Tesis doctoral

Universidad de Oviedo

Desarrollo de la Lectura y la Escritura en Inglés como Lengua Extranjera en Niños Españoles de Educación Primaria

Programa de Doctorado en Educación y Psicología

Carmen Hevia Tuero

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RESUMEN DEL CONTENIDO DE TESIS DOCTORAL

1.- Título de la Tesis	
Español: **Desarrollo de la Lectura y la Escritura en Inglés como Lengua Extranjera en Niños Españoles de Educación Primaria**	Inglés: **Literacy acquisition in English as a Foreign Language in Spanish children in Primary Education**

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RESUMEN (en español)

En España, los niños de Educación Primaria aprenden a leer y escribir en español y en inglés al mismo tiempo. Sin embargo, entre ambas lenguas existen diferencias a nivel ortográfico que harán de esto un desafío. Cuando los niños aprenden inglés como lengua extranjera (LE), tienen que aprender nuevos grafemas y patrones ortográficos, y adaptarse a nuevas estrategias de procesamiento. A pesar de la abundante literatura en aprendizaje del inglés como LE, no hay evidencia sobre cómo los niños de España lidian con la ortografía del inglés durante el aprendizaje de la lectoescritura. El objetivo de esta tesis doctoral es estudiar los aspectos que influyen en dicho aprendizaje, teniendo en cuenta factores lingüísticos, evolutivos y educativos. Para ello se llevaron a cabo estudios de lectura y escritura. En los estudios de lectura se utilizó el programa MouseTracker, con el que se recogieron errores, tiempos de reacción y trayectorias del ratón. En los estudios de escritura se analizaron errores, y se recogieron medidas online a través del programa Ductus y una pizarra digitalizadora.

El objetivo del primer estudio era comprobar la influencia de la congruencia y la complejidad grafémicas en niños españoles aprendiendo inglés. Esto se realizó a través de dos tareas de detección de letras utilizando el programa MouseTracker, en las que participaron niños de 2º, 4º y 6º de Primaria. El efecto de la congruencia sólo afectó a los más pequeños, mientras que la complejidad afectó en todos los cursos. Los resultados sugieren que los niños españoles interiorizan la fonología del inglés a edades tempranas. También que su decodificación es similar a la de los niños nativos.

En el segundo estudio se estudió la activación de la fonología del inglés y del español en el reconocimiento visual de palabras en inglés, en función del curso y de la exposición a la lengua. Se diseñó una tarea de decisión léxica visual en inglés con pseudohomófonos en MouseTracker, en la que participaron niños de diversos cursos de Educación Primaria (2º, 4º y 6º), y que pertenecían centros con diferentes metodologías de enseñanza del inglés. Los resultados indican que los niños distinguen las reglas ortográficas del inglés y del español desde los primeros cursos de Primaria.

También indican que una mayor exposición al inglés incrementa la activación de la fonología de esta lengua, y que influye en la conexión entre la fonología y la ortografía.

En el tercer estudio se investigó la influencia del país de origen y de la lengua nativa en el procesamiento visual de palabras y en la activación de la fonología de dos lenguas. Niños de dos centros escolares bilingües, uno en España y otro en Estados Unidos, realizaron una tarea de decisión léxica visual en inglés con pseudohomófonos en MouseTracker. Todos los niños activaron en mayor medida la fonología del inglés, que además produjo un patrón de procesamiento diferente en los niños de Estados Unidos.

El cuarto estudio consistió en un análisis detallado de errores de escritura a partir de narraciones espontáneas en inglés. Esto se hizo para identificar los elementos que suponen una mayor dificultad para los niños españoles escribiendo en inglés. Mediante el sistema POMAS se clasificaron los errores cometidos por niños de 4º, 5º y 6º de Primaria. La proporción de errores fonológicos, ortográficos y morfológicos varía en función del curso, aunque los errores de origen ortográfico fueron los más frecuentes para todos los cursos. Esto apunta a un conocimiento emergente pero incompleto de la ortografía del inglés.

Con el quinto y último estudio se quiso estudiar, a través de medidas kinemáticas, la influencia de diversas variables sobre la escritura en inglés. Niños de 4º, 5º y 6º de Primaria realizaron una tarea de escritura al dictado escribiendo en una pizarra digitalizadora. Mientras que la longitud afectó más a los niños más pequeños, los niños de 6º se vieron más afectados por la frecuencia léxica y el conocimiento semántico. Además, la consistencia de la rima facilitó la exactitud a la hora de escribir. La exposición acumulada al inglés mejora la escritura, gracias al aumento de vocabulario y a una creciente sensibilidad a los patrones y regularidades estadísticas de la nueva ortografía.

RESUMEN (en Inglés)

In Spain, Primary Education children learn to read and write in both Spanish and English at the same time. They will have to deal with differences between languages in terms of orthography. When learning English as a foreign language (EFL), Spanish children will have to learn new spelling patterns and adapt to new processing strategies. Despite the broaden literature scoping EFL, there is no evidence about Spanish children learning EFL during literacy acquisition. The aim of this doctoral dissertation was studying which variables may influence their learning, considering linguistic, developmental and educational factors. To achieve this, we carried out several studies involving reading and writing. For reading tasks we used the MouseTracker software, with which we collected measures like accuracy, reaction times and mouse trajectories. Writing studies comprised error analysis and online measures collected through Ductus software and a digital board.

The purpose of the first study was to determine if the congruency and complexity of English graphemes influence letter detection in Spanish children. Participants completed two different letter detection tasks using the mouse-tracking paradigm. Results indicate that only younger children were slightly affected by incongruent graphemes, while all participants performed worse with complex graphemes. This suggests children that interiorize English phonology at early stages, and they decode similarly to native English readers.

In the second study, we wanted to explore how instructional method and grade influenced phonological activation during visual word processing in English. To do so, a lexical decision task with pseudohomophones was designed with MouseTracker. This task was completed by children attending two Elementary schools in Spain, which differed in their instructional method. Results suggest that children discriminate between English and Spanish orthography since the beginning of their instruction. Level of exposure also influence on the degree of phonological activation, and the connection between orthography and phonology.

The third study focused on the influence of country of origin and native language on visual word processing and bilingual co-activation. Children attending bilingual schools in United States and Spain completed a lexical decision task with pseudohomophones in MouseTracker. All the participants activated English phonology. However, children from United States showed a different processing pattern.

In the fourth study a detailed spelling errors analysis was performed. 136 children in fourth, fifth and sixth grades completed a free narrative task. Using the POMAS system and based on Triple Word Form theory (phonology, orthography and morphology), we classified the spelling errors. Through this classification and according to previous literature, we identified the elements that are more challenging for Spanish children spelling in English. Furthermore, orthographic errors were the most frequent across the grades, showing an incomplete knowledge of English orthography.

The aim of the fifth and final study was to assess the influence of several variables on English spelling: P-O consistency, lexical frequency, word length and children's semantic knowledge. Children in Primary Education performed a spelling-to-dictation task on a digital board, which was used to collect errors and kinematic measures. Word length affected younger participants, suggesting a reliance on sublexical strategies. Older participants' performance was more determined by lexical frequency, semantic knowledge and consistency. Cumulative exposure to English improves spelling, possibly due vocabulary growth joined to an increasing sensitivity to new spelling patterns and statistical regularities.

SR. PRESIDENTE DE LA COMISIÓN ACADÉMICA DEL PROGRAMA DE DOCTORADO EN __________________

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PARTE I: MARCO TEÓRICO

El inglés es inevitable. No en vano es la lengua más hablada del mundo. Lo más común es que estemos en contacto con ella casi todos los días, en casi todas las situaciones: si viajamos, si navegamos por internet, si vemos películas y series de televisión, si escuchamos música... Está en la calle, en el ocio, en el trabajo y en la escuela. Se trata de una exposición que en nuestro país se inicia a edades tempranas, dentro del entorno escolar. Esto significa que los niños españoles deberán aprender a gestionar dos lenguas durante etapas críticas para la adquisición de la lectoescritura.

Hoy en día el número de personas que aprenden inglés como lengua extranjera (LE) o segunda lengua (L2) supera al de nativos (L1). Por este motivo, existe cada vez más interés por conocer cómo es el procesamiento del lenguaje en los bilingües. Pero para ello es indispensable considerar la influencia de nuevas variables, que son inherentes a la condición de hablante de más de una lengua. Por un lado, existe la posibilidad de que se produzcan interferencias entre lenguas. El cerebro bilingüe debe contar con herramientas para gestionar la activación de la lengua objetivo y la inhibición de la lengua no-objetivo. Por otra parte, existirán variables lingüísticas únicas que determinarán la transferencia entre la L1 y la L2/LE. Es posible que entre una lengua y otra existan diferencias a nivel ortográfico y fonológico, diferencias que podrán requerir una adaptación a estrategias de lectura y escritura no habituales. Finalmente, la manera en que se aprenda la L2/LE también tendrá relevancia, sobre todo si se inicia durante la adquisición de la lectoescritura en L1. Variables como el método de enseñanza, el tipo y la cantidad de exposición, o la enseñanza explícita del código ortográfico determinarán cómo se produce el aprendizaje y el posterior desarrollo de la lectoescritura en una lengua diferente a la nativa. El creciente interés científico por el bilingüismo ha producido una abundante literatura sobre el tema, que incluye la mayoría de las lenguas y sistemas de escritura de los países desarrollados. Desde el punto de vista educativo, también se han comparado los efectos de los diferentes métodos de instrucción en busca de una potencial mejora de la enseñanza. No obstante, el conjunto de variables que pueden influir en el aprendizaje del inglés como L2 o como LE hace que no todos los hallazgos puedan generalizarse.

Los niños españoles de Educación Primaria son bilingües secuenciales a nivel oral, pues primero han aprendido a hablar en su lengua nativa, el español, y más tarde han aprendido una lengua extranjera, el inglés. Sin embargo, la enseñanza del inglés se inicia durante las etapas en las que están aprendiendo a leer y escribir (a veces incluso antes), por lo que pronto se verán expuestos a ambos códigos alfabéticos. Esto tendrá unos efectos en su aprendizaje, al igual que lo tendrán las diferencias entre los inventarios fonológicos y las ortografías del inglés y del español. Los estudios realizados en población bilingüe español-inglés, principalmente en Estados Unidos, son una gran fuente de información acerca de las diferencias lingüísticas entre las dos lenguas. No obstante, los métodos de enseñanza y el nivel y la calidad de exposición al inglés no son comparables a los de España. Existe una falta de evidencia acerca del aprendizaje de la lectura y escritura en inglés como LE de los niños españoles. Los estudios realizados en esta tesis doctoral tienen como fin aportar más conocimientos acerca de este tema.

Este trabajo consta de una primera parte, que se corresponde con el marco teórico, y una segunda parte experimental. Respecto a la primera, se pueden diferenciar tres capítulos. En el primer capítulo se expondrán las características del procesamiento bilingüe, incluyendo modelos que explican la interacción entre dos o más lenguas. El segundo capítulo comienza abordando la lectura y la escritura y su aprendizaje. A continuación, se explica cómo este aprendizaje puede variar en función de la lengua. En el tercer y último capítulo se analizarán las semejanzas y diferencias que existen entre el español y el inglés a nivel ortográfico. Teniendo en cuenta todo lo anterior, se describirán las adaptaciones que son necesarias para la adquisición de la lectoescritura en una L2/LE. Por último, se tratará el tema de la enseñanza del inglés en contextos educativos. Se describirán las variables que influirán en su aprendizaje, y las diferencias entre los métodos de enseñanza de los centros escolares de otros países y de los de España.

El propósito de estos tres capítulos será destacar las características y peculiaridades del aprendizaje de la lectoescritura en inglés como LE, específicamente por parte de niños españoles de Educación Primaria. Así mismo, también servirá para señalar algunas de las lagunas que existen en la literatura actual sobre el tema. Estas lagunas se tuvieron en cuenta a la hora de establecer los objetivos y plantear las hipótesis para esta tesis doctoral. Son cuestiones a las que se tratará de dar respuesta a través del trabajo experimental presentado en la segunda parte.

El trabajo experimental se compone de cinco estudios, tres de ellos publicados y dos en revisión. El primero de ellos investiga los efectos de congruencia y complejidad a través de una tarea de detección de letra, aportando evidencia acerca del procesamiento visual de elementos novedosos del inglés. Tanto el segundo como el tercer estudio comparan la activación de la fonología del español y del inglés a través de una tarea de decisión léxica visual con pseudohomófonos. Mientras que en el segundo estudio se profundiza en las diferencias evolutivas y de métodos de enseñanza, el tercero determina los efectos de dicha activación durante el reconocimiento de palabras en función de cuál sea la lengua dominante del entorno. El cuarto estudio analiza los errores de escritura en narraciones, e investiga en qué fuentes se apoyan más los niños a la hora de escribir en inglés. Además, detalla los elementos que suponen una mayor dificultad para los hispanohablantes. El quinto y último estudio explora los efectos de diferentes variables en la escritura al dictado del inglés. Gracias a las medidas kinemáticas es posible conocer si los niños españoles son sensibles a unidades lingüísticas de diferente tamaño, y si la escritura se ve influida por la consistencia ortográfica, la frecuencia léxica, la longitud o el conocimiento semántico. En conjunto, estos estudios informan sobre el desarrollo de la lectoescritura en inglés como LE, centrándose los tres primeros en la lectura y el reconocimiento visual, y los dos últimos en la producción escrita. Los resultados de este trabajo se discutirán en un último apartado, siendo comparados con los estudios realizados por otros autores en diferentes lenguas y/o contextos. También se enumerarán las conclusiones obtenidas de este trabajo, que incrementarán el conocimiento existente sobre el tema y contribuirán a sentar las bases de la transferencia desde la investigación a la práctica educativa.

1. Procesamiento del lenguaje bilingüe

Aunque se han planteado multitud de definiciones del bilingüismo, la de Grosjean (1989, 2010) es la más abierta y la que potencialmente incluye todas las variantes posibles: bilingüe es aquella persona que usa dos o más lenguas (o dialectos) en su vida cotidiana. Este autor advierte que "las personas bilingües no son dos mentes monolingües en una misma persona". Efectivamente, la comprensión y la producción del lenguaje no es igual en monolingües y en bilingües, pues estos últimos tienen una configuración lingüística única derivada de la coexistencia de dos lenguas. Esto incluirá tanto aspectos lingüísticos y cognitivos, como la experiencia social y cultural.

El proceso por el cual los bilingües llegan a conocer las lenguas que hablan y cómo operan con ellas ha sido objeto de estudio desde hace años. Algunos investigadores han mostrado interés por el procesamiento y uso del lenguaje (tanto su comprensión como su producción) en poblaciones bilingües. Otros autores se han centrado en cómo se produce el aprendizaje de una lengua distinta a la nativa. El estudio de estas áreas se ha delimitado, dando lugar a dos campos distintos, conocidos como bilingüismo y adquisición de segundas lenguas, respectivamente. Tal y como manifiestan Elgort y colaboradores (2023), esa delimitación ha trascendido a la terminología utilizada para referirse a uno u otro campo, a las teorías y modelos e incluso a los instrumentos y la metodología de investigación. Sin embargo, estos autores destacan que ambos campos ofrecen enfoques complementarios desde el punto de vista de la psicolingüística. Una complementariedad que es especialmente útil a la hora de explicar fenómenos como los que se estudian en este trabajo.

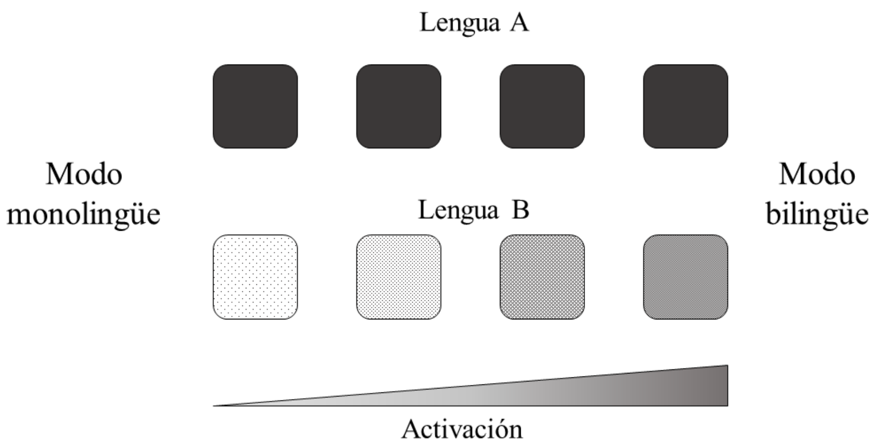
1.1. Características del bilingüismo

Luk y Bialystok (2013) consideran que el bilingüismo es una condición con múltiples dimensiones interrelacionadas que describen la experiencia bilingüe y determinan el procesamiento del lenguaje. No es lo mismo aprender las dos lenguas a la vez (bilingüe simultáneo) que aprender una después de la otra (bilingüe secuencial). Tampoco es lo mismo aprender una L2/LE durante la primera infancia (bilingüe temprano) que en la adolescencia o la edad adulta (bilingüe tardío). El nivel de exposición, el uso y el contexto de cada lengua, la calidad del input recibido… Todas estas características afectan al modo en que las lenguas interaccionan y se influyen mutuamente, pudiendo provocar interferencias fonológicas, léxicas y morfosintácticas (Elgort et al., 2023).

El fenómeno de las interferencias debe ser controlado para que no afecte a la comprensión y la producción del lenguaje. Sin embargo, también es necesaria cierta flexibilidad para cambiar de una lengua a la otra, según las necesidades del contexto. El bilingüe gestiona ambos aspectos a través de lo que Grosjean (1997, 2020) llama modos del bilingüe. Según este autor, estos modos representan "el estado de activación de las lenguas del bilingüe y de los mecanismos de procesamiento del lenguaje en un momento dado". Indican la activación relativa de cada lengua dentro de un equilibrio, en el cual el nivel de activación de la lengua objetivo o base es alto, mientras que en la otra se mantiene bajo. Esto permite que se limiten las interferencias de la lengua no-objetivo, pero manteniéndola en un estado latente a la espera de que se necesite recurrir a ella. El nivel de activación puede variar dentro de un continuo (ver Figura 1), partiendo de un nivel muy bajo de activación de la lengua no-objetivo (modo monolingüe) hasta llegar a un nivel de alta activación (modo bilingüe). Este último se produce si la tarea requiere cambiar de una lengua a otra (como en la traducción), o si el interlocutor también es bilingüe y la situación permite el uso de ambas lenguas. Los grados de activación de las lenguas pueden ser alterados de manera experimental, con el fin de observar cuándo, cómo y por qué aparecen las interferencias (Grosjean & P. Li, 2013).

Figura 1

Representación del Continuo de Activación Relativa de las Lenguas Base (A) y No-Objetivo (B)



Acceso al léxico y coactivación entre lenguas

La coexistencia de dos lenguas plantea otras cuestiones importantes, como la naturaleza del acceso al léxico. Este tema ha sido ampliamente discutido en el campo de la psicolingüística (Grosjean & P. Li, 2013), y concretamente en las investigaciones sobre lectura en bilingües. ¿Puede ocurrir que durante la lectura se activen las representaciones léxicas de ambas lenguas de manera no selectiva? ¿O esta activación es selectiva y sólo se produce en la lengua relevante para el contexto? Por un lado, algunos autores (Gerard & Scarborough, 1989; Rodriguez-Fornells et al., 2002) afirman que los léxicos de ambas lenguas están almacenados en sendos compartimentos estancos. Otros (Dijkstra & van

Heuven, 1998; van Heuven et al., 1998), defienden que todas las palabras, tanto de una lengua como de la otra, forman parte del mismo almacén léxico.

Hoy en día existe suficiente evidencia como para afirmar que el acceso es fundamentalmente no-selectivo, al menos en lo que respecta al procesamiento del lenguaje escrito (Dijkstra, 2005; Duyck et al., 2007; Palma & Titone, 2020; van Assche et al., 2012, 2020). Los estudios de reconocimiento de palabras cognadas (Brenders et al., 2011; Lemhöfer & Dijkstra, 2004; van Hell & Dijkstra, 2002), homógrafos inter-linguales (de Groot et al., 2000; Dijkstra et al., 2000) y vecinos ortográficos cros-lingüísticos (van Heuven et al., 1998) confirman una coactivación ortográfica que sólo puede darse si, efectivamente, el acceso es no selectivo. Como resultado, se pueden activar en paralelo palabras candidatas de ambas lenguas, y competir para ser seleccionadas (Dijkstra, 2005; Dijkstra & van Heuven, 2012).

Por otra parte, también se puede producir una coactivación en la fonología capaz de provocar un solapamiento durante la lectura (Jared & Szucs, 2002; Jared et al., 2012). La mediación de la fonología durante el acceso al léxico en lectura se ha demostrado en monolingües gracias al efecto de los pseudohomófonos (Braun et al., 2009). Los pseudohomófonos son estímulos que difieren en la ortografía pero equivalen en la fonología a palabras reales (como *dreem* y *dream*). Mientras que tienen un efecto facilitador para la lectura en voz alta, en tareas de decisión léxica son más difíciles de descartar que las palabras control (Goswami et al., 2001; Seidenberg et al., 1996; Ziegler et al., 2001). Esto se explica porque la activación de la representación fonológica entra en conflicto con la ausencia de representación ortográfica (Briesemeister et al., 2009).

En población bilingüe, la no-selectividad del lenguaje hace que los pseudohomófonos activen la fonología de ambas lenguas (transferencia fonológica entre lenguas) incluso cuando existan diferencias en las correspondencias grafema-fonema. Así se ha demostrado en diversos conjuntos de lenguas, como holandés-inglés (Duyck, 2005; Nas, 1983) y francés-inglés (Commissaire et al., 2019; Haigh & Jared, 2007). Estos estudios demuestran que la representación fonológica de las palabras de una lengua se puede activar con las correspondencias grafema-fonema de la otra. Es decir, que el acceso no-selectivo no sólo se produce para la codificación fonológica, sino que también tiene lugar a un nivel subléxico (Jared & Kroll, 2011).

1.2. Modelos de procesamiento bilingüe

Estudios como los anteriormente mencionados han permitido el desarrollo de modelos teóricos sobre el procesamiento del lenguaje bilingüe. Estos modelos tratan de proponer una representación teórica que explique todos los fenómenos observados cuando existen dos lenguas en conflicto. Se han propuesto diversas teorías para explicar el procesamiento del lenguaje de las personas bilingües, así como para establecer las diferencias con el monolingüe. Una de las aspiraciones de los modelos de acceso al léxico bilingües es, por un lado, describir cómo es la negociación de los límites entre lenguas que pueden compartir o no rasgos. Por otro lado, determinar cuáles serían las representaciones mentales, los procesos y los mecanismos de aprendizaje que dan soporte a esto. A continuación, se describen aquellos modelos más relevantes para el aprendizaje de la lectura y la escritura en una L2/LE.

