deep and shallow orthographies. *Journal of Research in Reading*, *33*(4), 374-391. doi: 10.1111/j.1467-9817.2009.01417.x

Papadopoulos, T. C., Georgiou, G. K., & Kendeou, P. (2009). Investigating the double-deficit hypothesis in Greek: Findings from a longitudinal study. *Journal of Learning Disabilities*. *42*(6), 528-547. doi: 10.1177/0022219409338745

Perfetti, C. A. (1997). Sentences, individual differences, and multiple texts: Three issues in text comprehension. *Discourse Processes*, *23*(3), 337-355. doi:10.1080/01638539709544996

Perfetti, C. A. (1997). The representation problem in reading acquisition. In P. B. Gough, L. C. Ehri, & R. Treiman (Eds.), *Reading acquisition* (pp. 145-174). Hillsdale, NJ: Lawrence Erlbraum Associates.

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior research methods*, *40*(3), 879-891. doi: 10.3758/BRM.40.3.879

Querido, L., Fernandes, S., Verhaeghe, A., Carvalho, C., & Morais, J. (2015). *Does orthographic knowledge influence reading and spelling acquisition? A longitudinal study.* Manuscript in preparation.

Reis, A., Faísca, L., Castro, S.-L., & Petersson, K. M. (2010). Preditores da leitura ao longo da escolaridade: Um estudo com alunos do 1º ciclo do ensino básico. In C. Nogueira, I. Silva, L. Lima, A. T. Almeida, R. Cabecinhas, R. Gomes, C. Machado, A. Maia, A. Sampaio, & M. C. Taveira (Eds.), *Actas do VII Simpósio Nacional de Investigação em Psicologia* (pp. 3117-3132). Braga: Universidade do Minho.

Riedel, B. W. (2007). The relation between DIBELS, reading comprehension, and vocabulary in urban first-grade students. *Reading Research Quarterly*, *42*(4), 546-567. doi: 10.1598/RRQ.42.4.5

Rothe, J., Schulte-Körne, G., & Ise, E. (2014). Does sensitivity to orthographic regularities influence reading and spelling acquisition? A 1-year prospective study. *Reading and Writing*, *27*(7), 1141-1161. doi: 10.1007/s11145-013-9479-7

Rust, J. (1996). *Wechsler Objective Language Dimensions*. London: Psychological Corporation.

Savage, R., Pillay, V., & Melidona, S. (2008). Rapid serial naming is a unique predictor of spelling in children. *Journal of Learning Disabilities*, *41*(3), 235-250. doi: 10.1177/0022219408315814

Schlagal, B. (2001). Traditional, developmental, and structured language approaches to spelling: Review and recommendations. *Annals of Dyslexia*, *51*(1), 147-176. doi: 10.1007/s11881-001-0009-y

Shanahan, T., MacArthur, C. A., Graham, S., & Fitzgerald, J. (2006). Relations among oral language, reading, and writing development. In C. MacAuthur, S. Graham, & J. Fitzgerald (Eds.), *Handbook of writing research* (pp. 171-183). New York: Guilford.

Share, D. L. (1995). Phonological recoding and self-teaching: sine qua non of reading acquisition. *Cognition*, *55*(2), 151-218. doi: 10.1016/0010-0277(94)00645-2

Share, D. L. (1999). Phonological recoding and orthographic learning: A direct test of the self-teaching hypothesis. *Journal of Experimental Child Psychology*, *72*(2), 95-129. doi: 10.1006/jecp.1998.2481

Share, D. L. (2004). Orthographic learning at a glance: On the time course and developmental onset of self-teaching. *Journal of Experimental Child Psychology*, *87*(4), 267-298. doi: 10.1016/j.jecp.2004.01.001

Stanovich, K. E., & Siegel, L. S. (1994). Phenotypic performance profile of children with reading disabilities: A regression-based test of the phonological-core variable-difference model. *Journal of Educational Psychology*, *86*(1), 24-53. doi: 10.1037/0022-0663.86.1.24

Swanson, H. L., Trainin, G., Necoechea, D. M., & Hammill, D. D. (2003). Rapid naming, phonological awareness, and reading: A meta-analysis of the correlation evidence. *Review of Educational Research*, *73*(4), 407-440. doi: 10.3102/00346543073004407

Treiman, R. (1993). *Beginning to spell: A study of first-grade children*. New York: Oxford University Press.

Treiman, R., & Kessler, B. (2006). Spelling as statistical learning: Using consonantal context to spell vowels. *Journal of Educational Psychology*, *98*(3), 642-652. doi: 10.1037/0022-0663.98.3.642

Wagner, R. K., Puranik, C. S., Foorman, B., Foster, E., Wilson, L. G., Tschinkel, E., & Kantor, P. T. (2011). Modeling the development of written language. *Reading and writing*, *24*(2), 203-220. doi: 10.1007/s11145-010-9266-7

Wagner, R., Torgesen, J., & Rashotte, C. (1999). *Comprehensive test of phonological processing (CTOPP).* Austin, Texas: Pro-Ed.

Verhoeven, L., & Van Leeuwe, J. (2008). Prediction of the development of reading comprehension: A longitudinal study. *Applied Cognitive Psychology*, *22*(3), 407-423. doi: 10.1002/acp.1414