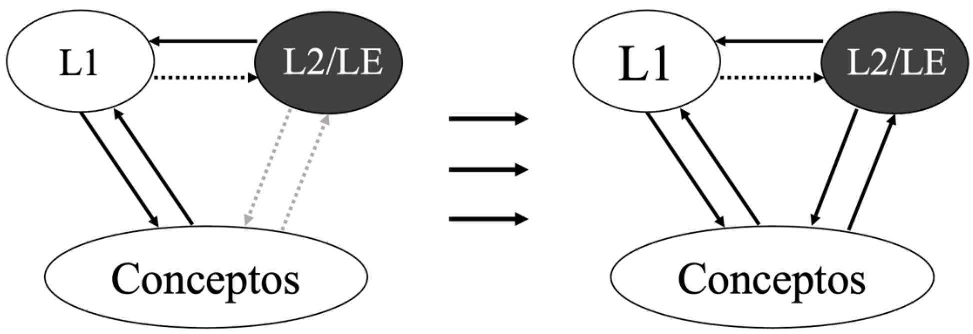
Modelo Jerárquico Revisado

El modelo jerárquico revisado (*Revised Hierarchical Model*, RHM, en inglés) fue propuesto por Kroll y Stewart (1994) a raíz de observar asimetrías en tareas de traducción. Una de las mayores aportaciones de este modelo es la descripción del aprendizaje del léxico en una L2/LE. Según estas autoras, los conceptos y los significados son compartidos por las dos lenguas (nivel conceptual), mientras que las formas de las palabras se almacenan por separado (niveles léxicos de la L1 y de la L2/LE). Cuanto mayor sea la competencia en una lengua, más fuertes serán las conexiones entre su sistema léxico y el sistema semántico. Esto implica que la activación del significado se produce con mayor facilidad en la lengua nativa por tener mayor competencia.

Al comenzar a aprender una L2/LE, el acceso al léxico se realiza a través de la recuperación de la traducción equivalente de la lengua nativa (acceso al concepto de *house* a través de *casa*). A medida que el hablante se vuelve más competente en la L2/LE, se van creando conexiones entre las palabras y sus significados (Figura 2). El peso de la traducción se va reduciendo hasta volverse innecesaria para acceder a los conceptos en la L2/LE. Uno de los planteamientos del modelo es que, hasta alcanzar cierta competencia, la recuperación léxica de la L2/LE requerirá de la activación de la L1.

Figura 2

Esquema del Modelo Jerárquico Revisado (Adaptada de Kroll & Stewart, 1994)



Sin embargo, esto no sucederá siempre así, tal y como Duyck y Brysbaert (2004) sugirieron a posteriori. Estos autores plantearon un modelo RHM revisado que contemplaba diferentes contribuciones de la ruta léxica y la ruta semántica durante la traducción. Así pues, no es que se establezcan conexiones de la L2/LE a la L1, sino que éstas tendrán un peso cada vez más fuerte e influirán en el grado de activación. Este enfoque más conectivista sigue la línea de otros modelos de procesamiento bilingüe centrados en el reconocimiento de palabras, como el BIA y el BIA+.

Modelos BIA y BIA+

Uno de los modelos más utilizados para explicar el reconocimiento visual de palabras en bilingües es el modelo de Activación Interactiva en Bilingües (BIA) (Dijkstra & van Heuven, 1998; Dijkstra et al., 1998; Grainger & Dijkstra, 1992). Este modelo, asentado sobre las bases del acceso no selectivo, fue creado para explicar el reconocimiento de palabras y la integración del léxico en dos lenguas (L1 y L2). Los autores lo desarrollaron a partir de otro modelo (monolingüe) de Activación Interactiva—IA (McClelland & Rumelhart, 1981; Rumelhart & McClelland, 1982).

El BIA se basa en principios de interactividad, y simula hallazgos empíricos que más tarde fueron confirmados de manera experimental. Está constituido por tres niveles de representación principales: rasgos, letras y palabras (Figura 3 - A). En este último nivel se encuentra un léxico integrado en el que se incluyen todas las palabras ambas lenguas. El modelo se completa con un nivel adicional específico que representa la lengua, el cual está formado por dos nodos, uno para L1 y otro para L2. Las palabras de cada lengua están conectadas a su nodo correspondiente, que contiene la información de pertenencia a la lengua de cada una de ellas (*language membership*). Los nodos cumplen la función de filtrar y modular la activación relativa de cada lengua (activando la lengua objetivo e inhibiendo la lengua no-objetivo). Para ello recopilan información lingüística y no-lingüística.

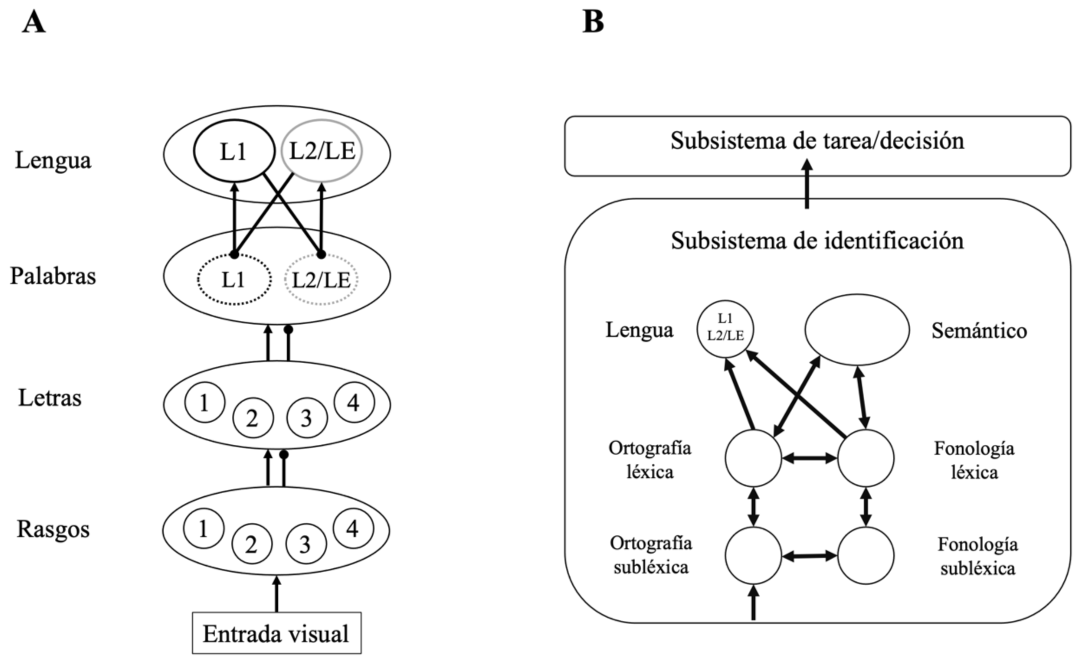
El flujo de información se puede producir de abajo-arriba y de arriba-abajo. En el primer caso, las letras activarán las palabras, y éstas a su vez activarán el nodo correspondiente. En el segundo caso, los nodos lingüísticos inhiben la activación de las palabras que pertenecen a la lengua no-objetivo. Cuando se presenta una entrada visual se activarán las representaciones correspondientes a las letras y su posición, inhibiendo aquellas que no se correspondan ni con las letras ni con la posición de éstas. La activación llegará entonces a todas aquellas palabras que contengan estas letras en ambas lenguas, inhibiendo y descartando las palabras que no las contengan. La representación de la palabra presentada será la que active el nodo de la lengua objetivo, e inhiba el de la lengua no objetivo.

El BIA fue un modelo pionero para explicar el reconocimiento visual de palabras en bilingües, pero tiene ciertas limitaciones (Dijkstra et al., 1999; van Heuven et al., 1998). La primera de ellas es que no incluye un nivel semántico, por lo que no explica completamente el efecto de las palabras cognadas. Por otro lado, tampoco hace distinción entre las representaciones léxicas y subléxicas, ni en términos ortográficos ni en términos fonológicos. A raíz de estas limitaciones se desarrolló una revisión que dio lugar al modelo de Activación Interactiva en Bilingües Plus, o modelo BIA+.

Desarrollado por Dijkstra y van Heuven (2002), esta versión implementada del BIA se asemeja al modelo anterior. Una novedad es la incorporación de un nivel semántico y de dos niveles fonológicos (léxico y subléxico). Otro cambio afectará a los nodos de lenguaje, que ahora solo representan la pertenencia lingüística para las palabras. El modelo ahora consta de dos sistemas independientes pero interconectados, que asumirán el rol de modular la activación relativa (ver Figura 3 - B). Al sistema lingüístico que ya se había descrito en el BIA se le une un esquema de tarea, que también recopila la información contextual. Esta distinción entre un sistema de identificación de palabras y un sistema de tarea/decisión, así como la consideración del contexto lingüístico y no lingüístico, constituyen importantes avances teóricos (van Hell, 2019)

Figura 3

Representación de los Modelo BIA (A) y BIA+ (B) (Adaptadas de Dijkstra et al., 1998, y Dijkstra & van Heuven, 2002)



El BIA+ hace referencia de manera más explícita la identificación de palabras, las interacciones entre diferentes tipos de representaciones (ortográficas, fonológicas y semánticas) y la representación de los homógrafos inter-linguales y las etiquetas de pertenencia lingüística. Además, hace distinción entre el efecto que tienen los contextos lingüístico y no lingüístico en el desempeño de la tarea. Mientras que el contexto lingüístico afecta directamente a la actividad del Sistema de identificación de palabra, el contexto no lingüístico afecta al sistema de tarea/decisión.

El reconocimiento se inicia como en el modelo anterior: una entrada visual activará los niveles ortográficos, primero el subléxico (letras) y posteriormente el léxico (palabra completa). El BIA+ propone que a partir del nivel léxico se active el nivel semántico, mientras que los nodos fonológicos (tanto léxico como subléxico) podrán activarse en cualquier momento. Las conexiones bidireccionales entre niveles harán que se pueda propagar la activación a través del sistema y que cualquier nivel pueda activar ambas lenguas. El sistema de identificación y el esquema de la tarea serán los moduladores de la activación relativa de cada lengua. Esto lo harán gracias a la información del contexto lingüístico y no lingüístico. Los cambios respecto a su predecesor hacen que el modelo BIA+ explique de manera más precisa los hallazgos empíricos en tareas de reconocimiento visual de cognados y homógrafos inter-linguales (Lemhöfer & Dijkstra, 2004; Lemhöfer et al., 2004). También es capaz de representar el acceso al léxico bilingüe y los efectos observados en nuevas tareas, como la repetición de palabras (Lam & Dijkstra, 2010)

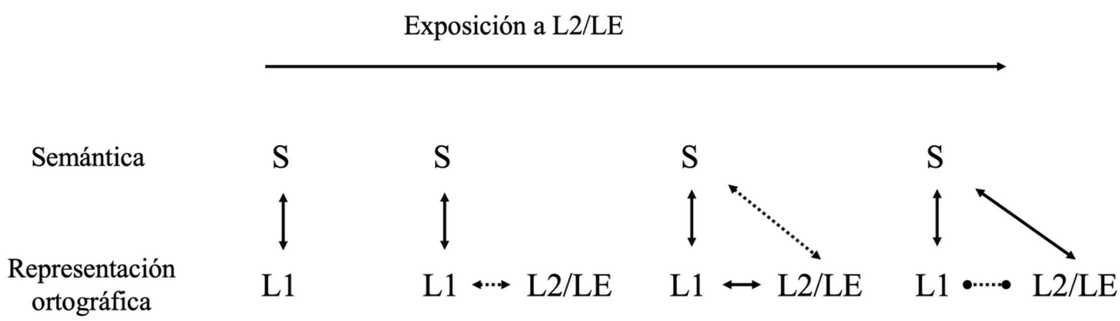
BIA-d

Los modelos anteriores explican el reconocimiento visual de bilingües relativamente fluentes, sin especificar cómo dicha arquitectura puede emerger durante el aprendizaje de otra lengua tras haber aprendido la lengua nativa. Con el fin de dar respuesta a esta última cuestión, Grainger y colaboradores (2010) desarrollaron un modelo desde una perspectiva evolutiva, acuñándolo como BIA-d (*developmental BIA-model)*. Este modelo tiene en cuenta las limitaciones del aprendizaje de otra lengua cuando la lengua nativa ya está establecida. Está simplificado para representar solo la forma ortográfica de las palabras y su significado, así como para describir conjuntos de lenguas que tengan un alfabeto común, como el inglés y el francés (en el modelo original) o el inglés y el español.

El BIA-d describe el paso de un estado inicial en el que el procesamiento está basado en la traducción (como en el modelo RHM) a un nivel de competencia en el que ya no es necesaria la conexión entre la palabra de la L2/LE y su equivalente en L1. Esta secuencia implica cambios en la conectividad entre lenguas. La exposición a la L2/LE genera conexiones entre las traducciones que se fortalecen a medida que la exposición aumenta (Figura 4). Al mismo tiempo, se crean conexiones entre las representaciones léxicas de la L2/LE y las representaciones semánticas ya existentes, tal y como propone el RHM. A medida que las conexiones entre representaciones léxicas de la L2/LE y las representaciones semánticas se fortalecen, las conexiones entre traducciones se van debilitando.

Figura 4

Representación del Modelo BIA-d (Adaptada de Grainger et al., 2010)



Este modelo implica dos fases de aprendizaje del vocabulario en la L2: una fase inicial supervisada y otra no supervisada. En la primera se informa al aprendiz del significado de una palabra en la L2/LE y su equivalencia traducida de la L1. Tendrá que integrar tres tipos de información: la forma ortográfica/fonológica de la palabra de la L2, su significado obtenido de la traducción en la L1, y la información de pertenencia lingüística que indica que dicha palabra pertenece a la L2. La segunda fase, no supervisada, consiste en el establecimiento de conexiones entre la forma de la palabra y los rasgos semánticos. El aprendiz interioriza la representación y establece las conexiones, abandonando el proceso de traducción e inhibiendo la L1. Este cambio cualitativo en la conectividad se acompaña de una mejora en el control de la activación de la L2/LE y de la inhibición de la L1. Esto será necesario para minimizar las interferencias entre lenguas, pues éstas aumentarán con la incorporación de las palabras de la L2/LE al léxico integrado.

Multilink

Mientras que el modelo RHM explicaba los hallazgos en tareas de producción y traducción de palabras, el BIA+ era el modelo bilingüe de referencia para el reconocimiento visual de palabras. En la búsqueda de un modelo universal, Dijkstra y colaboradores (2019) decidieron integrar las bases de ambos para proponer el Multilink. Este nuevo modelo localista-conectivista contempla no solo la comprensión de palabras y el procesamiento léxico-semántico, sino también la producción de palabras. Su compleja arquitectura muestra una red interactiva en la que la activación fluye de manera bidireccional. El propósito de este modelo es simular el procesamiento bilingüe en diferentes de tareas y tipos de palabras, y que además sea aplicable a un mayor número de lenguas. Incluimos el modelo Multilink en este apartado dada su relevancia para la investigación en bilingüismo. No obstante, y puesto que su aplicación al procesamiento del lenguaje escrito está basada en las aportaciones del BIA+, no entraremos en una explicación detallada de su funcionamiento.

Estos modelos explican diversos aspectos que serán relevantes para la lectura en una L2/LE. Sin embargo, hay fenómenos que los autores no consideraron, como la identificación de la lengua a partir de la información subléxica y las reglas ortotácticas (van Kesteren et al., 2012). Mientras que el modelo BIA+ representa la pertenencia lingüística como una propiedad únicamente léxica, ciertos elementos específicos de la ortografía también permitirán la identificación de la lengua. Esto será especialmente útil en casos en los que dos lenguas comparten el mismo alfabeto. Por ejemplo, los dígrafos *th* o *sh* son marcadores ortográficos del inglés, mientras que la letra *ñ* lo será del español. La identificación de la lengua, por tanto, puede producirse por una activación directa desde el nivel sublexical de ortografía, sin necesidad de que dicha activación de propague a los nodos de las palabras. A pesar de esto, los modelos teóricos son perfectamente válidos para simular las influencias cros-lingüísticas (van Heuven y Dijkstra, 2023), un fenómeno que, como veremos a continuación, tendrá gran relevancia en el procesamiento del lenguaje bilingüe.

1.3. Otras teorías relacionadas con el bilingüismo

1.3.1 Influencias cros-lingüísticas

Las influencias cros-lingüísticas se refieren a cómo el conocimiento de una lengua puede afectar al aprendizaje y al uso de una lengua adicional (Elgort et al., 2023). Estas influencias han sido objeto de estudio desde hace años, aunque se han referido a ellas con otros términos, como "transferencias" o "interferencias" (Odlin, 2003). Ambas etiquetas han sido y continúan siendo utilizadas como sinónimos, tal y como recogen Jarvis y Pavlenko (2008), aunque estos autores señalan la connotación tradicionalmente conductista de ambas palabras. Por ello recomiendan que se recurra a "influencias cros-lingüísticas", un término más neutral y que resulta más apropiado para denominar las múltiples formas en las que una lengua puede influir en la otra. Por otro lado, Grosjean (1989) considera las interferencias y las transferencias no como sinónimos, sino como dos tipos de influencias. Las interferencias son esporádicas y provocan errores espontáneos, que el bilingüe tratará de evitar desarrollando mecanismos de inhibición de la lengua no-objetivo. Las transferencias, en cambio, son las relacionadas con la competencia del hablante, que se apoya o recurre a elementos de una lengua para procesar la otra. Independientemente de su denominación, se trata de un fenómeno que en algunos casos podrá beneficiar al bilingüe y en otros casos podrá perjudicarlo.

En cuanto a su causa, son numerosos los estudios que investigan cómo y por qué se producen las influencias entre lenguas, y qué variables están implicadas. Algunas de estas variables serán la exposición (Brysbaert et al., 2017; Monaghan et al., 2017), la competencia lingüística (Haigh & Jared, 2007; van Hell & Tanner, 2012), y la fonología y la ortografía específica de ambas lenguas (Beauvillain, 1992; Bialystok et al., 2005; Hamada & Koda, 2008; Ota et al., 2010; Lallier & Carreiras, 2018). Las influencias cros-lingüísticas podrán afectar a una multitud de procesos lingüísticos (Elgort et al., 2023), incluyendo el reconocimiento visual y la lectura (Akamatsu, 2003; Lemhöfer et al., 2008). En el caso específico de la influencia del español sobre el inglés, se han observado efectos tanto en lectura (Deacon et al., 2013; Goodwin et al., 2015; Ota et al., 2010; Ramírez et al., 2010; Sun-Alperin & M. Wang, 2011) como en escritura (Zutell & Allen, 1988; Fashola et al., 1996; Howard et al., 2012; Sun-Alperin & M. Wang, 2008).

Las influencias cros-lingüísticas tienen un papel relevante en el aprendizaje de la lectoescritura en una L2/LE. En este contexto, y siguiendo las definiciones de Grosjean, la literatura utilizará el término de transferencia. Se han propuesto distintas teorías, que en general estarán agrupadas dentro de dos corrientes: las hipótesis de especificidad lingüística y las hipótesis de integración lingüística. Las primeras asumen que las habilidades cognitivas y lingüísticas necesarias para el aprendizaje de la lectoescritura son comunes en la lengua nativa y en la L2/LE (Geva et al., 1993; Geva & Siegel, 2000; Gholamain & Geva, 1999; Sparks, 1995; Sparks et al., 2009; Sparks et al., 2008)). Las segundas sostienen que el aprendizaje está determinado por las características del sistema ortográfico de la lengua, y por tanto es un proceso específico para cada lengua (Kahn-Horwitz et al., 2011; Lado, 1957).

Hipótesis de especificidad lingüística

Dentro de las hipótesis de especificidad están las teorías basadas en la hipótesis de análisis contrastivo de Lado (1957). Según estas teorías, la influencia dependerá de los elementos de la estructura lingüística que compartan ambas lenguas. Si son similares, será una influencia positiva, mientras que si son diferentes afectará negativamente. En esta línea, Selinker (1972) propone el enfoque inter-lingüístico, que hará referencia a la evolución del sistema de reglas de la L2/LE. No solo influirá la lengua nativa, sino que la propia L2/LE podrá afectar al aprendizaje por la excesiva generalización de las reglas recién aprendidas. Otra teoría que siguen esta misma línea es la hipótesis dependiente del sistema de escritura (Geva & Siegel, 2000), que sostiene que la transferencia dependerá de la distancia que exista entre los sistemas ortográficos de las dos lenguas.

Hipótesis de integración lingüística

Una de las teorías más representativas dentro de este grupo fue la hipótesis de transferencia del lenguaje o interdependencia, propuesta por Cummins (1979). Según esta teoría, existen habilidades cognitivas y lingüísticas que serán comunes para ambas lenguas, y podrán facilitar el aprendizaje de la L2/LE. Así, la competencia en la lengua nativa determinará el éxito en el aprendizaje de la L2/LE por apoyarse en mismo sustrato de habilidades lingüísticas. La idea de que existan habilidades lingüísticas subyacentes y comunes para ambas lenguas es precisamente la esencia de la hipótesis de procesamiento central (Durgunoğlu et al., 1993; Geva & Siegel 2002; Geva et al., 1997; Jared et al., 2013). Esta hipótesis apoya la existencia de procesos cognitivo-lingüísticos compartidos, implicando que si existen dificultades en la lengua nativa también las habrá en la L2/LE (Geva & Siegel 2000).

Chung y colaboradores describen en su revisión (2019) todas estas teorías en detalle. Se basan en ellas para proponer un hipotético marco interactivo que integre todos los componentes cognitivos y lingüísticos involucrados en la transferencia entre lenguas. Estas autoras sugieren que las transferencias entre lenguas son interactivas por naturaleza, y que se ven influidas por numerosos factores. La complejidad de estas interacciones hace que ninguna de las teorías explicativas esté exenta de limitaciones, por lo que hoy en día no existe ningún modelo que explique de manera consistente todos los hallazgos empíricos encontrados hasta la fecha.

1.3.2 Hipótesis del Afianzamiento Léxico

El nivel de exposición a una L2/LE siempre es menor que a la lengua nativa, lo que hará las palabras de la L2/LE se encuentren de manera menos frecuente. Esto hace que las representaciones léxicas sean más débiles y que se consoliden o afiancen peor. El concepto de afianzamiento léxico se ha utilizado para explicar el incremento en el efecto de frecuencia léxica que afecta a los aprendices de una L2/LE (Brysbaert et al., 2017; Diependaele et al., 2013; Flor et al., 2015; Whitford & Titone, 2019). Tal y como sugieren Diependaele y colaboradores (2013), las representaciones de las palabras no están tan definidas e integradas en la memoria léxica como lo están las de la lengua nativa. Esto afectará a la lectura (Verhoeven et al., 2019) y a la escritura (Andrews et al., 2020). Si las representaciones son menos precisas, la selección léxica en la L2/LE supondrá un mayor esfuerzo que en la lengua nativa. Esto afectará a la lectura (Verhoeven et al., 2019) y a la escritura (Andrews et al., 2020). Si las representaciones son menos precisas, la selección léxica en la L2/LE supondrá un mayor esfuerzo que en la lengua nativa. Esta hipótesis de afianzamiento léxico está estrechamente relacionada con la Hipótesis de Conexiones más Débiles (*Weaker Links Hypothesis*) (Gollan et al., 2008, 2011). Esta teoría sugiere que las conexiones entre los códigos semántico, fonológico y ortográfico son más débiles en la L2/LE debido a la experiencia limitada que han tenido los aprendices. Por eso, las palabras estarán representadas de una manera menos precisa que las de la lengua nativa.

No solo la selección léxica es más difícil en la L2/LE, sino que también se tendrán que dedicar más recursos cognitivos a la integración de la información fonológica, ortográfica, y semántica de cada palabra (Barcroft, 2004). Durante el aprendizaje de la lectoescritura en su lengua nativa los niños ya tienen desarrollado un vocabulario oral. Solo tendrán que asociar la nueva información ortográfica al conocimiento fonológico y semántico que ya tienen disponible. El aprendizaje de palabras en la L2/LE implica conectar las nuevas representaciones ortográfica y fonológica a un concepto semántico conocido, que está almacenado en el léxico de la lengua nativa con sus ya existentes representaciones. La facilidad con las que se aprendan las nuevas representaciones dependerá de cómo de similares a las pre-existentes sean (Otwinowska & Szewczyk, 2019). En el caso del español, existe un alto número de palabras provenientes del latín que serán similares en inglés, es decir, serán palabras cognadas. Sin embargo, la mayor parte de éstas formarán parte de un vocabulario académico y técnico (Lubiner & Hiebert, 2011). La ventaja de las palabras cognadas no se produciría para vocabulario básico, que se adquiere al iniciar el aprendizaje del inglés como L2/LE.

Las diferencias de procesamiento entre monolingües y bilingües han sido ampliamente demostradas. Estudios de neuroimagen (Liu & Cao, 2016), medidas conductuales (Bialystok & Craik, 2010; Diependaele et al., 2013; Schwieter, 2015) o paradigmas como el de seguimiento del ratón (Bartolotti & Marian, 2012; Incera & McLennan, 2016; Lin & Lin, 2016) han contribuido a ello. Sin embargo, la heterogeneidad que existe en la población bilingüe hace necesario que se consideren otros factores, como el contexto de aprendizaje o las características específicas de cada lengua. La adquisición de la lectoescritura en una L2/LE es un proceso complejo, que se verá influenciado por los fenómenos que se han descrito en este capítulo, pero también por las características específicas del sistema ortográfico. El siguiente capítulo se compone de varios apartados, en los que se abordarán el aprendizaje de la lectura y la escritura, las diferencias entre sistemas ortográficos y el aprendizaje en una L2/LE. Finalmente, se concluirá con un repaso del escenario actual en cuanto a la enseñanza del inglés y sus consecuencias sobre el aprendizaje del inglés como L2/LE.

2. Aprendizaje de la lectura y escritura

Todos los sistemas de escritura constituyen una representación del lenguaje oral. Pero mientras que el aprendizaje de la lengua oral sucede de forma natural a través de la exposición a esta, la lectura y la escritura requieren de una enseñanza específica. No nacemos con genes que nos preparen para un desarrollo espontáneo de la alfabetización, pero estamos dotados con la capacidad de aprender. Por este motivo sigue siendo necesaria una enseñanza y años de práctica para poder llegar a ser lectores y escritores competentes. Ser capaces de comunicarnos a través del lenguaje escrito es imprescindible en nuestra sociedad. Prueba de ello es el porcentaje de alfabetización de la población mundial, que alcanza un 86% (UNESCO Institute for Statistics, 2020; The World Bank Group, 2021). Dada su importancia, numerosos autores han propuesto modelos que explican cómo se produce la lectura y la escritura.

2.1. Modelos de lectura

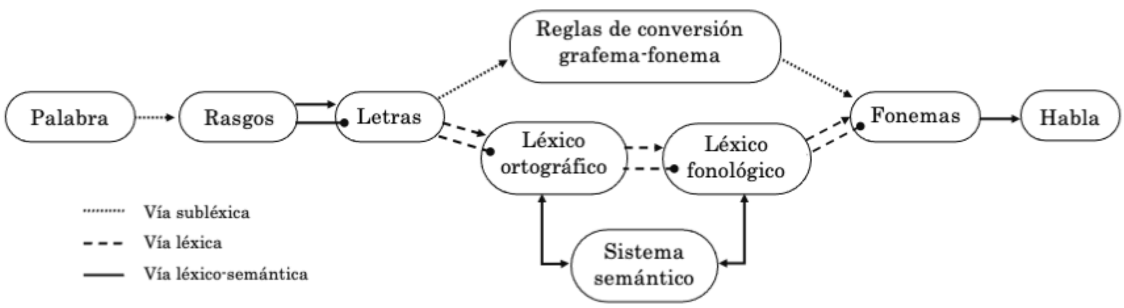
2.1.1. Modelo de Doble Ruta

Aunque en la literatura existen diversos modelos de lectura, uno de los más relevantes es el modelo de Doble Ruta o Modelo Dual (Coltheart, 1978, Coltheart & Rastle, 1994). Este modelo propone dos rutas, una subléxica o fonológica, y otra léxica. La primera se basa en una lectura serial en el que se aplican las reglas de correspondencia grafema-fonema. Mediante dicha ruta se procesan las palabras nuevas o las pseudopalabras, aunque el grado de exactitud dependerá en gran medida de la regularidad de cada palabra. Por otro lado, las palabras irregulares deben leerse a través de la ruta léxica, la cual también es útil para la lectura de palabras familiares cuyas representaciones ya están almacenadas en el léxico ortográfico. Partiendo de esta premisa, (la existencia de dos rutas de lectura), Coltheart y colaboradores (2001) propusieron un modelo computacional denominado modelo de Doble Ruta en Cascada (*Dual Route Cascaded, DRC,* en inglés).

En este modelo sugieren que la información no es procesada de manera serial, sino secuencial y en cascada (ver Figura 5). La lectura de una palabra comienza con el procesamiento visual de las letras que la forman (análisis grafémico). Se produce entonces la activación de un primer módulo, que desencadena una reacción de excitación o de inhibición en los siguientes. Esto da lugar a una actividad simultánea en los diferentes niveles, que facilita un reconocimiento más rápido y eficiente. En este modelo, la aportación de cada ruta depende de las características de la palabra y de la habilidad lectora del sujeto. De esta manera, si la forma ortográfica de la palabra se encuentra almacenada, se producirá una activación del léxico ortográfico. Esto a su vez activará el léxico fonológico, lo que permitirá pronunciar la palabra tras activar los correspondientes fonemas (ruta léxica-no semántica). Otra ruta, la subléxica, contempla la utilización de las reglas de correspondencia grafema-fonema con el fin de identificar los fonemas que forman la palabra. Una vez estos son ensamblados en el sistema fonético, se activa el léxico fonológico y la palabra puede ser pronunciada. Finalmente, del léxico fonológico se accede al sistema semántico, aunque existe una última ruta que permite el acceso al significado desde el léxico ortográfico sin que la fonología intervenga (ruta léxico-semántica).

Figura 5

Modelo de Doble Ruta en Cascada (Adaptada de Cuetos et al., 2015)



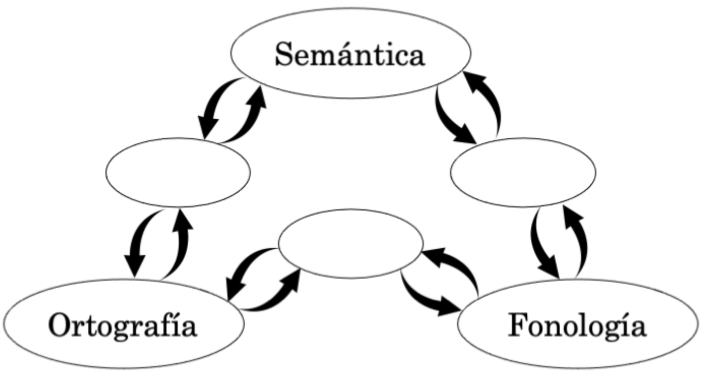
Durante el inicio del aprendizaje de la lectoescritura la ruta subléxica será esencial, pues las palabras todavía no son conocidas. Mediante la aplicación de las reglas correspondencia grafema-fonema, el lector podrá pronunciar las palabras y activar su representación en el léxico fonológico. Pero las palabras irregulares no se pronuncian siguiendo las reglas de conversión grafema-fonema, por lo que para su lectura será necesaria la ruta léxica. En ese caso, la activación semántica y/o fonológica se llevará a cabo gracias a una activación directa desde el léxico ortográfico, donde la representación ortográfica debe estar previamente almacenada.

2.1.2. Modelo conexionista triangular

Otro modelo que también ha gozado de popularidad es el modelo conexionista triangular de la lectura (en inglés, *Triangle Model*) (Harm & Seidenberg, 1999, 2004; Plaut et al., 1996; Seidenberg & McClelland, 1989). Este modelo interactivo describe tres capas, las cuales representan la ortografía, la fonología y la semántica (ver Figura 6).

Figura 6

Representación del Marco Teórico del Modelo Triangular de Lectura Introducido por Seidenberg y McClelland en 1989 (Adaptada de Seidenberg, 2005)



Nota. Los círculos vacíos representan las unidades ocultas.

Estas tres propiedades constituyen los principales componentes de la identidad de la palabra (Perfetti & Hart, 2002; Perfetti, 2007, 2017), por lo que su activación será imprescindible para el reconocimiento léxico. Entre las capas mencionadas existen asociaciones, que están mediadas por unidades ocultas. Cuando se presenta el input, es decir, una palabra formada por un conjunto de letras, se activan los niveles ortográfico y fonológico con el fin de acceder al significado. La eficiencia de este sistema de trabajo es gracias a la cooperación de ambos niveles: la contribución de uno dependerá de la capacidad del otro. Cuando el lector se vuelve más competente el patrón de activación se estabiliza, dando lugar a la representación de la palabra. Este modelo, además, contempla una generalización de lo aprendido para leer nuevos estímulos, lo que posibilita la integración de dos estrategias diferentes en un único mecanismo.

La conexión fonológica-semántica comienza a establecerse con el aprendizaje oral de la lengua, que normalmente tiene lugar antes de la lectoescritura. Al inicio de la lectura, la activación semántica se producirá en gran medida gracias a la contribución del nivel fonológico, a través de una conexión indirecta que sigue el trayecto ortografía-fonología-semántica. A medida que aumenta la exposición a la lengua escrita y se construyen representaciones ortográficas para las palabras, comenzará a establecerse un patrón de conexión directo entre la ortografía y la semántica. Esta conexión se pondrá en práctica especialmente con palabras muy frecuentes o familiares, pero será dependiente de la experiencia y la habilidad lectora, así como de otras variables relacionadas con la palabra (como longitud o regularidad).

Ambos modelos describen el comportamiento de lectores expertos que ya han pasado por un aprendizaje. El proceso por el cual los lectores principiantes pasan a ser lectores expertos se describe en otras teorías que se desarrollan a continuación.

2.2. Aprendizaje de la lectura

Los sistemas de escritura constituyen un código que representa a la lengua oral y por tanto, el aprendizaje de la lectoescritura implica aprender a descifrar dicho código. En el caso de los sistemas de escritura alfabéticos, los niños deben aprender las correspondencias entre grafemas y fonemas. El conocimiento de las reglas de conversión grafema-fonema y su automatización es lo que permitirá al lector decodificar y formar representaciones ortográficas.

Algunos autores explican el aprendizaje de la lectura como un proceso que tiene lugar a través de etapas, mientras que otros lo consideran un proceso continuo basado en ítems. Dentro de los primeros se encuentran los modelos de Frith (1985), de Seymour (Seymour, 1990, 1997; Seymour & Evans, 1994, 1999; Seymour & McGregor, 1984) y de Ehri (1987, 1995, 1998, 1999, 2000, 2005) (ver revisión de Castles et al., 2018). En cuanto a los modelos que contemplan la adquisición de la lectoescritura como un proceso continuo, destaca la hipótesis de Autoaprendizaje o *Self-teaching* de Share (1995).

2.2.1. Hipótesis del Autoaprendizaje

La decodificación es el núcleo de la hipótesis del autoaprendizaje, en palabras de Share "el *sine qua non* del aprendizaje de la lectura". La hipótesis de Autoaprendizaje o *Self-teaching* fue propuesta por Share (1995) con el fin de explicar cómo el lector principiante comienza a crear las representaciones ortográficas, y aún más importante, cómo lo hace de manera independiente.

En esta teoría se describen dos componentes esenciales para la lectura y que contribuyen al aprendizaje de la ortografía: un componente fonológico primario y un componente ortográfico secundario. El componente fonológico, que es fundamental para la decodificación, consiste en la aplicación de las correspondencias grafema-fonema. El proceso ortográfico hace referencia al reconocimiento visual de representaciones de palabras. El autor propone la existencia de un mecanismo de autoaprendizaje que, a través de la decodificación exitosa y repetida de una palabra, posibilita la construcción de su representación ortográfica. Se denomina autoaprendizaje porque los lectores, una vez conocen el código ortográfico y las correspondencias entre grafemas y fonemas, podrán decodificar cualquier palabra y construir su correspondiente representación por sí mismos, sin que sean necesarias instrucciones. De esta manera, el lector principiante comienza utilizando más frecuentemente la ruta subléxica para leer las palabras, pero desde las primeras etapas será capaz construir su léxico ortográfico y apoyarse en la ruta léxica para leer las palabras conocidas. A medida que se vuelva más experimentado irá formando representaciones y utilizando cada vez más la ruta léxica, lo cual facilitará la lectura fluida y eficiente.

La hipótesis de autoaprendizaje ha sido comprobada en diferentes ortografías, como inglés (Cunningham et al., 2002; Kyte & Johnson, 2006; H. C. Wang et al., 2012), español (Álvarez-Cañizo et al., 2019; Suárez-Coalla et al., 2016), holandés (de Jong & Share, 2007), francés (Bosse et al., 2015), hebreo (Share, 1999; Share & Shalev, 2004) y chino (L. Li et al., 2020; Y. Li et al., 2020). Sendas revisiones de Y. Li y colaboradores (2022) y de Nation y Castles (2017) confirman que el autoaprendizaje es un mecanismo universal para aprender representaciones ortográficas.

2.3. Modelos de escritura

Aunque menos estudiada que la lectura, la escritura también ha sido explicada mediante diferentes modelos teóricos. Algunos de ellos han abordado la composición escrita y la producción de textos. Otros modelos, al igual que ocurre en lectura, se han centrado en describir el procesamiento léxico. Finalmente, otros autores han contemplado la interacción entre los procesos centrales y periféricos.

2.3.1. Modelos de producción de textos

Estos modelos describen los procesos cognitivos a través de los cuales se lleva a cabo la composición escrita (Deane et al., 2008; Chenoweth & Hayes, 2001; Hayes 1996, 2012; Hayes & Flower, 1986). Se parte de una planificación de las ideas a transmitir, las cuales se traducen a su forma lingüística. Una vez seleccionadas las estructuras sintácticas y las palabras que van a representar las ideas, será necesaria la recuperación ortográfica y los procesos motores que transformarán los signos lingüísticos en signos gráficos. Finalmente, se monitoriza y evalúa el resultado para mejorarlo o corregir errores. En la escritura reproductiva (como en la copia o el dictado) no participarán la planificación ni la selección sintáctica. Sí intervendrán los procesos lingüísticos o centrales, que consisten en la recuperación y activación de las representaciones ortográficas; y los procesos motores o periféricos, que hacen referencia a la ejecución grafomotora necesaria para producir la respuesta escrita (Purcell et al., 2011; van Galen, 1991).

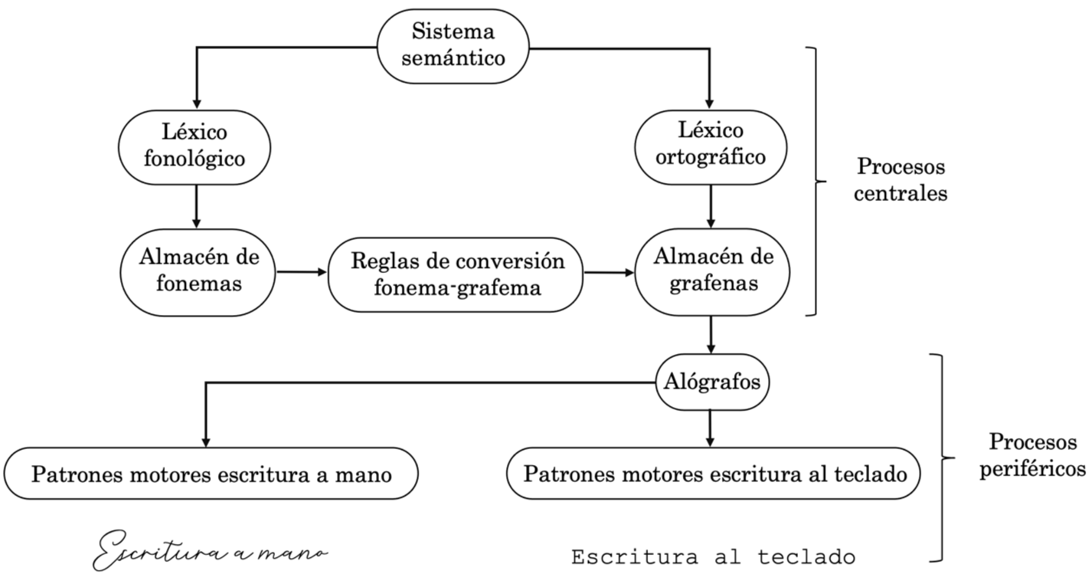
2.3.2. Modelos de procesamiento léxico

Uno de los modelos de escritura centrado en el procesamiento léxico es el modelo de doble ruta (Coltheart, 1978; Ellis, 1982; Ellis & Young, 1996; Tainturier

& Rapp, 2001). En su modelo, Ellis (1982) propone dos tipos de procesos: centrales, encargados de realizar la recuperación ortográfica de las palabras; y periféricos, responsables de los patrones motores (Figura 7).

Figura 7

Modelo de Escritura de Doble Ruta de Ellis (1982) (Adaptada de Cuetos et al., 2015).



En los procesos centrales están incluidas la ruta léxica y la ruta subléxica. La ruta léxica, al igual que sucede en lectura, se emplea cuando escribimos palabras cuya representación se encuentra almacenada en nuestro léxico ortográfico. Además, será especialmente útil a la hora de escribir palabras con una ortografía irregular. La ruta subléxica, en cambio, se emplea para escribir mediante la aplicación de las reglas de conversión fonema-grafema aquellas palabras de cuya representación no disponemos (bien porque no las conocemos o porque no existen) (Caramazza, 1988; Tainturier & Rapp, 2001). Independientemente de la ruta empleada, la información procesada se mantiene en el buffer grafémico y se seleccionan las unidades grafémicas para poder escribir la palabra (Tainturier & Rapp, 2004). Es en este punto en el que los procesos centrales dan paso a los periféricos, mediante los cuales se seleccionarán los grafos necesarios para representar los grafemas, y se pondrán en marcha los procesos motores para realizar la escritura a mano o a teclado.

El modelo triangular también ha servido de inspiración para otros modelos, esta vez de escritura. Algunos de ellos replican en escritura los supuestos siguiendo el enfoque conexionista (Brown & Loosemore, 1994; Rapp et al., 2002), mientras que otros lo combinan con el modelo dual para formar una arquitectura híbrida (Houghton & Zorzi, 2003). Todos estos modelos coinciden en que cada vez que se escriba correctamente una palabra se fortalecen las conexiones entre sus niveles de representación, siendo más fácil la escritura cuanto más fuertes sean estas conexiones.

2.3.3. Interacción de procesos centrales y procesos periféricos

En su modelo, van Galen (1991) describe la escritura como un proceso organizado de manera jerárquica y de procesamiento paralelo, en el que el control motor está involucrado. A partir de este modelo se ha estudiado más en profundidad la interacción entre los procesos centrales y periféricos. Así, se ha demostrado que, en muchos casos, los procesos que ocurren a un nivel central no terminan antes de iniciar la ejecución grafomotora, dando lugar a un procesamiento en cascada (Bonin et al., 2012, Kandel et al., 2013; Lambert et al., 2011; Roux & Bonin, 2012). En un principio se creía que los procesos centrales y periféricos eran independientes, y que la recuperación ortográfica se completaba antes de iniciar la respuesta motora, independientemente de la ruta utilizada (Bonin et al., 1998). Esto hizo que se investigaran ambos procesos por separado, utilizando medidas diferentes como la latencia y la duración de escritura. La latencia es el tiempo que pasa entre la presentación de un estímulo y el primer contacto del bolígrafo sobre el papel. La duración es el tiempo transcurrido desde ese primer contacto hasta la separación del bolígrafo, cuando ha finalizado la escritura de la palabra (o del segmento que se quiera investigar). De esta forma, los estudios enfocados en la recuperación ortográfica se basan en las diferencias entre latencias para investigar los procesos que ocurren antes del inicio de la escritura (Afonso & Álvarez, 2011; Bonin, Peereman & Fayol, 2001). En cambio, la duración de escritura y otras medidas kinemáticas se utilizarían para investigar los procesos que ocurren a nivel periférico (van Galen et al., 1989).

Sin embargo, diversos estudios observaron que algunas de las variables que afectaban al componente central también afectaban al periférico, confirmando la interacción entre ambos procesos (Afonso, Álvarez, & Kandel, 2015; Afonso, Suárez-Coalla, & Cuetos, 2015; Delattre et al., 2006; Kandel et al., 2013; Kandel & Perret, 2015; Lambert et al., 2011; Roux et al., 2013). No obstante, la interacción no será siempre igual: la manera en la que se produce el efecto en cascada dependerá tanto de variables lingüísticas como del sujeto.

En cuanto a las variables lingüísticas, se han reportado efectos de variables léxicas, como frecuencia (Afonso et al., 2018; Bonin & Fayol, 2002; Delattre et al., 2006), y subléxicas, como la consistencia ortográfica (Afonso, Álvarez & Kandel, 2015; Afonso, Suárez-Coalla, & Cuetos, 2015; Bonin et al., 2015; Delattre et al., 2006; Lambert et al., 2011; Roux et al., 2013). Sin embargo, los efectos de estas variables no producen el mismo tipo de cascada (Roux et al., 2013). Por ejemplo, el conflicto causado por la irregularidad ortográfica (nivel subléxico) genera una carga cognitiva más importante que la que pueda generar la frecuencia de la palabra (nivel léxico) (Delattre et al., 2006; Kandel & Perret, 2015). En cuanto a las características del sujeto, serán determinantes la habilidad ortográfica y grafomotora (Afonso, Suárez-Coalla & Cuetos, 2015; Sausset et al., 2012) y la edad (Kandel & Perret, 2015; Kandel &Valdois, 2006;

Suárez-Coalla et al., 2018). La escritura de los niños se verá influida por el desarrollo, el cual se describirá en el siguiente apartado.

2.4. Aprendizaje de la escritura

Diversos autores han descrito modelos de aprendizaje de la escritura, como Uta Frith (1984). Frith sugiere que los niños atraviesan diversos estadios: un primer estadio de segmentación silábica y fonémica; un aprendizaje de las reglas de conversión fonema-grafema; una automatización de la ruta subléxica; y finalmente una etapa de apoyo en la ruta léxica. Otros autores, sin embargo, defienden el aprendizaje de la escritura como un proceso continuo como la lectura, en el que ambas estrategias (léxica y subléxica) se desarrollan de forma paralela.

2.4.1. Estrategias léxicas y subléxicas

De esta manera, en las primeras etapas del aprendizaje la ruta subléxica contribuye de manera más activa (Sprenger-Charolles et al., 2003), mientras se forman las representaciones ortográficas para las palabras (Lété et al., 2008; Sprenger-Charolles et al., 1998; Sprenger-Charolles et al., 2003). Aunque los escritores principiantes se apoyan más en la ruta subléxica, la ruta léxica ya se utiliza desde etapas tempranas del aprendizaje (Martinet et al., 2004; Sprenger-Charolles et al., 1998). De igual manera, aunque los escritores competentes recurran a estrategias léxicas para escribir, la ruta subléxica también sigue contribuyendo (Brown & Ellis, 1994). De hecho, sigue participando incluso en la escritura de palabras conocidas (Afonso, Álvarez & Kandel, 2015; Afonso, Suárez-Coalla & Cuetos, 2015; Bonin et al., 2015).

La escritura también tiene una función de autoaprendizaje que contribuye al crecimiento del conocimiento ortográfico (Shahar-Yames & Share, 2008; Share, 1995). La lectura y la escritura están estrechamente relacionadas, existiendo una transferencia entre ambas (Conrad, 2008). No obstante, la asimetría que existe entre ellas hace que la lectura sea más fácil que la escritura (Bosman & van Orden, 1997). En la lectura la representación ortográfica puede ser menos específica, o al menos lo suficiente como para que se produzca el reconocimiento. Sin embargo, escribir correctamente implica recuperar todos y cada uno de los elementos que componen una palabra y su orden correcto dentro de esta. La ganancia de conocimiento ortográfico es mayor durante la escritura, pero también lo son la atención y el esfuerzo necesarios para su correcta ejecución (Shahar-Yames & Share, 2008).

2.4.2. Triple Forma de la Palabra

Para llevar a cabo la ardua tarea de recuperar la representación ortográfica completa, los niños deben apoyarse en diferentes tipos de información: la fonología, la ortografía y la morfología (Bourassa & Treiman, 2009). Estos tres elementos lingüísticos constituyen la base de la teoría de la Triple Forma de la Palabra (Bahr et al., 2009; Berninger et al., 2009; García et al., 2010). De acuerdo con esta teoría, los tres tipos de conocimientos sobre la estructura de las palabras se almacenan y se coordinan entre ellos para construir la forma escrita del lenguaje. Las interrelaciones entre sonidos (fonología) y letras (ortografía), así como las relaciones entre las raíces y los afijos (morfología) serán relevantes para el desarrollo de la escritura.

Al principio, las habilidades fonológicas contribuyen de manera directa, sobre todo la conciencia fonológica y el conocimiento de las correspondencias fonema a grafema (Blachman, 2000; Ziegler & Goswami, 2005). Sin embargo, la ruta subléxica no es suficiente para escribir palabras si la ortografía es irregular (Moats, 2010, 2016). Por ello, se necesitan unas habilidades ortográficas avanzadas. Este tipo de conocimiento es importante, por ejemplo, para interiorizar las secuencias legales e ilegales de la lengua, o los patrones ortográficos (Cassar & Treiman, 1997). El conocimiento de la ortografía es especialmente relevante para aquellas lenguas cuya ortografía sea compleja y profunda, como la del inglés. En estos casos también lo es la conciencia morfológica (Carlisle, 2000, 1995). La morfología es una fuente de valiosa información, ya que conocer las formas de las palabras (los sufijos) facilitará su escritura con una ortografía correcta (Bourassa & Treiman, 2008; García et al., 2010).

A raíz de los estudios que han confirmado el apoyo en estos tres tipos de información (Bahr et al., 2009; García et al., 2010), se han llevado a cabo otras investigaciones que demuestran que el desarrollo de la escritura no es lineal. Por ejemplo, Bahr y colaboradores (2012) realizaron un análisis del patrón lingüístico de niños americanos desde primero hasta noveno grado (edades comprendidas entre los 6 y los 15 años). Descubrieron que los niños de cursos inferiores se apoyaban principalmente en la fonología, mientras que cuanto más se incrementaba el curso más recurrían a su conocimiento ortográfico y morfológico. Los autores atribuyeron el cambio a un crecimiento de vocabulario, con la incorporación de palabras morfológicamente complejas que hacen necesario el uso del conocimiento morfológico. Además, el crecimiento del léxico ortográfico tras años de experiencia explicaba un menor apoyo en la información fonológica. De igual manera, Bahr y colaboradores (2020) comprobaron que niños de tercero a quinto curso integran sus conocimientos de fonología, ortografía y morfología con el fin de escribir patrones ortográficos de manera correcta. Estos autores, además, destacan la multidimensionalidad de la exactitud a la hora de escribir: no sólo consiste en entender las reglas ortográficas, sino que habrá más habilidades involucradas.

2.4.3. Desarrollo de la escritura a mano

Para aprender a representar la lengua de forma escrita, el desarrollo de las habilidades de recuperación ortográfica se unirá al desarrollo de las habilidades motoras.

Cuando los niños están aprendiendo a escribir, los procesos centrales y periféricos son independientes, pues ambos les requieren un gran esfuerzo. A medida que los niños adquieran habilidades grafomotoras los programas motores se consolidarán (Mojet, 1991), y podrán dedicar más recursos cognitivos a otros procesos (McMurray, 2006). En torno a los 9 años de edad esta producción motora se automatiza, por lo que podrá ser procesada en paralelo con la recuperación ortográfica. En este momento, los procesos centrales comienzan a interaccionar con los periféricos. Este cambio evolutivo se verá reflejado en las latencias y las medidas kinemáticas, que mostrarán diferencias entre los niños de distintos cursos (Afonso et al., 2018; González-Martín et al., 2017; Kandel & Perret, 2015). Estas diferencias también informan de las estrategias en las que se apoyan los niños durante la escritura, y permiten establecer en qué momento pasan de una estrategia serial a una escritura basada en la recuperación de las representaciones ortográficas (González-Martín et al., 2017; Suárez-Coalla et al., 2018). Pero el apoyo en una u otra estrategia no sólo dependerá del desarrollo. También dependerá del sistema ortográfico.

2.5. Diferencias entre sistemas de escritura

Diversos estudios han confirmado la existencia de mecanismos y principios universales en la lectura y la escritura (Caravolas, 2004; Caravolas et al., 2012; X. Li et al., 2022; Shankweiler & Fowler, 2019; Verhoeven & Perfetti, 2022). Sin embargo, existen diferencias entre lenguas que afectan a la lectura y a la escritura, y también a su desarrollo (Borleffs et al., 2019; Castles et al., 2018).

Aunque los sistemas de escritura representan el lenguaje oral, no todos representan las mismas unidades. Es por eso que las estrategias utilizadas para la lectura y escritura no serán las mismas (Frost, 2005). Por ejemplo, en los sistemas que son logográficos, como el chino, cada símbolo representa un morfema o unidad con significado, sin que necesariamente tenga relación con su pronunciación. Por ello, se requiere un mayor apoyo en la información visual. En los sistemas de escritura silábicos, como el kanji japonés, cada caracter representa una sílaba. En los sistemas alfabéticos, como el inglés y el español, los grafemas codifican el sonido a nivel de fonema. Esto implicará un mayor apoyo en la información fonológica (X. Li et al., 2022; Ziegler et al., 2010). Muchas lenguas europeas tienen sistemas alfabéticos. Sin embargo, a pesar de que están basados en un mismo principio, existirán diferencias entre ortografías que condicionarán la lectura y la escritura. Estas diferencias se deben a diferentes aspectos, como la complejidad silábica o la densidad ortográfica (Marinus et al., 2015). Pero una de las variables más determinantes es la profundidad ortográfica.

2.5.1. Teoría de la profundidad ortográfica

La hipótesis de la profundidad ortográfica (Frost et al., 1987; Katz & Frost, 1992) sugiere que las diferencias entre sistemas ortográficos se deben a la cercanía en la relación entre la forma ortográfica de una palabra y su pronunciación, es decir, al grado en el que la ortografía es una representación fonética del habla (Katz & Feldman, 2017). La profundidad ortográfica no es un concepto dicotómico, sino que varía en un continuo entre los distintos sistemas de escritura (Frost et al., 1987; Goswami et al., 1998; Seymour et al., 2003; Sprenger-Charolles et al., 2011). Está determinado por la transparencia de las correspondencias entre los grafemas y los sonidos que representan. Las ortografías más superficiales son aquellas cuyas correspondencias grafema-fonema son relativamente consistentes, simples y completas; mientras que las correspondencias de las ortografías más profundas son sustancialmente inconsistentes, complejas e incompletas (Katz & Frost, 1992, Richlan, 2014). En este sentido, son inconsistentes si un mismo grafema se corresponde con múltiples fonemas, o si un fonema puede ser representado por varios grafemas. Son complejas si la pronunciación de un grafema depende de múltiples letras, bien porque forman parte de dicho grafema o porque la pronunciación está determinada del contexto ortográfico. Y son incompletas si la información subléxica no siempre es suficiente, dependiendo la pronunciación del significado de la palabra (el sustantivo *object* /ɒbʤɪkt/ y el verbo *object* /əbˈʤɛkt/).

Así, pese a que todos los lectores usan ambas estrategias, el grado relativo en que se apoyen más en una u otra dependerá de la profundidad ortográfica de la lengua. Las correspondencias de las ortografías más superficiales facilitan la decodificación de las palabras mediante la aplicación de las reglas de correspondencia grafema-fonema, pues son altamente fiables. Por el contrario, la complejidad y la impredecibilidad de las ortografías profundas hará que las correspondencias sean menos fiables (Schmalz et al., 2015; de Simone et al., 2021). Una menor fiabilidad empeora la eficiencia de la ruta subléxica y empuja a los lectores a incrementar su apoyo relativo en la ruta léxica (Schmalz et al., 2016). Schmalz y colaboradores profundizan en este aspecto en su revisión teórica (2015). Los autores proponen que la profundidad ortográfica es un conglomerado de dos conceptos relacionados pero disociables: la complejidad de las correspondencias entre grafemas y fonemas y la impredecibilidad de la pronunciación de las palabras en base a su ortografía. La complejidad ralentiza la velocidad de aprendizaje de la lectura de una lengua, mientras que la impredecibilidad reduce la exactitud durante la decodificación, incluso cuando se han aprendido todas las correspondencias.

Katz y Frost (1992) afirman que "cada lengua tiene la ortografía que se merece". A esto, de Groot y colaboradores (2002) añaden: "y cada ortografía tiene las estrategiasde procesamiento a las que invita". Estas estrategias, que vienen dterminadas por la ortografía, tienen un papel relevante en la teoría del tamaño de grano psicolingüístico o teoría de la granularidad.

2.5.2. Teoría del tamaño de grano psicolingüístico

Propuesta por Ziegler y Goswami (2005), esta teoría explica las diferencias observadas entre lenguas en el aprendizaje de la lectura. Los autores sugieren la existencia de unidades de procesamiento (auditivo y visual) de diversos tamaños de grano psicolingüístico. Los rasgos específicos del sistema ortográfico de una lengua determinan qué tamaños de grano psicolingüístico son preferibles para su procesamiento, y qué mecanismos de aprendizaje son más efectivos para la adquisición de la lectoescritura. Para que la decodificación sea exitosa, los niños tienen que encontrar tamaños de grano en la ortografía y la fonología de su lengua que les permita realizar correspondencias directas e inequívocas entre ambos dominios. De esta manera, todos los lectores principiantes se enfrentan a tres problemas relativos a estas correspondencias: disponibilidad, granularidad y consistencia (ver figura 8). La competencia lectora depende de la resolución de estos tres problemas (Rayner et al., 2001), y la eficiencia para resolverlos varía en función del sistema ortográfico.

La *disponibilidad* se refiere al hecho de que no todas las unidades fonológicas son accesibles de manera consciente antes de la lectura. Las palabras son las unidades fonológicas más grandes, siendo además las más accesibles. Son las primeras que los niños dominan, para posteriormente pasar a dominar sílabas y rimas, y finalmente fonemas. La *granularidad* implica que, cuanto mayor sea el tamaño de las unidades en las que se basa el acceso al sistema fonológico, mayor es el número de unidades ortográficas que se deben aprender. Es decir, existen más palabras que sílabas, más sílabas que rimas, más rimas que grafemas, y más grafemas que letras. Los niños comienzan aprendiendo las letras, y progresivamente aprenden unidades de mayor tamaño hasta llegar a un procesamiento léxico. Por último, la *consistencia* ortográfica (que ya describe la hipótesis de profundidad ortográfica) hace referencia a que algunas unidades ortográficas tienen múltiples pronunciaciones, y que algunas unidades fonológicas se representan mediante múltiples patrones ortográficos (Glushko, 1979; Ziegler et al., 1997).

Figura 8

Problemas en el Aprendizaje de la Lectura Desde la Perspectiva de la Teoría de la Granularidad: Disponibilidad, Granularidad Y Consistencia (Adaptada de Ziegler & Goswami, 2005)

Los distintos tamaños de grano emergen como respuesta a diferentes tipos de presiones: una presión funcional hacia unidades pequeñas, que son ortográficamente menos complejas; una presión lingüística hacia unidades más grandes, que son fonológicamente más accesibles; y una presión estadística hacia unidades que son más consistentes que otras. Aprender a leer en ortografías transparentes permite un mayor apoyo en estrategias de decodificación grafema-fonema, porque las correspondencias son relativamente consistentes. En las ortografías profundas la falta de fiabilidad debe minimizarse mediante el apoyo en unidades más grandes, pues la pronunciación tiende a ser más predecible (Brown & Deavers, 1999; Treiman et al., 1995). Esto empuja a los lectores de ortografías profundas a recurrir a estrategias adicionales, suplementando la conversión grafema-fonema con el procesamiento de unidades de un tamaño de grano mayor, como la rima o incluso la palabra completa (Goswami et al., 2001; Goswami et al., 2003).

Tanto la teoría de la profundidad ortográfica como la teoría de la granularidad concluyen que las características de la ortografía son el origen de las diferencias entre lenguas. Sin embargo, la primera lo considera un cambio cuantitativo en la contribución relativa de cada ruta (léxica y subléxica), mientras que la segunda propone un cambio cualitativo en la naturaleza del procesamiento subléxico (preferencia por tamaños de granos diferentes).

2.5.3. Repercusiones en el aprendizaje de la lectoescritura

La teoría de profundidad ortográfica y la del tamaño de grano psicolingüístico han sido confirmadas por multitud de estudios enfocados en el aprendizaje de la lectura. Estos estudios se han llevado a cabo en diversas lenguas, como inglés (Seymour & Duncan, 2001), francés (Sprenger-Charolles et al., 1998), alemán (Wimmer et al., 1999), italiano (Burani et al., 2017) o español (Alegría & Carrillo, 2014; Cuetos & Suárez-Coalla, 2009; Defior & Serrano, 2014; Goikoetxea, 2006). Las diferencias que existen entre lenguas se hacen evidentes gracias a estudios comparativos de ortografías con distinta profundidad (Aro & Wimmer, 2003; Sprenger-Charolles, 2004). Algunos autores han comparado el inglés con lenguas más transparentes como el alemán (Landerl, 2000; Landerl et al., 1997; Mann & Wimmer, 2002; Wimmer & Goswami, 1994; Wimmer & Landerl, 1997; Rau et al., 2015), el italiano (Marinelli et al., 2020), y el galés (Ellis & Hooper, 2001; Spencer & Hanley, 2004). Otros autores han comparado el español con ortografías más profundas como el francés y el portugués (Carrillo et al., 2013; Defior et al., 2002; Serrano et al., 2011) o el inglés (Caravolas et al., 2013). Todos ellos confirman el uso de diferentes estrategias lectoras: los lectores de ortografías transparentes se apoyan más en la decodificación, mientras que los lectores de ortografías profundas recurren en mayor medida a una recuperación léxica (Perfetti & Harris, 2013).

El desarrollo de múltiples estrategias de decodificación es necesario en las ortografías profundas para garantizar la precisión lectora. Sin embargo, también requerirá un mayor tiempo de aprendizaje. Las diferencias observables entre lenguas se deben precisamente al ritmo de aprendizaje, y no a diferencias cualitativas (Defior & Serrano, 2005). Con el objetivo de conocer en qué momento del desarrollo lector emergen estas diferencias, Seymour y colaboradores (2003) realizaron un macroestudio. Estos autores investigaron la adquisición de la lectura en diferentes ortografías europeas, comparando la precisión lectora de niños de diversos países al final de su primer año de escolaridad. Las 13 ortografías consideradas para el estudio, que incluían el español y el inglés, se clasificaban según dos dimensiones: estructura silábica (simple o compleja) y profundidad ortográfica (Figura 9). Los resultados demostraron un gran impacto de la profundidad ortográfica. Los niños que alcanzaban una mayor precisión y fluidez lectora eran aquellos aprendiendo a leer en ortografías más transparentes, como el español o el italiano. Alcanzar el mismo nivel de precisión requería casi el doble de tiempo a los niños aprendiendo a leer en inglés, con diferencias de hasta un año.

Figura 9

Clasificación Hipotética de las Ortografías Europeas Propuesta por Seymour y Colaboradores (2003)

		PROFUNDIDAD ORTOGRÁFICA				
		Superficial				Profunda
ESTRUCTURA SILÁBICA	Simple	Finés	Griego Italiano **Español**	Portugués	Francés	
	Compleja		Alemán Noruego Islandés	Holandés Sueco	Danés	**Inglés**

En cuando a la escritura, la coexistencia de las rutas léxica y subléxica ha sido demostrada en ortografías de diferente profundidad, como inglés (Niolaki et al., 2020), portugués (Fernandes et al., 2008), francés (Hazard et al., 2020), español (Defior et al., 2009; Defior y Serrano, 2005; Suárez-Coalla et al., 2018), e italiano (Notarnicola, et al., 2012). Sin embargo, el desarrollo y la contribución de las estrategias de procesamiento depende, al igual que en la lectura, de las características ortográficas de la lengua (Caravolas 2004; Sprenger-Charoles et al., 2006). Así, en los sistemas más transparentes se producirá un mayor apoyo en estrategias subléxicas, mientras que en los sistemas profundos será necesario el desarrollo de la ruta léxica (Lété et al., 2008). La consistencia (Caravolas, 2004; Carrillo et al., 2013) y los tamaños de grano preferidos (Kandel & Valdois, 2006) serán responsables de las diferencias de aprendizaje entre ortografías de distinta profundidad. Aunque si en lectura solo implicaban un retraso en el ritmo de adquisición, en escritura implicarán también diferencias cualitativas, con un mayor efecto de la regularidad y la frecuencia (Marinelli et al., 2015). Esta no será la única diferencia con la lectura, pues su aprendizaje es más difícil que el de la lectura (Bosman & van Orden, 1997). En algunos sistemas ortográficos, como el francés, las correspondencias de fonología a ortografía son menos consistentes que de ortografía a fonología (Lété et al., 2008; Ziegler et al., 1996). Esto implica una mayor dificultad para el desarrollo de la escritura, comparado con el de la lectura. En otros sistemas, como el inglés, la inconsistencia se dará por igual en ambas direcciones. Este es uno de los motivos por los que aprender a leer y escribir en inglés es tan difícil. Y lo será aún más para quienes lo aprenden como L2/LE, tal y como se describe en el siguiente capítulo.

3. Aprendizaje del inglés

El inglés tiene unas características únicas que hacen del aprendizaje de la lectura y la escritura todo un desafío. No solo por la propia complejidad del código alfabético, sino por sus diferencias con otras ortografías. A lo largo de este capítulo, el tercero y último, se describen de manera detallada las características de la ortografía del inglés, haciendo hincapié en aquellos aspectos en los que se distingue de la ortografía del español. También se detalla cómo es el aprendizaje de la lectura y la escritura en una L2/LE. Y, finalmente, se expone la situación del aprendizaje del inglés como L2/LE en el mundo, en Europa y en España.

3.1. Sistema ortográfico del inglés y diferencias con el español

El inglés es una lengua germánica que pertenece a la familia de las lenguas indoeuropeas. Su origen se remonta a los reinos anglosajones, y a lo largo de la historia ha ido evolucionando y extendiéndose hasta convertirse en una lengua global (Crystal, 2018). Hoy en día es el idioma más hablado del mundo, con más de 1.452 millones de hablantes (en su mayoría, como L2/LE). Una de sus particularidades es la amplitud de su vocabulario, con numerosas incorporaciones de diversas lenguas europeas, como el francés y el alemán, pero también del latín y de antiguos dialectos nórdicos y germánicos. Estas incorporaciones no siempre se han adaptado de la misma manera a la representación escrita de la lengua. Como resultado de esta amalgama de influencias, el inglés tiene una ortografía aparentemente irregular (Venezky, 1970).

A pesar de que el inglés y el español tienen en común tanto el sistema de escritura como el alfabeto, las diferencias en términos ortográficos son suficientes como para determinar las estrategias de procesamiento del lenguaje escrito.

Existen rasgos del inglés que pueden dificultar su aprendizaje como L2/LE, rasgos que dependen de la lengua nativa del estudiante y de la similitud de esta con el inglés. A continuación, se describen las características fonológicas, ortográficas y morfológicas del inglés. Todas ellas son relevantes para explicar las particularidades de la ortografía inglesa y sus diferencias con la ortografía española. Estas diferencias, además, tendrán un papel fundamental en el aprendizaje de la lectura y la escritura del inglés de los hablantes de español.

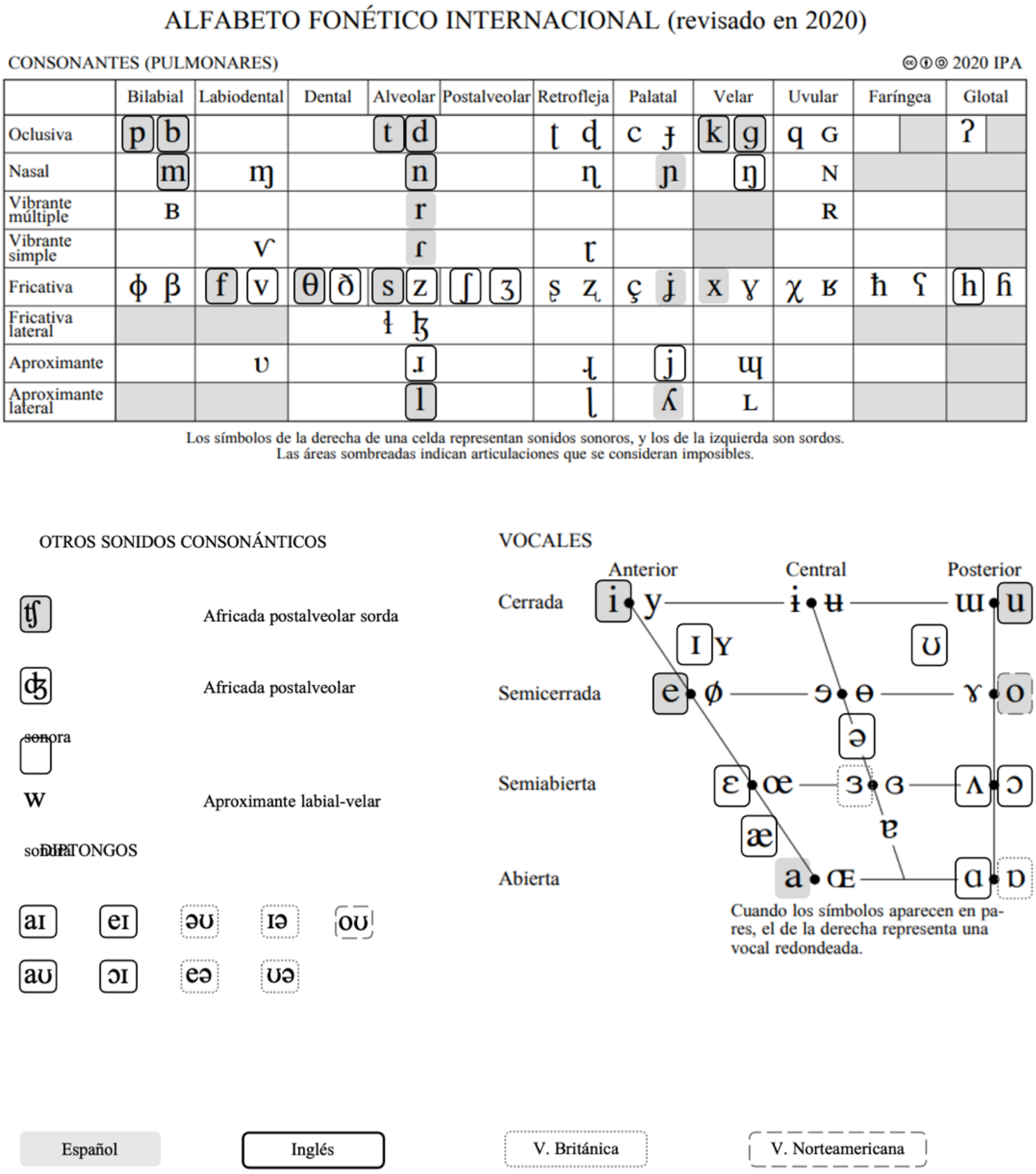
3.1.1. Fonología

En términos generales, el repertorio fonémico del inglés se compone de aproximadamente 44 fonemas (Giegerich, 1992; Ogden, 2017; Pennington, 2014). De estos, 24 son consonánticos y al menos 11 vocálicos, aunque dependiendo de la variedad pueden llegar a ser más (Bizzocchi, 2017; Deterding, 2004). El español, por el contrario, consta de 18 fonemas consonánticos (19, si consideramos /ʎ/), y cinco fonemas vocálicos (Alarcos Llorach, 1971; Navarro, 2004/1918).[1] La diferencia entre inventarios implica que algunos fonemas del inglés no están presentes en el inventario del español, y viceversa. Al no existir un fonema idéntico en la lengua nativa, los fonemas novedosos de la L2/LE son más difíciles de procesar, y su discriminación y reconocimiento es peor (Wade-Woolley & Geva, 2000; M. Wang & Geva, 2003). Como resultado, pueden ser sustituidos por el fonema más próximo que esté disponible en el repertorio del español. Esto afecta tanto a las vocales (Baigorri et al., 2019; Iverson & Evans, 2007) como a las consonantes (Howard et al., 2012; Zutell & Allen, 1988), tal y como se detalla a continuación (Figura 10).

[1] Debido a las características de la población de estudio, los fonemas del español descritos en este trabajo pertenecen a la variedad de castellano peninsular neutro. Por tanto, no se considerarán otros fonemas o variaciones de pronunciación propias de países de Latinoamérica u otras regiones de España.

Figura 10

Tabla del Alfabeto Fonético Internacional con el Inventario Fonémico del Inglés (Bordeado) y del Español (Sombreado)



Nota. Se indican los fonemas de las variedades de inglés más comunes en la enseñanza del inglés a nivel europeo (Carrie, 2017; Henderson et al., 2012), que son *Received Pronunciation* (inglés británico) y *General American* (inglés norteamericano). (Adaptado de International Phonetic Association, 2015

Fonemas vocálicos

Comparando ambos sistemas vocálicos, encontramos que el número de fonemas del inglés es muy superior al del español. Las vocales que son comunes a ambas lenguas (*e*, *i*, *o*, *u*), además, difieren ligeramente en su formante F2 (Bradlow, 1995). Muchas de las otras vocales inglesas se encuentran en posiciones intermedias (tanto en apertura como en localización) respecto a las vocales españolas. Esto provoca que algunos fonemas se perciban como el fonema más cercano del español (Levey, 2004). Por ejemplo, los fonemas /æ/ y /ʌ/ (como en *cat* y *cut*) pueden ser percibidos indistintamente como /a/. Lo mismo ocurre en el caso de algunas vocales de diferente longitud. La longitud de las vocales es un concepto que no existe en español, pero que en inglés será determinante (Lindau, 1978). Las diferencias entre fonemas cortos y largos son sutiles para los nativos españoles, como en el caso de los fonemas /ɪ/ e /i:/ (como en *ship* /ʃɪp/ y *sheep* /ʃi:p/), que pueden ser percibidos indistintamente como /i/ (Whitley, 2002). Finalmente, el inglés tiene un ritmo de isocronía acentual (Carr, 2019). Las sílabas no acentuadas de las palabras inglesas pueden sufrir una reducción vocálica, que transforma el fonema vocálico en un fonema neutro conocido como *schwa* (/ə/). En algunas ocasiones, el fonema se omite por completo, como en *chocolate* (/ˈʧɒkəlɪt/) (Ahn, 1997; Burzio, 2007; Flemming, 2009). Este fenómeno es novedoso para los hablantes de español, una lengua que tiene un ritmo de isocronía silábico y en la cual la reducción de las sílabas no existe (Defior & Serrano, 2014).

Fonemas consonánticos

Respecto a los fonemas consonánticos, 13 de ellos son compartidos por el inglés y el español. Sin embargo, su pronunciación no es exactamente igual en ambas lenguas (Anderson & Centeno, 2007). Por otro lado, existen ciertos fonemas consonánticos que sólo existirán en inglés y serán difíciles de discriminar por los nativos españoles. Estos fonemas, que pertenecen a categorías diferentes en inglés, son percibidos como de una misma categoría preexistente en español. Algunos ejemplos son /ʤ/ (*jeans)* y /j/ (*yellow)*; /s/ (*see*) y /ʃ/ (*she*); /ð/ (*they*) y /d/ (*day*). Además de los evidentes efectos en la pronunciación, esto también tendrá implicaciones en la lectura y en la aplicación de las reglas fonema-grafema a la hora de escribir.

Los niños españoles deben aprender a representar tanto los fonemas que no existen en su lengua nativa como los que están compartidos por ambas lenguas. Para ello, tienen que utilizar o bien nuevas correspondencias que no se corresponden con las del español, o bien nuevos grafemas exclusivos del inglés. En el siguiente apartado se describen elementos y características ortográficas del inglés que, por su novedad o por estar compartidos con el español, pueden suponer un obstáculo para los hispanohablantes: el contexto ortográfico y la consistencia, los grafemas incongruentes y los grafemas complejos y los grupos consonánticos.

3.1.2. Ortografía

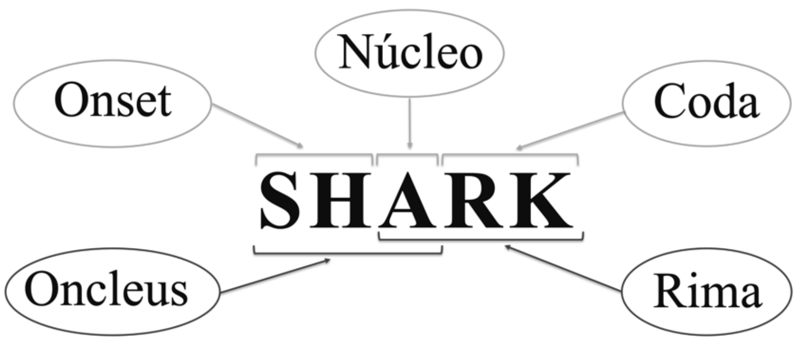
Contexto ortográfico y consistencia

La ortografía del inglés es muy profunda en comparación con otras lenguas indoeuropeas. Se caracteriza por ser altamente compleja y opaca. Las correspondencias entre grafemas y fonemas son muy inconsistentes, pues un fonema puede representarse mediante varios grafemas (/i:/ puede escribirse *ee* como en *see*, o *ea* como en *sea*), y a su vez un grafema puede representar diferentes fonemas (el grafema *th* puede representar el fonema /ð/ como en *brother*, o el fonema /θ/ como en *thing*) (Ziegler et al., 1997). Sin embargo, la fama de ser una ortografía impredecible, irregular y caótica es inmerecida. Lo cierto es que es más regular de lo que aparenta (Kessler, 2003). Venezky recoge en sus estudios (1967, 1970, 1999) numerosas reglas que, si bien no rechazan las excepciones, sí demuestran que la ortografía del inglés se rige por unos patrones y puede llegar a ser en gran medida predecible. Esto es así gracias al contexto ortográfico. Esta dependencia del contexto se produce también en español, con la presencia de consonantes cuya pronunciación varía en función de la letra siguiente (la *c* y la *g*), o de la posición dentro de la palabra (la *r)*. Sin embargo, estas inconsistencias obedecen a reglas conocidas (Cuetos & Barbón, 2006; Real Academia Española, 2023). En inglés, en cambio, el contexto ortográfico será esencial para averiguar la pronunciación y el patrón ortográfico de las palabras. A pesar de que existen excepciones (*yacht, aisle, choir*), cuando se tiene en cuenta el contexto ortográfico la aparente inconsistencia de muchas palabras desaparece (Kessler & Treiman, 2001; Perry et al., 2010; Steacy et al., 2019; Treiman, et al., 2003; Treiman et al., 2006). Por eso, las unidades de un tamaño de grano mayor (como las rimas o las sílabas) tienden a ser mucho más consistentes (Treiman et al., 1995).

La consistencia de las correspondencias entre la ortografía y el sonido hace referencia el grado en el que la pronunciación de una palabra se puede derivar de su ortografía, y viceversa. Su valor depende del número de "amigos" y "enemigos" que tenga. Los primeros son palabras con una pronunciación similar y que comparten el mismo patrón ortográfico. Los segundos son palabras con el mismo patrón ortográfico, pero con una pronunciación diferente. El grado de consistencia es el resultado de dividir el número de amigos por el total de amigos y enemigos (Treiman et al., 1995), resultando un valor que podrá oscilar entre 0 (extremadamente inconsistente) y 1 (altamente consistente). Esta medida no será necesariamente igual para la consistencia de las correspondencias de grafema a fonema (consistencia *feedforward,* G-F) y de fonema a grafema (consistencia *feedback*, F-G) (Stone et al., 1997; Ziegler et al., 1997). Por ejemplo, la palabra *roar* es consistente en la dirección G-F, pues se pronuncia igual que otras palabras que tienen el mismo patrón ortográfico (*boar*, *soar*). Sin embargo, es inconsistente en la dirección F-G porque el sonido /ɔr/ puede escribirse con otros patrones ortográficos, como "-ore" (*more, core*), por lo que hay más de una correspondencia de fonología a ortografía. La lectura y escritura de palabras inconsistentes implica una mayor dificultad (Caravolas et al., 2005; Davies & Weekes, 2005; Lété et al., 2008; Perry & Ziegler, 2004; Planton et al., 2019; Weekes et al., 2006). Cuando las correspondencias son inconsistentes existe un mayor riesgo de cometer errores durante la decodificación, o de hacer una selección incorrecta de los patrones ortográficos (por ejemplo, leer *dive* como /dɪv/ en lugar de /daɪv/, por analogía con *give*; o escribir *peepal* en lugar de *people*). Este riesgo se reduce al procesar unidades de un tamaño superior al del grafema, pues son más consistentes. A nivel subsilábico, los segmentos que forman parte de la estructura de la sílaba son: onset, núcleo, coda, rima y oncleus (ver figura 11) (Vennemann, 1988).

Figura 11

Representación de los Elementos de la Estructura Silábica.



Nota. Las concatenaciones de orden inferior (onset, núcleo y coda) se representan en color gris claro, y las concatenaciones de orden superior (oncleus y rima) en gris oscuro.

El onset está compuesto por la consonante o consonantes que preceden a la vocal; el núcleo siempre es la vocal o vocales que integran la sílaba; y la consonante o consonantes finales que siguen a la vocal constituyen la coda. Además, las concatenaciones de onset + núcleo y de núcleo + coda forman el oncleus y la rima, respectivamente. Diversos estudios demuestran que la consistencia de estos elementos influye en la lectura y la escritura (Chee et al., 2020). Por ejemplo, el onset influye tanto en el reconocimiento visual (Balota et al., 2004; Yap & Balota, 2009) como en la lectura en voz alta (Jared et al.,1990; Jared, 1997; Treiman et al., 1995), al igual que la rima. La consistencia de esta también tendrá efectos sobre la escritura (Caravolas et al., 2005; Davies & Weekes, 2005; Kessler & Treiman, 2001; Treiman et al., 2002; Weekes et al., 2006).

Las vocales del inglés son muy inconsistentes, por lo que la rima es especialmente relevante para su lectura (Treiman et al., 2006) y escritura (Hayes et al., 2006; Treiman & Kessler, 2006). A modo de ejemplo, el grafema *a* representa fonemas distintos en cada una de las siguientes palabras: *car* /kɑr/, *cat* /kæt/, *cake* /keɪk/, *call* /kɔl/. Todas comienzan por la misma letra, pero las diferencias de pronunciación las determinan las consonantes que siguen a la vocal. Si se comparan los patrones ortográficos con otras palabras, las rimas consistentes nos facilitan la lectura correcta: *bar* /bɑr/, *bat* /bæt/, *bake* /beɪk/, *ball* /bɔl/. Otros elementos contextuales que informarán sobre la pronunciación de la vocal serán las *e* silentes y los grafemas dobles. Las *e* finales, también llamadas silenciosas, modifican la pronunciación de las vocales. Cuando una vocal y una consonante van seguidas de la letra *e* dentro de una misma sílaba, la *e* con frecuencia es silente y afecta a la vocal anterior (*bit* / bɪt/ y *bite* /baɪt/). Sin embargo, esta regla tiene algunas excepciones (*have, give*) que es preciso conocer. En cuanto a los grafemas dobles, en español están normalmente asociados a un cambio de pronunciación (*caro* y *carro, mala y malla)*. En inglés no modifican la pronunciación de las consonantes involucradas, pero sí determinan la pronunciación de la vocal que les precede (normalmente para indicar que corta). Por ejemplo, en el caso de la palabra *tabby*, podemos saber que la *a* será pronunciada como una vocal corta (diferente de *table*) porque va seguida de una doble consonante. De manera similar, los verbos *hope* (/hoʊp/) y *hop* (/hɑp/) se distinguen porque la pronunciación de la vocal larga de *hope* está señalada por la *e* final silente. En la conjugación del pretérito, en cambio, la vocal corta de hop está marcada por una doble consonante: *hopped* (/hɑpt/) y *hoped* (/hoʊpt/). Es un patrón ortográfico complejo, que los nativos no dominan hasta etapas relativamente tardías (Cassar & Treiman, 1997; Ehri, 1986). Por tanto, para los niños españoles aprendiendo inglés como LE también implicará dificultad.

Grafemas incongruentes

Algunos de los fonemas comunes para el inglés y el español son representados por grafemas distintos en cada lengua. Esto también ocurre a la inversa: los grafemas comunes a veces representan fonemas diferentes (ver Tabla 1). Por ejemplo, en español la letra *z* representa el sonido /θ/ (como en *zapato*), mientras que en inglés representa el fonema /z/ (*zoo*/), y el fonema /θ/ normalmente es representado con el dígrafo *th* (*thank you*). De la misma manera, la letra *j* representa el sonido /x/ en español (*jarrón*) pero el sonido /ʤ/ en inglés (*jelly*). Por otra parte, algunos grafemas del español no representan fonemas diferentes, sino variantes alofónicas. Es el caso de la *b* y la *v*, que sin embargo en inglés representan fonemas diferentes (/b/ y /v/) (*bowel* y *vowel*). En cuanto a la letra *h*, es la única letra silente del español (exceptuando cuando va precedida por la *c*, como *chaqueta*). En cambio, en inglés representa el fonema /h/ (*house*), que no existe en español, aunque también puede ser silente en algunas palabras (*honest*). De hecho, la mayor parte de las letras del inglés pueden ser silentes en según qué palabras, tanto consonantes (*sword, castle*) como vocales (*basically, people*).

Tabla 1

Elementos Compartidos (Grafemas Y Fonemas) por el Inglés y el Español Cuya Correspondencia es Incongruente Entre Lenguas

Elemento compartido		**Español**		**Inglés**	
Grafemas	*h*	-	*huevo*	/h/ y -	*house, honor*
	j	/x/	*jarrón*	/ʤ/	*jump*
	z	/θ/	*zapato*	/z/	*zoo*
	c	/θ/ y /k/	*ceja, casa*	/s/ y /k/	*city, cage*
	g	/g/ y /x/	*gato, genio*	/g/ y /ʤ/	*get, gem*
	v	/b/	*vaca*	/v/	*vase*
Fonemas	/θ/	*c/z*	*ceja*	*th*	*think*
	/b/	*b/v*	*barco*	*b*	*boat*

Elementos novedosos: grafemas complejos y grupos consonánticos

Teniendo en cuenta las diferencias entre los repertorios fonémicos de ambas lenguas, es lógico pensar que la ortografía del inglés debe tener más grafemas que la del español. Si además consideramos que en inglés un fonema puede ser representado por múltiples grafemas, podemos deducir que habrá muchos, muchos más grafemas que en español. Pues bien, para representar los 44 fonemas del inglés existen más de 200 grafemas (Caravolas, 2013). Pero dado el limitado número de letras del alfabeto, muchos grafemas estarán formados por más de una letra, y serán complejos. Independientemente del número de letras que los compongan (pueden ser dos letras o más, como *bri<u>dge</u>*), los grafemas complejos representan un único fonema, y son unidades ortográficas funcionales (Tainturier & Rapp, 2004). En español también existen, concretamente los dígrafos (formados por dos letras). Aun así, su número es más reducido (*rr, ch, ll, qu* y *gu*) y siempre contienen al menos una consonante. En inglés encontraremos muchos más, que además de ser novedosos para los hispanohablantes (*th, sh, ph, wh, gh, gn, ck*), podrán estar exclusivamente formados por vocales. Por ejemplo, en *h**ea**d (*/hɛd/), *str**ee**t (*/striːt*/)*, y ***toe*** (/təʊ/) aparecen grafemas complejos que representan un solo fonema. Estos mismos conjuntos de letras existen también en español, como en las palabras *mar**ea***, ***lee**r* y *p**oe**ma.* Sin embargo, en este caso representan dos fonemas vocálicos diferentes, pues en español se pronuncian todas las vocales salvo excepciones (la *u* sin diéresis cuando acompaña a las consonantes *q* y *g*).

Los grafemas que representan algunas de las vocales denominadas "cortas" a también representan fonemas similares en español. Es el caso de la letra *a* en *fat*, la *e* en *bed*, la *i* en *pick*, la *o* en *dog* y la *u* en *put*. Otras vocales se representarán con grafemas incongruentes con el español, como la *u* en *run*. En cuanto a las vocales largas, algunas están representadas por grafemas simples (*bird* (/bɜːd/), y otras por grafemas complejos (*dream* / driːm/). Respecto a los fonemas vocálicos que forman parte de diptongos, pueden representarse con un grafema simple, como la *u* en *music* (/mjuːzɪk/), o con un grafema complejo, como *oa* en *boat* (/bəʊt/). A veces están representados con una consonante funcionando como vocal, como la *y* (*boy*) o la *w* (*bow*). Aunque la *y* también está presente en español (*rey*), la *w* será única del inglés.

En cuanto a los grupos consonánticos o *clusters*, también pueden ser un obstáculo para los nativos españoles. El español se caracteriza por una estructura silábica generalmente simple (Alegría & Carrillo, 2014), y a pesar de que existen algunos grupos de consonantes, estos no suelen contener más de dos letras (*playa*, *cruz*). Tampoco se localizan al final de la sílaba, salvo contadas excepciones (existen palabras de origen latino que contienen un grupo consonántico al final de la sílaba, tales como *bíceps* o *fórceps*). En cambio, en inglés los grupos consonánticos son comunes tanto al principio como al final de la sílaba (*street*, *earth*). Estos grupos pueden llegar a estar formados hasta por cuatro letras (*prompts*), y suponen una dificultad incluso para los niños nativos (Bahr et al., 2012; Treiman, 1991; Treiman & Cassar, 1996).

Por último, para comprender la complejidad del sistema ortográfico del inglés es necesario considerar su naturaleza morfofonémica (Nunes & Bryant, 2006; Venezky, 1999, 1970), pues incrementará la irregularidad de la ortografía.

3.1.3. Morfología

La morfofonología hace referencia a la interacción entre los componentes morfológicos y fonológicos. En las lenguas con morfología profunda, como es el caso del inglés, algunos patrones ortográficos preservan su identidad morfológica a expensas de la consistencia entre fonema y grafema (Chomsky & Halle, 1968; Cummings, 1988). La ortografía en estos casos no puede representar a la morfología y a la fonología al mismo tiempo, por lo que se favorece la transparencia de una en detrimento de la otra. Es decir, la pronunciación de algunas palabras se modifica cuando sufren procesos de derivación o flexión morfológica, pero conservan la ortografía. Un ejemplo de derivación es el de *sign* (/saɪn/) y *signature* (/ˈsɪgnətʃər/). Mientras que la raíz se conserva (se mantiene el grafema *i*), su pronunciación cambia (/aɪ/ en *sign*, /ɪ/ en *signature*). Además, en este caso no sólo varía la pronunciación de la vocal, sino también la de la consonante (/g/ en *signature*). Esta inconsistencia en la pronunciación también ocurrirá al añadir otros morfemas, como en los casos de *signal* (/sɪgnəl/) y *design* (/dɪzaɪn/). En cuanto a los procesos flexivos, una de las modificaciones más frecuentes ocurre en la construcción del pasado simple de los verbos regulares. A pesar de que se añade la misma terminación -*ed*, en algunos casos se pronunciará /t/ como en *worked* (/wɜːkt/), en otros /d/ como en *loved* (/lʌvd/) y en otros /ɪd/ como en *wanted* (/wɒntɪd/).

Conocer la composición morfológica de las palabras y los procesos de flexión y derivación implica ser consciente de que ambas palabras comparten el mismo lexema, y que por tanto se escriben igual, aunque se pronuncien de manera diferente. La identificación de los lexemas y los morfemas de las palabras será una estrategia más en las que los niños podrán apoyarse. Por eso, la conciencia morfológica y el conocimiento de la morfología son especialmente importantes para el aprendizaje de la lectoescritura en inglés (Nunes y Bryant, 2006; Treiman & Cassar, 1996).

3.2. Aprendizaje de la lectura y la escritura en inglés como L2/LE

Cuando aprendemos a leer y escribir en nuestra lengua nativa, la lengua oral ya está considerablemente desarrollada. La exposición a la fonología y a los fonemas de la lengua ha sido suficiente como para que las representaciones fonológicas sean precisas y de calidad (Walley et al., 2003). Sin embargo, las representaciones de las palabras de la L2/LE se caracterizan por tener una menor resolución y calidad (Bordag et al., 2022; Gor et al., 2021). Representar fonemas específicos de la L2/LE que no están presentes en la lengua nativa es un todo un desafío (Darcy et al., 2013; Pallier et al., 2001). Este fenómeno es explicado por la hipótesis de restricción de la afiliación lingüística (Russak & Saiegh-Haddad, 2011; Saiegh-Haddad et al., 2011). Las autoras se basan en la idea de que la identidad y el perfil fonológico de los fonemas influye en su accesibilidad. En el caso de los fonemas de la L2/LE, la accesibilidad viene determinada por su familiaridad: si existe un fonema idéntico en el repertorio de la lengua nativa, será más fácil de reconocer e identificar. En cambio, la accesibilidad para los fonemas novedosos que solo existen en la L2/LE será peor. De esta manera, la fonología del inglés puede resultar compleja para algunas lenguas cuyo inventario fonémico es menor.

En cuanto a la ortografía, el grado de proximidad y las diferencias que existan entre la lengua nativa y el inglés son muy determinantes, pues pueden facilitar o perjudicar el aprendizaje de la lectoescritura. Las lenguas con un mismo sistema de escritura pueden recurrir a ciertas habilidades comunes para aprender a escribir y leer en la lengua adicional (Dong et al., 2021; Hamada & Koda, 2008; Kahn-Horwitz et al., 2011; Nassaji, 2014; Sparks et al., 2008; Schwartz et al., 2014). Por ejemplo, el desarrollo de las habilidades de decodificación para inglés como L2/LE se producirá con mayor facilidad si la lengua nativa también es alfabética, como en el caso del español (Deacon et al., 2013; Koda, 1988; Koda & Zehler, 2008). Por el contrario, en los sistemas de escritura distintos al alfabético, como el chino, los lectores se apoyan más en otros tipos de información. Esto limita la transferencia de habilidades de la lengua nativa al procesamiento del inglés (M. Wang et al., 2003).

Las diferencias a nivel de ortografía también tienen repercusión en el aprendizaje, produciendo cambios incluso a nivel de activación cerebral (Dong et al., 2021; Liu & Cao, 2016; Shen & del Tufo, 2022). La ortografía de la lengua nativa determina las estrategias que se aplican al leer en la L2/LE (Bhide, 2015). Así, los bilingües que hayan adquirido la lectoescritura en una ortografía más transparente se apoyarán más en la fonología al leer en una ortografía profunda (Koda, 1988; de León et al., 2016; Egan et al., 2019; Lallier et al., 2016). El origen de este fenómeno es explicado por la hipótesis de acomodación al tamaño de grano ortográfico (Lallier & Carreiras, 2018). Según esta hipótesis, cuando entre dos lenguas existen diferencias a nivel de profundidad ortográfica, el bilingüe sufre un proceso de acomodación cognitiva y neural. Esta acomodación hace que se apoye en estrategias de procesamiento acordes a un tamaño de grano híbrido, una mezcla entre los que usarían los monolingües de una y otra lengua. De esta forma, aprender a leer y escribir al mismo tiempo en una ortografía muy profunda y en otra muy transparente resulta en la utilización de un tamaño de grano intermedio.

Independientemente de las habilidades comunes o de la adaptación a nuevas estrategias, para leer y escribir en inglés es indispensable aprender e interiorizar su ortografía. El desarrollo del aprendizaje ortográfico depende de variables como la competencia lingüística (Chung et al., 2019; Fu et al., 2023), el nivel de exposición (Y. Li et al., 2022), la distancia entre ortografías (Geva y Siegel, 2000; Schwartz et al., 2014) y las propiedades lexicales y sublexicales de cada lengua (Piasecki y Dijkstra, 2023). La tarea de aprender el código ortográfico de esta lengua, que ya de por sí es complejo incluso para los nativos, no será fácil.

3.2.1. Lectura

Para leer correctamente en inglés como L2/LE, es necesario conocer su código alfabético. Por un lado, aunque la lengua nativa y el inglés tengan el mismo alfabeto, pueden existir elementos novedosos con los que los estudiantes deben familiarizarse, como los grafemas complejos (Commissaire et al., 2014). En muchos casos la habilidad para gestionar estos elementos dependerá de la adaptación al tamaño de grano preferible para la ortografía (Lallier et al., 2013). Por otro lado, aunque existan elementos compartidos, las correspondencias entre la ortografía y la fonología no tienen por qué ser las mismas. En estos casos se producirá una incongruencia entre los dos códigos (Brysbaert, 2002; Goswami et al., 1998). Basándose en esto, Commissaire y colaboradores (2019) estudiaron la activación fonológica cros-lingüística durante la lectura. Adolescentes franceses aprendiendo inglés realizaron una tarea de decisión léxica con pseudohomófonos. Los resultados demostraron que las reglas de correspondencia de ambas lenguas (francés L1- inglés L2) eran capaces de activar la fonología durante la lectura. Estas mismas autoras también investigaron el efecto de la congruencia fonológica cros-lingüística mediante una tarea de detección de letras dentro de grafema (2014). Así, concluyeron que el procesamiento de las correspondencias es mejor cuando son congruentes (un grafema representa el mismo fonema en ambas lenguas) que incongruentes (un grafema representa un fonema distinto en cada lengua).

3.2.2. Escritura

Los estudios sobre escritura también confirman el desafío que suponen ciertos elementos para los estudiantes de inglés como L2/LE, como las correspondencias incongruentes (Iniesta et al., 2021), o las dificultades para discriminar fonemas específicos del inglés. Estas dificultades se han observado en estudiantes de diferentes orígenes lingüísticos, como chino (M. Wang & Geva, 2003), hebreo (Russak, 2022; Russak & Kahn-Horwitz, 2015), árabe (Allaith & Joshi, 2011; Russak, 2022) y español (Raynolds & Uhry, 2010).

En el caso de la escritura, los errores son una fuente de información sobre la comprensión que los niños tienen de la lengua (Bahr et al., 2009). Charles Read (1971, 1975, 1986) observó que estos errores reflejan las estrategias que los niños nativos utilizan para escribir palabras cuando aún no han aprendido la ortografía convencional. Las clasificaciones de errores permiten identificar el origen de estos errores y el conocimiento de la fonología, ortografía y morfología de la lengua (Moats, 1993; Quick & Erickson, 2018). Por eso, se han utilizado con diferentes objetivos, como la observación de patrones de desarrollo (Bahr et al., 2012; Masterson & Apel, 2010) o la detección de déficits para orientar la intervención logopédica (Apel & Masterson, 2001; Masterson & Apel, 2010; Masterson & Crede, 1999). En el caso de los estudiantes de inglés como L2/LE, indican qué elementos implican una mayor dificultad y permiten conocer cómo coordinan las múltiples fuentes de conocimiento lingüístico necesarias para escribir (Bahr et al., 2015)

Los errores de escritura no son iguales en todos los casos, pues se ven influidos por la lengua nativa (ver las revisiones de Figueredo, 2006, y de Sammour-Shehadeh et al., 2022). Fashola y colaboradores (1996) describieron una serie de "errores predecibles" típicos de los hablantes de una lengua determinada, y que tienen su origen en las diferencias entre dicha lengua y el inglés. En la literatura podemos encontrar evidencias de errores característicos en hablantes de italiano (Bonifacci et al., 2017; Palladino et al., 2016), hebreo (Russak, 2022; Russak & Kahn-Horwitz, 2015), árabe (Alsaawi et al., 2015; Abu-Rabia & Sammour, 2013) y diferentes lenguas asiáticas (Dixon et al., 2010; O'Brien et al., 2020), entre otros.

En el caso específico de los hablantes de español, la mayor parte de los estudios se centran en población infantil de Estados Unidos. Numerosos autores han descrito errores de escritura asociados a elementos del inglés potencialmente difíciles de representar. Algunos, incluso, han descrito las distintas estrategias en las que los niños se apoyan para tratar de representar las palabras inglesas. A pesar de que ciertos errores coinciden con aquellos cometidos por nativos durante su aprendizaje, muchos de ellos se deben a la influencia del español (Sun-Alperin & M. Wang, 2008). Algunos de los errores reportados afectan a los grupos consonánticos al final de palabra (*stan* por *stand*), tal y como describen Fashola y colaboradores (1996), o Lindner y colaboradores (2022). La confusión con las vocales largas (*sid* por *seed*) y con las cortas (*ran* por *run*) (Sun-Alperin & M. Wang, 2008), los dígrafos (*weder* por *weather*) y los grafemas incongruentes entre lenguas (*jospital* por *hospital*) también son frecuentes (Cronnell, 1985; Howard et al., 2012; Zutell & Allen, 1988), así como las dificultades con los dobles grafemas (*rabit* por *rabbit*) (Howard et al., 2006). En cuanto a los diptongos, es frecuente que los hablantes de español los representen siguiendo las reglas de correspondencia del español (*teik* en lugar de *take*) (Fashola et al., 1996; Rolla San Francisco et al., 2006; Raynolds et al., 2013). Los fonemas difíciles de discriminar por los españoles nativos, como /d/ y /ð/ también originarán gran cantidad de errores (*fader* por *father*) (Bahr et al., 2015; Cronnell, 1985; Raynolds & Uhry, 2010). Incluso los fonemas compartidos que tienen una pronunciación ligeramente distinta, como las plosivas, tendrá efectos en la escritura (Raynolds & Uhry, 2010).

Respecto a la interacción de los procesos centrales y periféricos en la escritura en inglés como L2/LE, existe una laguna en la literatura. Si bien algunos autores han investigado los procesos de escritura on-line en estudiantes de inglés como L2/LE, todos utilizan el paradigma de la escritura a teclado. Además, se centran en el estudio de pausas

(Barkaoui, 2019; Xu y Qi, 2017), o en los procesos cognitivos durante la composición (Michel et al., 2020). El estudio de Iniesta y colaboradores (2023) es el único que aborda las diferencias entre español e inglés. Su objetivo era conocer las estrategias utilizadas para escribir en cada lengua, para lo cual se estudió el efecto de variables léxicas y fonológicas en la escritura al dictado. Los resultados confirman la adaptación de los bilingües a estrategias específicas para cada lengua. Al escribir en español los bilingües se apoyaban más en estrategias fonológicas, mientras que para escribir en inglés recurrían a estrategias léxicas. Sin embargo, los participantes eran adultos escribiendo en un teclado. Los mismos autores remarcan la necesidad de estudiar la adaptación de los bilingües a ortografías de distinta profundidad durante la escritura a mano.

3.3. Enseñanza del inglés como lengua extranjera

A lo largo de estos dos capítulos se han descrito diversas variables que condicionan la lectura y la escritura en inglés cuando no es la lengua nativa. El primer capítulo se ha centrado en los fenómenos que caracterizan el procesamiento bilingüe, y en cómo se produce la gestión de dos lenguas. En este segundo capítulo se ha detallado cómo es el aprendizaje de la lectoescritura en L1 y en L2/LE, considerando las diferencias a nivel de ortografía, y se han descrito las características lingüísticas del inglés que lo diferencian del español. Sin embargo, es necesario concluir esta parte del marco teórico refiriéndonos a la enseñanza del inglés como lengua extranjera y al contexto educativo.

La adquisición de la lectoescritura no es igual en la lengua nativa y en una lengua adicional, y tampoco es lo mismo aprender un idioma como segunda lengua y como lengua extranjera. A lo largo de esta introducción se ha utilizado el término L2/LE para englobar ambos conceptos, pues los dos hacen referencia a una lengua que no es la nativa. Sin embargo, cuando se aprende una segunda lengua o una lengua extranjera, los contextos de aprendizaje, y la cantidad y el tipo de exposición a la lengua son diferentes, así como las oportunidades en la vida diaria para comunicarse con hablantes nativos (Gilquin, 2016; Sammour-Shehadeh et al., 2022). En España el aprendizaje del inglés se produce principalmente en los centros escolares. Las escuelas y los docentes desempeñan un papel esencial, pues de ellos dependen el nivel de exposición a la lengua y la calidad de esta o el método de enseñanza, entre otros. De estas variables está supeditado el aprendizaje explícito e implícito necesario para adquirir una lengua (L2 o LE) (Ellis, 2015).

Respecto a la exposición, multitud de estudios concluyen que estar expuesto desde edades tempranas a otra lengua diferente a la nativa tiene numerosos beneficios (Larson-Hall, 2008; Olulade et al., 2016; Winsler et al., 1999, Kovelman et al., 2008). Tanto la cantidad como la calidad de la exposición son importantes en el desarrollo de las habilidades orales (Gámez & Levine, 2013) y de las habilidades de lectura y escritura (Al Zoubi, 2018; Farukh & Vulchanova, 2016; Matusevych et al., 2017). También será relevante para la adquisición de vocabulario (Paradis, 2011; Thordardottir, 2011), algo que repercute directamente en el desarrollo de la lectura y escritura (Chang & Monaghan, 2019). Estar más expuesto a una lengua se traduce en tener más oportunidades para leer y escribir más palabras. Esto facilita la formación de representaciones ortográficas y la consolidación de las correspondencias grafema-fonema a través de la decodificación repetida (Y. Li et al., 2022; Monaghan et al., 2017). También incrementa el número de experiencias con diferentes patrones ortográficos, contribuyendo a que construya un conocimiento implícito de la ortografía (Kessler, 2009; Lété et al., 2008; Treiman, 1993). La sensibilidad a los patrones del sistema ortográfico del inglés, por tanto, se produce gracias a la exposición de la que puedan beneficiarse los niños en su centro escolar (y en algunos casos, en clases extraescolares).

En cuanto al método de enseñanza, existe una amplia variedad de ellos. Sin embargo, algunos enfoques tendrán una influencia más directa sobre el aprendizaje de la lectoescritura (Cook, 2013; Moughamian et al., 2009). Por ejemplo, la enseñanza sistemática de la fonética (*systematic phonics instruction*), que tiene gran repercusión para la lectura tanto en hablantes nativos (Ehri et al., 2001; Ehri, 2020) como en estudiantes de inglés como LE (Birch & Fulop, 2020; Murphy Odo, 2021; Woore, 2021). Por otro lado, diversos autores han sugerido que la enseñanza explícita de los patrones ortográficos es necesaria para el correcto aprendizaje de la escritura (Graham & Santangelo, 2014; Treiman, 2018). De hecho, una enseñanza explícita de las correspondencias entre grafemas y fonemas del inglés como LE puede facilitar la adquisición de la lectoescritura durante etapas tempranas (Grabe, 2008; Pérez-Cañado, 2006). Esta enseñanza dependerá en gran medida de los profesores, pues los libros de texto por sí solos resultan insuficientes (Fuchs et al., 2023; Joshi et al., 2009). Por tanto, el aprendizaje explícito se produce a través de la enseñanza y la labor de los docentes. Ellos serán quienes garanticen que los niños comprendan el funcionamiento del sistema de escritura del inglés y entiendan cómo se construye, lo cual será esencial para poder escribir y leer correctamente (Bowers & Bowers, 2017).

3.3.1. Aprendizaje del inglés en Estados Unidos

A lo largo de esta introducción teórica se han citado numerosos estudios que involucran el español como lengua nativa y el inglés como L2/LE. La mayoría de ellos, sin embargo, se ha centrado en poblaciones de Estados Unidos. El aprendizaje del inglés en Estados Unidos tiene una serie de características que lo diferenciarán del aprendizaje del inglés en España y otros países. La más evidente es que el inglés es la lengua oficial. Esto facilita un incremento de la exposición tanto en cantidad como en calidad, así como en una variedad de contextos. Otra característica es la influencia de unos factores socioculturales que no existen en España (Austin et al., 2015). Existen multitud de programas de enseñanza en Estados unidos (Durgunoğlu, 1998), pero gran parte de ellos tienen un objetivo común: que los niños hablantes de otra lengua alcancen una competencia mínima con el fin de incorporarse a la enseñanza monolingüe lo antes posible. Es decir, son programas de transición. Además, independientemente de si los niños son o no hablantes nativos de inglés, la enseñanza de la lectoescritura está basada en metodologías fundamentadas y que cuentan con apoyo gubernamental (National Reading Panel, 2000)

Estos factores impiden que el contexto educativo de Estados Unidos sea comparable al de España. A pesar de que la competencia en inglés está muy valorada por la sociedad española, esta lengua no forma parte del día a día de la mayoría de los niños. El contexto educativo será el único entorno en el que se utilice el inglés, y su uso en la mayor parte de los casos no será natural. Además, actualmente no están implantadas políticas específicas que aborden la enseñanza de la lectoescritura del inglés como lengua extranjera. Las diferencias entre en ambos países pueden resumirse de la siguiente manera: en Estados Unidos el inglés se aprende como segunda lengua; en España se aprende como lengua extranjera.

3.3.2. Aprendizaje del inglés en otros países

La metodología de enseñanza del inglés como lengua extranjera varía según la lengua nativa de los estudiantes y las políticas de cada país (Hall, 2016; Kirkpatrick, 2020). Así, la edad de inicio del aprendizaje será diferente, pues en algunos países los niños comenzarán con 6 años o incluso antes, como en China (Jiang, 2003; Sun et al., 2015; Zhou & McBride-Chang, 2009), mientras que en otros no empezarán hasta los 9 años, como en Arabia Saudí (Alrabai, 2018). En aquellas lenguas que no comparten sistema de escritura con el inglés, como el chino o el japonés, será necesario enseñar a los estudiantes de manera previa el principio alfabético (Cheng, 2015). Otras lenguas que utilizan diferentes alfabetos, como el hebreo o el árabe, tendrán que aprender el alfabeto latino (Russak, 2020). Las directrices gubernamentales de diferentes países, como Israel (Russak & Kahn-Horwitz, 2015) o Bahrein (Allaith & Joshi, 2011), destacan la relevancia de la lectoescritura y del aprendizaje de la ortografía del inglés. Sin embargo, no se proporcionan metodologías ni indicaciones acerca de cómo poner esto en práctica. A pesar de la diferencia del inglés con estas lenguas, la enseñanza explícita de las convenciones ortográficas es escasa.

Respecto al aprendizaje de una lengua extranjera en Europa, está incluido en el currículum educativo a nivel europeo desde el año 2000 (Council of Europe, 2000), siendo en el 96% de los casos el inglés (Eurostat, 2021). Esta inclusión obedece a demandas sociales, principalmente por la globalización e internacionalización que se está experimentando actualmente. Los estándares para la enseñanza y el aprendizaje de las lenguas extranjeras están establecidos en el Marco Común Europeo de Referencia para las Lenguas (MCER, o CEFR en inglés) (Consejo de Europa, 2002). Estos estándares constituyen una guía para el desarrollo de las competencias lingüísticas, pero a pesar de abordar el área de la lectoescritura no especifican ningún método de enseñanza para esta. El desarrollo de numerosos programas de educación bilingüe a nivel europeo hace que los métodos de enseñanza del inglés varíen de un centro escolar a otro (Hélot & Cavalli, 2017). No obstante, uno de los más utilizados es el sistema CLIL (*Content and Language Integrated Learning),* o aprendizaje integrado de contenidos y lenguas extranjeras (Nikula, 2017). Este método de enseñanza tiene el objetivo de que los alumnos aprendan de manera simultánea el contenido de una materia y una lengua extranjera. De esta manera, se incrementa la exposición a la lengua para favorecer la competencia lingüística, a la vez que se siguen desarrollando competencias de las materias en cuestión (como científicas o artísticas). A pesar de que existen programas CLIL con otras lenguas como el francés (Pérez et al., 2016), el inglés es el principal protagonista en países como Italia (Cinganotto, 2016; Minardi, 2021), Portugal (Piacentini et al., 2022), y por supuesto España, donde goza de gran popularidad (Lasagabaster & de Zarobe, 2010). Sin embargo, los resultados de este método varían de un país a otro. Sylvén (2013) compara en su revisión las diferencias entre cuatro países distintos: España, Alemania, Suecia y Finlandia. La autora expone cuatro factores fundamentales que, según ella, serán decisivos para explicar la variabilidad de los hallazgos: el marco político, la formación de los docentes, la edad de inicio de la enseñanza y nivel de exposición dentro del colegio; y el tipo y cantidad de exposición al inglés fuera del colegio. Si bien Sylvén avala la implementación del enfoque CLIL en España, lo cierto es que aún no existe demasiada evidencia sobre su eficacia respecto a la enseñanza ordinaria del inglés, siendo los hallazgos contradictorios (Agudo, 2019, 2022; Pérez-Cañado, 2020; Rallo Fabra & Jacob, 2015; Tragant et al., 2015). Por otro lado, aunque uno de sus fundamentos es el aprendizaje de contenidos, la competencia es mayor cuando los alumnos aprenden a través de la lengua nativa (Fernández-Sanjurjo et al., 2019). La brecha existente entre los fundamentos teóricos del enfoque y su aplicación práctica en el aula explica en parte sus limitaciones y desventajas (Fernández-Costales & Lahuerta-Martínez, 2014).

3.3.3. Aprendizaje del inglés en España

En nuestro país está estipulado que la enseñanza del inglés (o de otra lengua extranjera) tenga su inicio a la edad de seis años, coincidiendo con el primer curso de Educación Primaria (European Education and Culture Executive Agency, 2023; LOMLOE, 2020). No obstante, el contacto con el inglés puede tener lugar incluso antes, durante la etapa de Educación Infantil. Esta situación implica que, incluso en aquellos centros en los que se inicie de forma más tardía la enseñanza del inglés, su aprendizaje se producirá de forma paralela al de la lectoescritura en la lengua nativa. Puesto que ambas lenguas comparten el alfabeto latino, los niños españoles ya tienen conocimientos del principio alfabético y del sistema de escritura del inglés. Sin embargo, deberán adaptarse a una ortografía que requiere de estrategias de lectura y escritura diferentes, y aprender un código ortográfico que no siempre se enseña de manera explícita. A pesar de que el currículum educativo recoge los contenidos para cada etapa de Educación Primaria (LOMLOE, 2020), las únicas alusiones a este aprendizaje son los siguientes saberes básicos dentro del bloque de comunicación: "Iniciación en convenciones ortográficas elementales" y "Convenciones ortográficas básicas de uso común y significados asociados a los formatos y elementos gráficos".

Los métodos de enseñanza varían de un centro escolar a otro. Existen colegios en los que se aplican modelos de educación bilingüe propuestos por los propios centros, mientras que en otros (una minoría) está implantado el modelo elaborado conjuntamente del Ministerio de Educación y el British Council (Gisbert da Cruz et al., 2015). Así pues, en algunos casos será una asignatura más y en otros cobrará más protagonismo al existir programas específicos de bilingüismo, como el ya mencionado CLIL. Independientemente del método de enseñanza, existen varios aspectos a mejorar en la enseñanza del inglés en nuestro país. En cuanto a la enseñanza en Asturias, donde se ha llevado a cabo esta investigación, parece es similar a la del resto de España. En su estudio sobre el grado de satisfacción de los maestros de inglés de esta región, Fernández-Costales y González-Riaño (2018) reportan una percepción poco positiva de los recursos y condiciones disponibles por parte de los maestros de etapas tempranas como educación infantil. La importancia de estas etapas, coincidiendo con el desarrollo de las habilidades fonológicas y los prerrequisitos lectores, podría estar siendo obviada en el caso de la enseñanza del inglés. Por otra parte, al igual que señalaba Sylvén en su revisión (2013), estos autores también destacan la falta de exposición y uso del inglés fuera del entorno escolar, así como una instaurada tradición de doblaje al español de series y películas. Esto se traduce en menor exposición oral comparada con otros países, en los que los contenidos son consumidos en versión original. No obstante, existe un propósito de mejora de la enseñanza del inglés por parte de las administraciones, que en el caso de Asturias se ha materializado con la inminente implantación de nuevos programas de bilingüismo (Gobierno del Principado de Asturias 2023a, 2023b).

Para garantizar dicha mejora es esencial una investigación científica previa que permita tomar decisiones basadas en la evidencia. Mientras que el aprendizaje del inglés en las escuelas de España está relativamente bien documentado a nivel de políticas educativas, no lo está desde el punto de vista psicolingüístico. Si bien podemos citar algunas investigaciones con españoles nativos realizando tareas en inglés, los participantes son adultos (Macizo & Bajo, 2006; Macizo et al., 2010, 2012; Iniesta et al., 2021, 2023; Rodríguez-Cuadrado et al., 2022). Los estudios de Lahuerta-Martínez están más enfocados al aprendizaje del inglés como LE durante las etapas educativas. Sin embargo, esta autora se centra en poblaciones que ya han aprendido a leer y escribir, como estudiantes de Educación Secundaria (Lahuerta-Martínez, 2017, 2020) o universitarios (Lahuerta-Martínez, 2004, 2018). En cuanto a los niños de Educación Primaria, los estudios que abordan el tema del aprendizaje del inglés son escasos, y salvo excepciones (Álvarez-Cañizo et al., 2023; Suarez-Coalla et al., 2020), la mayoría no se centran en el procesamiento del lenguaje, sino en cuestiones educativas como la eficacia de los programas. Esta misma situación se da en Latinoamérica (Banegas et al., 2020; Cronquist & Fiszbein, 2017), donde tampoco existen estudios psicolingüísticos. Esto hace que sea necesario investigar en profundidad cómo se produce el aprendizaje de la lectura y la escritura en inglés como LE. ¿Qué conocimientos tienen los niños españoles sobre la ortografía y la fonología del inglés? ¿En qué fuentes de información y estrategias se apoyan durante el procesamiento? ¿Continúan apoyándose en las de su lengua nativa, o se adaptan al tamaño de grano preferible para la ortografía del inglés? ¿De qué manera influye el español en su aprendizaje, y cómo gestionan las posibles influencias cros-lingüísticas? Las respuestas a todas estas preguntas motivan los objetivos de este trabajo.

PARTE II: TRABAJO EXPERIMENTAL

Objetivos e Hipótesis Generales

Tras la revisión de la literatura se establecieron cinco objetivos generales de investigación, a los cuales se trató de dar respuesta mediante la realización de sendos estudios. Tres de ellos han sido publicados en revistas científicas, mientras que los otros dos se encuentran actualmente en revisión. Para cada uno de los objetivos, que serán expuestos a continuación, se plantearon diferentes hipótesis.

Objetivo 1: Comprobar la influencia de la complejidad y la congruencia grafémicas en niños españoles aprendiendo inglés como LE. Los efectos de complejidad y congruencia han sido demostrados en lectores nativos mediante tareas de detección de letras. Sin embargo, apenas hay evidencia en niños españoles aprendiendo inglés como LE, en los cuales su lengua nativa puede causar interferencias. Con este objetivo, se diseñaron dos tareas de detección de letras, una de las cuales incluía letras cuya correspondencia grafema-fonema podía ser congruente ("a" en *park*) o no ("a" en *name*) con la del español; y otra en la cual las letras podían formar parte de grafemas simples ("e" en *desk*) o complejos ("e" en *learn*), no existiendo estos últimos en español. Con el fin de observar diferencias a nivel evolutivo, se comparó el rendimiento de niños de 2º, 4º y 6º de Educación Primaria, así como de adultos.

Las hipótesis para este estudio, el cual consta de dos experimentos, fueron las siguientes:

- Un mejor rendimiento con los grafemas congruentes respecto a los no congruentes, así como en los grafemas simples respecto a los complejos.
- Un mejor rendimiento en los adultos y en los niños más mayores en ambos experimentos, debido a una mayor competencia lectora en inglés.

- Un mayor efecto de la congruencia y la complejidad en los niños de cursos inferiores, pues su inexperiencia puede incrementar la sensibilidad a la activación de la lengua nativa.

Objetivo 2: Determinar las diferencias de activación de la fonología del inglés y del español en el reconocimiento visual de palabras en inglés, en función del curso y de la exposición a la lengua. Los pseudohomófonos son pseudopalabras cuya representación fonológica es igual a la de palabras reales. En una tarea de decisión léxica visual, los pseudohomófonos provocan mayores tiempos de reacción, indicando cierta activación de la fonología durante el reconocimiento visual de palabras. El grado de activación puede verse afectado por factores evolutivos y por cómo ha sido aprendida una lengua. Para investigar esto, se aplicó una tarea de decisión léxica visual con palabras en inglés a niños de diversos cursos de Educación Primaria (2º, 4º y 6º), y que pertenecían a centros con diferentes metodologías de enseñanza del inglés. Dentro de la tarea se incluyeron pseudohomófonos siguiendo las reglas de correspondencia grafema-fonema del inglés y del español.

En el caso de este estudio, las hipótesis fueron las siguientes:

- Un mejor rendimiento en los niños más mayores, debido a su mayor experiencia
- Un mejor rendimiento en los niños del colegio bilingüe, debido a una mayor exposición al inglés y un método de enseñanza que enfatiza la comunicación oral
- Un incremento de las diferencias entre colegios en los cursos superiores, debido al efecto acumulado de la exposición y del método de enseñanza

Objetivo 3: Comparar la influencia que ejercen el país de origen y la lengua de una tarea en el reconocimiento visual de palabras y la activación de la fonología durante la lectura. Pese a que los programas de bilingüismo de los centros educativos buscan equilibrar la exposición a dos lenguas, el idioma oficial de un país suele ser el de mayor dominancia y en el que los niños tienen más competencia. El reconocimiento visual de palabras puede verse afectado por interferencias de la lengua no-objetivo, sobre todo si es la lengua dominante (interferencia inter-lingüística). También puede verse afectado por la propia lengua, como en el caso de los pseudohomófonos (interferencia intra-lingüística). Sin embargo, durante el procesamiento bilingüe también se ponen en marcha mecanismos de inhibición de la lengua no-objetivo. La activación de los léxicos fonológico y ortográfico puede verse influida por la lengua de mayor dominancia. Por eso, se quiso comparar el rendimiento de niños de colegios bilingües de España (español-inglés) y Estados Unidos (inglés-español) en una tarea de decisión léxica visual en inglés. Esta tarea, al igual que la del objetivo anterior, incluía pseudohomófonos que seguían las reglas del inglés y del español.

Para este estudio se plantearon las siguientes hipótesis:

- Un mejor rendimiento en los niños de Estados Unidos, debido a la inmersión lingüística que supone vivir en un país angloparlante.
- Un mejor rendimiento con los pseudohomófonos que siguen las reglas del español (interferencia inter-lingüística), por ser menos distractorios que los pseudohomófonos que siguen las reglas del inglés (interferencia intra-lingüística)
- Para los niños de España, si el país de origen y la lengua de dominancia tiene mayor relevancia, los pseudohomófonos en español serán más distractorios que para los niños de Estados Unidos; si la lengua de la tarea tiene mayor relevancia,

los pseudohomófonos en inglés serán igual de distractorios que para los niños de Estados Unidos

- Para los niños de Estados Unidos, los pseudohomófonos en inglés serán más distractorios en todos los casos.

Objetivo 4: Categorizar los tipos de errores ortográficos cometidos durante narraciones escritas en inglés, e identificar los elementos que suponen una mayor dificultad para la población de estudio. Los niños se apoyan en diferentes fuentes de información durante el aprendizaje de la escritura, que constituyen la Triple Forma de la Palabra: la fonología, la ortografía y la morfología. Esto se puede evidenciar a partir del análisis de errores ortográficos según el sistema POMAS (Bahr et al., 2012). Por otro lado, existen ciertos rasgos de la ortografía del inglés que representan una mayor dificultad para hispanohablantes. Con el fin de comprobar qué fuentes de información utilizan más los niños españoles escribiendo en inglés de forma espontánea, se analizaron y categorizaron los errores ortográficos cometidos. Este análisis, además, también daría información acerca de los rasgos específicos del inglés con los que los niños de España que aprenden inglés como una lengua extranjera tienen más dificultades, así como el origen de estas dificultades. Se compararon producciones de niños de 4º, 5º y 6º con el fin de observar el patrón evolutivo en esta población

Las hipótesis que se plantearon con este estudio fueron:

- Los errores ortográficos de los niños españoles afectarán a las tres categorías: fonología, ortografía y morfología
- La proporción de errores morfológicos se incrementará en los cursos superiores, mientras que la proporción de errores fonológicos decrecerá.

- Los errores ortográficos afectarán a rasgos que representan mayor dificultad para los hablantes nativos de español, tales como grafemas dobles, vocales largas, dígrafos vocálicos, grupos consonánticos o grafemas representando fonemas novedosos

Objetivo 5: Investigar las fuentes de conocimiento y las estrategias léxicas y subléxicas en las que los niños españoles se apoyan para escribir en inglés. El estudio de medidas kinemáticas, como la latencia o la duración de la escritura, nos permite conocer la interacción entre los procesos centrales y periféricos. Analizando el efecto de diferentes variables como la frecuencia léxica, la longitud, la consistencia de segmentos subsilábicos o el conocimiento semántico, se puede investigar qué estrategias se utilizan durante la escritura. Hasta la fecha, no existen estudios que investiguen esto en niños españoles escribiendo en inglés como lengua extranjera, y tampoco a través de medidas kinemáticas como la latencia o la duración de la escritura. Por ello, se diseñó una tarea de escritura al dictado en inglés en la que participaron niños de diferentes cursos de Educación Primaria (4º, 5º y 6º), con el fin de estudiar cambios evolutivos en la escritura.

Para el quinto y último estudio las hipótesis planteadas fueron:

- El rendimiento será mejor para aquellas palabras cuyo significado sea conocido, demostrando el apoyo en la información semántica.
- Los niños de cursos inferiores se verán más influidos por la longitud (estrategias subléxicas), mientras que a los niños de cursos superiores les afectará más la frecuencia léxica (estrategias léxicas)

- La consistencia de los segmentos subsilábicos tendrá más influencia en los niños más mayores, debido a un mayor conocimiento del código ortográfico del inglés y un incremento en la sensibilidad a los patrones ortográficos.

Método

Estudio I

Hevia-Tuero, C., Incera, S., & Suarez-Coalla, P. (2021). Does English orthography influence bilingual Spanish readers? The effect of grapheme crosslinguistic congruency and complexity on letter detection. *Cognitive Development*, *59*, 101074. DOI: 10.1016/j.cogdev.2021.101074

Factor de impacto *Cognitive Development* (2021): 1,897

Estudio II

Hevia-Tuero, C., Incera, S., & Suárez-Coalla, P. (2022). Influences of First and Second Language Phonology on Spanish Children Learning to Read in English. *Frontiers in Psychology*, 1376. DOI: 10.3389/fpsyg.2022.803518

Factor de impacto *Frontiers in Psychology* (2021): 4,232

Estudio III

Incera, S., Hevia-Tuero, C., Martín, I., & Suárez-Coalla, P. (2023). How Country of Origin and Stimuli Language Influence Visual Word Recognition in Bilingual Children (En revisión en *International Journal of Bilingualism*)

Factor de impacto *International Journal of Bilingualism* (2021): 1,721

Estudio IV

Hevia-Tuero, C., Russak, S., & Suárez-Coalla, P. (2022). Spelling errors by Spanish children when writing in English as a foreign language. *Reading and Writing*, 1-24. DOI: 10.1007/s11145-022-10356-5

Factor de impacto *Reading and Writing* (2021): 2,795

Estudio V

Suárez-Coalla, P., Hevia-Tuero, C., Martínez-García, C., & Afonso, O. (2023). Spanish children facing spelling in English as a Foreign Language: central and peripheral processes. (En revisión en *Journal of Research in Reading*)

Factor de impacto *Journal of Research in Reading* (2021): 2,792

Estudio I

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Does English orthography influence bilingual Spanish readers? The effect of grapheme crosslinguistic congruency and complexity on letter detection

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ABSTRACT

Phonemic correspondences for a particular grapheme are not always congruent across languages. Also, some complex graphemes can be found in some languages but not in others. The purpose of this study is to determine if the congruency and complexity of English graphemes influence letter detection in L2 learners. We further investigated whether age group (7-, 9- and 11-year-old children, and university undergraduates) determines the size of these effects. Participants completed two different letter detection tasks using the mouse-tracking paradigm. Results from Experiment 1 indicate that only younger children are slightly affected by incongruent graphemes. Results from Experiment 2 show that all readers perform worse with complex graphemes. L2 learners interiorize English phonology at early stages, being barely affected by their native Spanish language. Importantly, L2 learners decode complex graphemes similarly to native English readers. Interpretations based on the BIA-d model are discussed.

Reading is a cognitive function which requires specific instruction to be acquired. Becoming an expert reader means being able to read both known and unknown words, which are not processed through the same strategy. In the dual-route cascaded (DRC) model (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001) there are two different routes from print to speech: lexical, that allows known words processing through a sight-word recognition; and sublexical, which consists on applying grapheme-to-phoneme correspondences and allows reading nonwords and unknown words. While reading through the lexical route involves orthographic learning, the sublexical route also requires skilled phonological recoding. Moving from sublexical processing to lexical processing, which facilitates reading automation, depends on the implementation of a learning mechanism.

Share (1995) posited the *self-teaching hypothesis*, according to which children (as beginning learners) become expert readers by forming orthographic representations of each word through a self-teaching mechanism. Every successful decoding after learning the alphabetic code means an opportunity to acquire word-specific orthographic information. In the case of languages with a deep orthography (e.g., English), decoding implies processing the orthographic context and other elements (like syllables and rhymes). Despite potential differences between languages with deep and shallow orthographies, the self-teaching hypothesis has been tested in a variety of languages: Hebrew (Share, 1999, 2004), Dutch (de Jong & Share, 2007), English (Cunningham, Perry, Stanovich, & Share, 2002; Nation, Angell, & Castles, 2007) and Spanish (Suárez-Coalla, Álvarez-Cañizo, & Cuetos, 2016). Focusing on second languages, the hypothesis has also been evidenced in French (Chung, Chen, Commissaire, Krenca, & Deacon, 2019) and English (Schwartz,

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Kahn-Horwitz, & Share, 2014; van Daal & Wass, 2017). These last studies imply that many factors are involved in the orthographic learning of a second language (e.g., first and second language scripts proximity, transference of orthographic skills, instructional methods).

Research focused on second language literacy acquisition became prominent after the Common European Framework (Council of Europe, 2001), when second language (L2) learning at schools was enhanced by many European educational systems. English, in particular, gained a remarkable popularity in countries like Spain. As a result, Spanish children start their English instruction at very early ages. Furthermore, there is an increasing number of bilingual schools aimed at immersing Spanish children in English. In these environments, literacy acquisition occurs in both native and second language, thus, children face the challenge of learning to read simultaneously in two languages with dissimilar orthographic depths. The characteristics of the processing units vary across languages (Rau, Moll, Snowling, & Landerl, 2015; Ziegler & Goswami, 2005), and may require different recoding strategies from those developed for the native language. Children have to learn two different orthographic codes, as well as discriminate between the two to avoid interference.

When starting second language instruction, the new language gets activated and an effort has to be made in order to inhibit the first language (Jared & Kroll, 2011). The L2 excitatory and L1 inhibitory connections are generated, and the connections gradually grow stronger with incremental exposure. This is essential, as the activation and inhibition of the appropriate languages is necessary to control the potential intrusion of the non-target language. The *language-nonselective access hypothesis* (Dijkstra & van Heuven, 2002) in bilinguals (or those who use two or more languages in their everyday life (Grosjean, 2010)) has been widely debated. Although the evidence coming from written words cannot be directly extended to other domains of bilingualism like spoken word recognition (Wang, Hui, & Chen, 2020), authors have found empirical support for a nonselective access in visual word recognition (Dijkstra, Grainger, & van Heuven, 1999; van Heuven, Dijkstra, & Grainger, 1998; Zhou, Chen, Yang, & Dunlap, 2010). According to the *language nonselective access hypothesis*, when bilinguals read, lexical and sub-lexical information from both languages are subject to be activated. This coactivation produces cross-linguistic interference, the strength of which depends on variables like the specific orthography and phonology of each language. Interference can occur between different sets of languages, regardless of whether both languages have a common writing system or not (Bhide, 2015; Bialystok, Luk, & Kwan, 2005; Deacon, Wade-Woolley, & Kirby, 2009; Duyck, 2005; Hamada & Koda, 2008; Howard, Green, & Arteagoitia, 2012; Jared, Cormier, Levy, & Wade-Woolley, 2012; Jared & Szucs, 2002; Lallier & Carreiras, 2018; Lemhöfer et al., 2008; Ota, Hartsuiker, & Haywood, 2009; Sun-Alperin & Wang, 2008). In order to avoid this interference, bilinguals need an activation-inhibition mechanism described in the *bilingual interactive activation model* (BIA; Dijkstra, van Heuven, & Grainger, 1998) and its extensions the BIA + (Dijkstra & van Heuven, 2002) and the developmental BIA-d (Grainger, Midgley, & Holcomb, 2010). The BIA-d model discusses basic learning principles and addresses how these processes occur in early second language learners.

Proficient bilinguals are able to switch easily between their languages and their corresponding writing systems (Treutlein, Schöler, & Landerl, 2017). However, young children starting their L2 instruction could be very sensitive to crosslinguistic interference. During early developmental stages, children are likely to transfer native language phonological rules and processing strategies, some of them at the level of spelling errors (Howard et al., 2012). These transferences might arise also at the grapheme unit level. When focusing on graphemes, it is important to determine the effects of cross-linguistic congruency and grapheme complexity. These characteristics influence native language reading so, given the additional drawback that cross-linguistic interference represents, they are likely to also impact L2 learners.

1. Congruency

In English (an opaque orthographic system) consonants have almost invariant letter-to-sound relationships, however vowels are the most irregular feature in the English orthography. Some of them can be pronounced in multiple ways ("a" can be pronounced /ɑː/ or /eɪ/), and some phonemes have multiple spellings (/ʊ/ can be spelled "ou" or "oo"). They have multiple correspondences, and their pronunciation is sensitive to orthographic context (Frith, Wimmer, & Landerl, 1998; Venezky, 1967). This is something that children have to deal with during their phonological recoding development (Share, 1995, 2008). Many researchers have reported that orthographic transparency, which varies across languages, has an effect on reading in monolinguals (Glushko, 1979; Jared, 1997; Seidenberg, Waters, Barnes, & Tanenhaus, 1984; Ziegler, Montant, & Jacobs, 1997; Ziegler, Perry, & Coltheart, 2003). This effect is stronger during early stages of literacy acquisition, before orthographic representations are built. It also depends on grapheme frequency as more frequent associations facilitate decoding. A processing conflict appears when a unit (e.g., "a") has multiple associations from orthography to phonology (/ɑː/, /eɪ/, /æ/…). This activation of multiple pronunciations results in longer reaction times, as evidenced through letter detection tasks (Lange, 2002).

In L2 learners multiple pronunciation activation is likely to occur even more often than in monolingual learners, as the associations might come from both L1 and L2 phonologies. Languages with the same writing system (both alphabetic) have many graphemes in common. But when graphemes are shared, they are not always congruent. The same grapheme can be associated to a different phoneme in each language. Language nonselective access induces an overlap of L1 and L2 grapheme-to-phoneme correspondences activation during reading. As a result, the association congruent with the native language will be more frequent and, therefore, stronger.

Many investigations have studied cross-linguistic phonology activation in bilinguals, using a variety of tasks like lexical decision (Duyck, 2005), reading aloud (Jared & Szucs, 2002; Jared et al., 2012; Mairano, Bassetti, Cerni, & Sokolović-Perović, 2018), spelling (Fashola, Drum, Mayer, & Kang, 1996; Howard et al., 2012) or picture-word interference task (Kaushanskaya & Marian, 2004). Commissaire et al. (2014) investigated specifically the effect of cross-linguistic phonological consistency in a letter detection task. They assessed it in a sample of French high school students learning English, a population for whom both languages have relatively deep orthographies. These researchers found faster reaction times in graphemes shared across languages. The results suggest that congruent correspondences connections (when a grapheme has the same phoneme in both languages) are stronger than incongruent ones (when a grapheme has a different phoneme in each language). Will congruency effects emerge in Spanish speakers learning English?

2. Complexity

Not all graphemes are shared between languages. Some graphemes are specific to a particular language, as it is the case of some English complex graphemes formed exclusively by vowels and associated to a single sound (e.g., "ea" like in *beach* - /biʧ/). Graphemes, the written representations of phonemes, can be simple (if constituted by a single letter) or complex (if they are composed by two or more letters). Complex graphemes have their own phoneme-to-grapheme correspondence, as two or more letters are being processed as a whole unit in order to represent one phoneme (Joubert & Lecours, 2000). The existence of these graphemes, specifically when formed by vowels, is responsible for the apparent deep orthography of languages like English (Seidenberg, Plaut, Petersen, McClelland, & McRae, 1994). Moreover, the need to process other bigger-than-letter units impacts monolingual literacy acquisition: speakers of deep orthography languages like English reach reading accuracy later than speakers of shallow orthography languages like Spanish (Defior & Serrano, 2005; Seymour, Aro, & Erskine, 2003). Spanish speakers learning English have an additional difficulty with complex graphemes, as there are no graphemes with equivalent characteristics in the orthographic system of their native language. In Spanish, only 5 digraphs (complex graphemes composed of two letters) can be found, none of them formed exclusively by vowels (*ch*, *rr*, *ll*, *qu* and *gu*). Biliterate children must deal with two different phonological recoding strategies depending on each language's spelling-sound relationship: either pronouncing both vowels when they are found together (Spanish diphthongs and hiatuses; Aguilar, 1999; Face & Alvord, 2004), or identifying the complex grapheme and its correspondent phoneme (English /i/ for "ea"). Are Spanish children successful at recognizing complex graphemes in their second language? Or do they recode bigrams like they would do in their native language? A way to determine whether they are able to process these English specific graphemes is through investigating the *grapheme complexity effect*.

Detecting a letter forming part of a complex grapheme (e.g., detecting the letter "a" in *bean*) takes more time than detecting the same letter embedded in a simple grapheme (e.g., "a" in *park*) (Rey & Schiller, 2005; Rey, Jacobs, Schmidt-Weigand, & Ziegler, 1998). When processing the word *bean*, which includes a complex grapheme, two sub-lexical processes are activated: (1) Through letter detection the reader detects four letters, and (2) through grapheme detection the reader detects three graphemes. Both processes happen at the same time producing a conflict that delays reaction time and slows down identification. Complexity effects have been reported in monolingual adults (Rey et al., 1998; Rey, Ziegler, & Jacobs, 2000) and children (Marinus & de Jong, 2011) (however see Chetail, 2020 for a contrary point of view). In bilinguals, Commissaire et al. (2014) evaluated how specific English sub-lexical units like complex graphemes are processed by L2 learners. In their study, French speakers attending high school performed a letter detection task in English and were affected by complexity (they showed a significant complexity effect). Moreover, in line with the congruency effects discussed above, letters embedded in complex graphemes shared between languages were recognized faster. These findings support a cross-linguistic complexity effect, pointing to a benefit when processing complex graphemes that are equivalent across languages.

It is important to highlight that (to our knowledge) no one has tested the complexity effect with L2 readers of a native language that does not have complex graphemes formed by vowels (like Spanish). This particularity makes it impossible to investigate "cross-linguistic complexity effects" with Spanish/English readers. However, it opens the door to a new and intriguing question: are speakers of Spanish affected by the complexity effect when reading in English? This would mean that they are able to process English orthography (in this case, specific complex graphemes) as native speakers of English typically do. From a reading development perspective, it is important to determine how young are Spanish readers when they start to be affected by complex English graphemes. At which age do Spanish children start processing complex graphemes as native speakers of English do?

3. The present study

In two experiments we investigate the effects of congruency and complexity across readers in age groups 7-, 9-, and 11-year-old children, as well as university undergraduates. The goal is to measure English grapheme processing by L2 learners of a shallow language (Spanish) during literacy acquisition. Participants, whom we will refer to as L2 learners, were native speakers of Spanish who were learning English as a second language. The age groups were selected in order to assess developmental differences across participants. Two different experiments were carried out with the same participants, one focusing on cross-linguistic grapheme congruency and the other focusing on grapheme complexity effects. These experiments are designed to investigate how Spanish students process English sub-lexical units, while keeping in mind the differences in orthography between these two specific languages. Previous studies (Commissaire, Duncan, & Casalis, 2014; Marinus & de Jong, 2011; Rey et al., 2000) measured reaction times and errors. In this study we also measured mouse trajectories by using the MouseTracker software (Freeman & Ambady, 2010). Using the mouse-tracking paradigm (Spivey, Grosjean, & Knoblich, 2005) it is possible to obtain a more detailed measure of the ongoing cognitive processes underlying word recognition. Instead of measuring overall performance, mouse-tracking captures the ongoing decision-making processes underlying how participants respond to written words. The procedure was approved by the Ethics Committee of Research of the Principality of Asturias, and it has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans.

4. Experiment 1

In this first experiment, we explored how L2 leaners process graphemes that are shared while being congruent (equivalent phoneme) or incongruent (different phonemes) across languages. Participants had to detect letters embedded in words, in which half of them were congruent graphemes, that is, pronounced like Spanish vowels (e.g., "a" in *park*); and half of them were incongruent graphemes, that is, pronounced completely different (e.g., "a" in *name*). Incongruent graphemes were associated to multiple phonemes, one of them shared with the native language phonology but many of them different from it (*name* /neɪm/, *talk* /tɔːk/). If participants are affected by congruency, and native language phonology is strongly activated, their performance will be worse with incongruent than with congruent graphemes.

Our hypotheses for the first experiment are:

- Main Effect of Congruency: All participants will answer more efficiently to graphemes congruent with their native language ("a" in *park*) than to incongruent graphemes ("a" in *name*), because associations shared across languages will be more strongly activated.
- Main Effect of Age: Younger students will perform worse across both type of graphemes (congruent, incongruent), as their expertise in reading English is expected to be lower.
- Congruency by Age Interaction: Younger students will show a larger congruency effect (have a larger difference in performance between congruent and incongruent graphemes), as they will be more sensitive to L1 interference.

5. Method

5.1. Participants

Participants were Spanish-English bilinguals. The sample included children who attended a bilingual public elementary school and undergraduate students. The sample was formed by 96 participants, including 24 undergraduate students from University of Oviedo ($M_{age} = 20.2$, $SD = 21$ months) and 72 elementary school students. Twenty-four students were around 7 years old ($M_{age} = 7.7$; $SD = 3$ months), 24 were around 9 years old ($M_{age} = 9.7$; $SD = 3$ months) and 24 were around 11 years old ($M_{age} = 11.8$; $SD = 3$ months). All the 7-, 9-, and 11-year-old children attended grades second, fourth, and sixth respectively. None of the participants (undergraduate or elementary school students) had cognitive, learning or behavioral impairments.

The school and the university were located in northern Spain. Undergraduate student's participation was compensated with extra points for their classes. Undergraduate students were exposed to English since Primary school, and they continue being exposed to English between 2 and 3 h per week (M_{time} =2.47 h per week; $SD_{time} = 1.55$) during their university studies. The public school where data collection took place was chosen by the Spanish Government in 1996 to implement a bilingual learning program based on specific guidelines. The guidelines were developed and implemented by the Spanish Ministry of Education and the British Council as a result of a formal agreement signed in 1996. Elementary school students attend four hours of Literacy lessons per week. They also have teachers who are native English speakers. This instructional method emphasizes oral communication, as children start learning English before literacy acquisition. Furthermore, systematic teaching of phonics is contemplated during infant stage for both English and Spanish. Specific guidelines can be consulted in the Spanish/English integrated curriculum (Agudo et al., 2012). The recommendation of children not to take extra English lessons out of school is given to the families. The socioeconomic status of the students who attend this school is generally middle-income, but there are isolated cases of students that come from families with either lower or higher socioeconomic status.

5.2. Materials

A total of 40 words were selected (see Table A1). The words contained one of the target letters (either the letter A or the letter I) and they were controlled for length, word frequency, and mean bigram frequency. The mean length was 4.00 characters ($SD = 0.00$) for the congruent condition, and 4.10 ($SD = 0.31$) for the incongruent condition, with no significant difference between the two ($t = -1.45$, $p = .162$). According to the MCWord database (Medler & Binder, 2005), the mean bigram frequency was 2,242.47 ($SD = 1{,}049.48$) for the congruent condition and 1,945.60 ($SD = 1{,}028.93$) for the incongruent condition with no significant difference between the two ($t = 0.90$, $p = .372$). The mean word frequency was 250.10 per million ($SD = 185.78$) for the congruent condition and 239.55 ($SD = 184.55$) for the incongruent condition with no significant difference between the two ($t = 0.18$, $p = .858$), according to the Children's Printed Word Database (Masterson, Stuart, Dixon, & Lovejoy, 2010).

Half of the selected words contained graphemes whose phonemic correspondence is shared across languages (e.g., "a" in *park*). The other half were words containing graphemes whose phonemic correspondence is different in English and Spanish (e.g., "a" in *name*). That is, English words that are read differently than how a native Spanish speaker would read them following Spanish grapheme-to-phoneme correspondences (GPC) conversion rules. In addition, 20 words in which the target letter was absent were added as fillers.

Two different versions of the experiment were created in order to counterbalance the response options. For half the participants the "present" correct response (green check mark image) was placed on the top left corner of the screen, while for the other half the "present" correct response was placed on the top right corner of the screen (see Fig. 1). Each participant responded to 60 trials across three different conditions (20 words with the letter present containing a congruent grapheme, 20 words with the letter present containing an incongruent grapheme, and 20 letter-absent filler words). The order of presentation was random for all participants. Each participant (n = 96) responded to 60 trials for a total of 5760 observations.

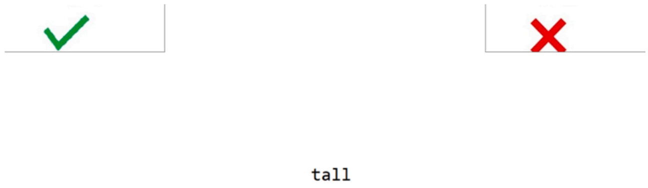

Fig. 1. Screenshot of the participants' view of the task (detecting the "a" in tall).

5.3. Procedure

A target letter detection task was created with the computer software MouseTracker (Freeman & Ambady, 2010). The mouse-tracking paradigm has been widely used in psycholinguistics research (Spivey et al., 2005), specifically in bilingualism (Barca & Pezzulo, 2015; Bartolotti & Marian, 2012; Incera & McLennan, 2016; Incera, 2018; Incera, Tuft, Fernandes, & McLennan, 2020). A Medion Akoya S3409 laptop was used to present the stimuli to the participants, and participants were asked to answer using a wireless computer mouse and a large mouse pad (17.8 by 15.5 in.). Participants were tested individually (performance feedback was not provided). Testing took place in a room free of noise and distracting elements to ensure the accuracy of the results. Each participant was randomly assigned to one of the two versions of the experiment with the correct response ("green check mark") on the top right or left corners of the screen. Nonlinguistic trials (with the response options "Click Here") were included as a baseline preceding the experiment. The purpose is to have a baseline measure of motor movement performance (independent of cognitive processes) before presenting the participants with stimuli they need to process, as well as a training phase in order to familiarize the students with the computer program (for a detailed discussion of the importance of including a baseline task when using the mouse tracking paradigm, see Incera & McLennan, 2018).

The procedure of the task followed previous works (Commissaire et al., 2014; Rey et al., 2000) except for a few modifications. The original task was designed for adults, so we increased the target word time to 66 ms in order to make the task accessible to children. Also, previous versions of the task used key press, while our version was adapted to use with the MouseTracker software (see the folder "Experiments" within the Open Science Framework). At the beginning of each trial, the START button and the response options (green tick for "yes", red cross for "no) appeared. As soon as participants clicked START, the target letter was displayed for 700 ms in uppercase in the center of the screen. After a fixation point of 1000 ms, the target word appeared in lowercase for 60 ms. A blank screen presented for 70 ms replaced the word, and then a mask consisting of hashes appeared in the screen for 50 ms (see Fig. 2). Participants started moving the mouse at word onset. They had to click "yes" if they detected the target letter in the word, or "no" if they did not. They were told to click on one of the two response options as quickly and accurately as possible. The cursor remained in the same position after the participants clicked on their response and while the START button appeared at the bottom of the screen. Participants had to move the cursor down to click on the START button that would initiate the next trial. Forcing participants to click START guaranteed that the starting position of the mouse was at the bottom center of the screen for all participants and items. If participants took more than 750 ms to initiate a mouse movement, a warning appeared instructing them to start moving the mouse earlier on in future trials. The task lasted about 10−15 min, depending on the age of the participant (i.e., younger children took longer than older children and undergraduate students).

5.4. Analysis plan

R (version 3.6.2) was used to run mixed model analyses using the lme4 package (version 1.1–21) (Bates, Mächler, Bolker, & Walker,

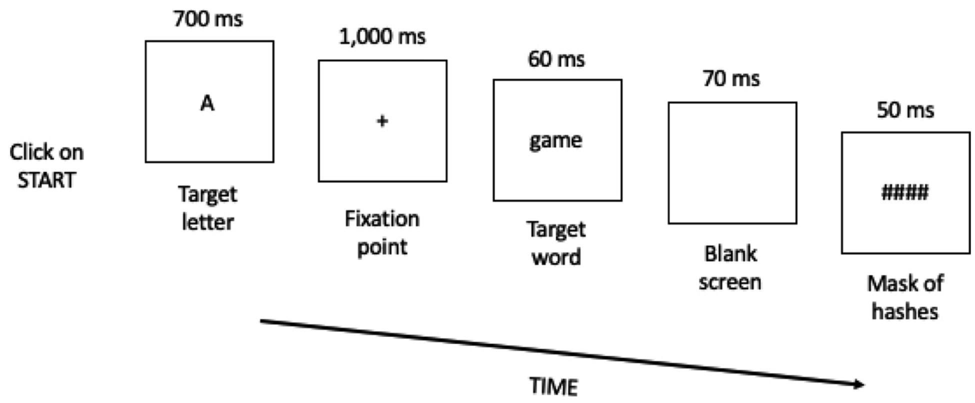

Fig. 2. Steps and timing of the online procedure (detecting the "a" in "game").

2015). The independent variables included in the analyses were the between-participant variable age (7-, 9-, and 11-year-old children, undergraduates) and the within-participant variable congruency (congruent, incongruent). Trials of filler words that did not include the target letters were excluded from the analyses. The dependent variables included in the analyses were number of errors, reaction times, and mouse trajectory (the slope of the mouse position –*X*-coordinate– over time). In the case of reaction times and mouse trajectories, the clock started at the exact moment the target word appeared on the screen (see Fig. 2 above). Furthermore, in the analysis of reaction times and mouse trajectories errors were removed. Outliers were excluded as well, deleting correct responses with reaction times over and under 2 standard deviations for each grade and condition. We started by including the crossed random effects of participants and items in all models. However, when the model was over fitted, we eliminated the random effect of items (even though different words were presented the task required participants to look for only two letters "a" and "i"). Models were compared using the Chi Square test; only factors that significantly contributed to model fit, as determined by a significant *p* value in the Chi square test, were included in the final model. The estimates and standard errors are reported for all factors that significantly improved model fit and are included in the final model.

The experiment, the data, and the scripts to reproduce the analyses are available at the Open Science Framework: https://osf.io/w2buv/?view_only=66d5a48720c048bf89ee65aaa70c97cb.

6. Results

6.1. Errors

When analyzing errors, model comparisons indicate that there is a main effect of Age ($\chi^2(3) = 37.12$, $p < .001$), no effect of Congruency ($\chi^2(1) = 1.82$, $p = .176$) and no Age by Congruency interaction ($\chi^2(3) = 2.72$, $p = .436$). The main effect of Age emerged because, as expected, age 7 group had more errors (104/960−10.8%), than age 9 group (35/960−3.6%; *Estimate* = -1.14, *SE* = 0.3), age 11 group (26/960, 2.7 %; *Estimate* = -1.46, *SE* = 0.32) and undergraduate students (14/960, 1.4 %; *Estimate* = -2.09, *SE* = 0.36). Not surprisingly, undergraduate students were the best performers (see Fig. 3).

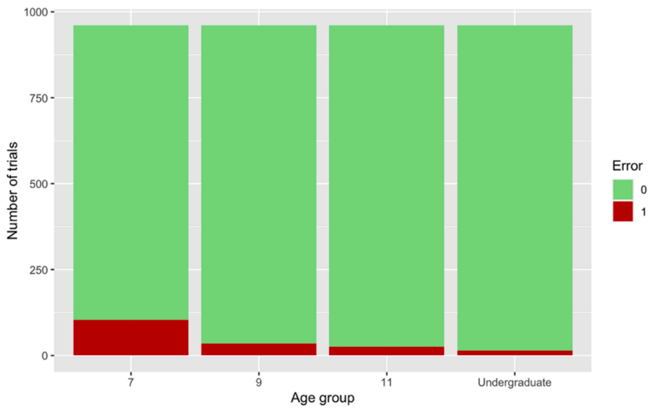

Fig. 3. Number of correct (green) and incorrect (red) trials for students per age group (age 7, age 9, age 11 and undergraduate). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

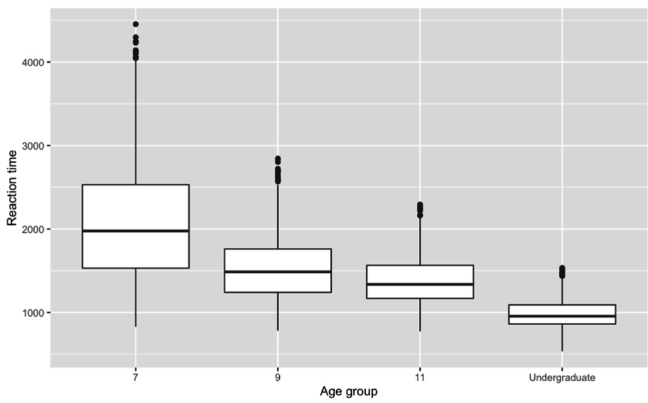

Fig. 4. Reaction times for students per age group (age 7, age 9, age 11 and undergraduate).

6.2. Reaction times

When analyzing reaction times, model comparisons indicate that there is a main effect of Age ($\chi^2(3) = 116.76$, $p < .001$), no effect of Congruency ($\chi^2(1) = 0.43$, $p = .508$), and no Age by Congruency interaction ($\chi^2(3) = 0.24$, $p = .970$). Overall, students took about 2000 ms to respond (*Estimate* = 2,151, *SE* = 55.5). Not surprisingly, the effect of Age emerged because age 7 group responded 598 ms (*SE* = 78.46) slower than age 9 group, 765 ms (*SE* = 78.46) slower than age 11 group, and 1163 ms (*SE* = 78.43) slower than undergraduate students (see Fig. 4 and Table 1).

6.3. Mouse trajectories

When analyzing the mouse position over time, model comparisons indicate that the slope of the mouse trajectory shows a main effect of Age ($\chi^2(3) = 18.49$, $p < .001$) and an Age by Congruency interaction ($\chi^2(7) = 47.68$, $p < .001$). However, the main effect of Congruency did not significantly improve model fit ($\chi^2(1) = 1.32$, $p = .250$). The significant Age by Congruency interaction that emerges is driven by the fact that the effect of Congruency (better performance for congruent than incongruent graphemes) only emerges in the age 7 group (see Fig. 5). For the youngest children, the slope of the mouse trajectory is steeper (meaning that they move faster towards the correct response) when answering to congruent than incongruent graphemes (*Estimate* = −0.39, *SE* = 0.17, $t(350000) = -2.25$, $p = .024$). In contrast, mouse trajectories went against the predicted pattern of responses in age 9 group (*Estimate* = 0.79, *SE* = 0.24, $t(350000) = 3.21$, $p = .001$), age 11 group (*Estimate* = 0.63, *SE* = 0.24, $t(350000) = -2.58$, $p = .009$) and undergraduate students (*Estimate* = 0.81, *SE* = 0.24, $t(350000) = -3.31$, $p < .001$).

7. Experiment 2

In the second experiment we investigated if L2 learners were affected by complex English graphemes. In this case, the letters to be detected were embedded either in a simple grapheme formed by a single letter (e.g., "a" in *park*), or in complex graphemes specific to the English orthography (e.g., "a" in *beach*). If participants processed complex graphemes as a set (and not as two different letters), they would be sensitive to the complexity effect. Therefore, they would be decoding English sub-lexical units following the English spelling rules, even though these complex graphemes do not exist in their native language (Spanish). Our hypotheses in the second experiment were:

- Main effect of Complexity: All participants will perform better when answering to simple than complex graphemes.
- Main Effect of Age: Younger children will perform worse than the rest of participants.

Table 1
Descriptive statistics (means and standard deviations) of reaction for students per age group (age 7, age 9, age 11 and undergraduate) and condition. Differences across conditions were not significant.

Age group	Congruent	Incongruent
Age 7	2,107 (731)	2,125 (766)
Age 9	1,540 (417)	1,541 (380)
Age 11	1,373 (283)	1,390 (303)
Undergraduate	985 (175)	986 (169)

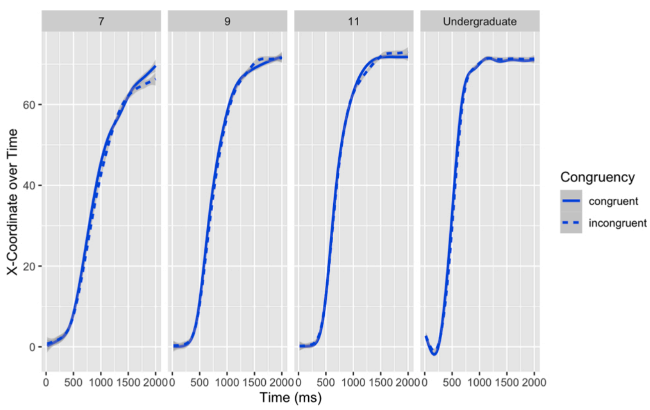

Fig. 5. The first two seconds of the mouse trajectories per age group (age 7, age 9, age 11 and undergraduate) responding to congruent and incongruent graphemes.

- Complexity by Age Interaction: Undergraduate students will have larger complexity effects (i.e., larger differences in performance between simple and complex graphemes). Undergraduates have been more exposed to written English and its orthography, therefore, they will be more likely to process complex graphemes as whole sets.

8. Method

8.1. Participants

The same children and undergraduate students that participated in Experiment 1 participated in Experiment 2. Again, participants were 7-, 9-, and 11-year-old children, while undergraduate students were recruited from the University of Oviedo. None of the participants had cognitive, learning or behavioral impairments.

8.2. Materials

48 words were selected for this task (see Table A2). They all contained one of the target letters (A, E, O), and they were controlled for word frequency, length and mean bigram frequency. The mean length was 4.29 characters (*SD* = 0.46) for simple condition, and 4.46 (*SD* = 0.51) for complex condition with no significant differences between both ($t = 1.18$, $p = .242$). The mean bigram frequency was 1,632.89 (*SD* = 929.88) for simple condition and 2083.86 (*SD* = 1,471.08) for complex condition with no differences between both ($t = 1.26$, $p = .211$) according to the MCWord database (Medler & Binder, 2005). The mean word frequency was 171.96 per million (*SD* = 115.14) for simple condition and 173.08 (*SD* = 174.14) for complex condition with no significant differences between both ($t = 0.02$, $p = .979$),

Selected words contain letters which may be part of a simple grapheme formed by a single letter (e.g., "a" in *park*), or embedded in a complex grapheme that is specific to the English orthography (e.g., "a" in *beach*). Filler words with absent target letters were also presented to the participants.

As in Experiment 1, response options were counterbalanced by creating two versions of the experiment. Each participant responded to 72 trials across three different conditions (24 letter-present words containing a simple grapheme, 24 letter-present words containing a complex grapheme, and 24 letter-absent filler words) for a total of 6912 observations.

8.3. Procedure

The procedure was the same as described in Experiment 1. The task also lasted about 10–15 min.

8.4. Analysis plan

The analysis plan was described in Experiment 1. For Experiment 2, the independent variables included in the analyses were the between-participant variable age (7-, 9-, and 11-year-old children, undergraduates) and the within-participant variable complexity (simple, complex).

The experiment, the data, and the scripts to reproduce the analyses are available at the Open Science Framework: https://osf.io/w2buv/?view_only=66d5a48720c048bf89ee65aaa70c97cb.

9. Results

9.1. Errors

When analyzing errors, model comparisons indicated that there is a main effect of Age ($\chi^2(3) = 48.7$, $p < .001$) and a main effect of Complexity ($\chi^2(1) = 6.06$, $p = .013$). However, the Age by Complexity interaction did not emerge ($\chi^2(3) = 3.33$, p = .342). The main effect of Age emerged because, not surprisingly, age 7 group had the worst performance (77/576–13.3% in simple graphemes; 116/576–20.1% in complex graphemes), followed by the age 9 group (19/576–3.2% in simple; 31/576–5.3% in complex; *Estimate* = −1.51, *SE* = 0.29), age 11 group (19/576–3.2% in simple; 29/576–5% in complex; *Estimate* = -1.57, *SE* = 0.29) and undergraduate group (13/576–2.2% in simple; 10/576–1.7% in complex; *Estimate* = −2.34, SE = 0.33) (see Fig. 6). Furthermore, all the participants performed better with simple graphemes (128/2304 – 5.55 %) than with complex graphemes (186/2304 – 8.07 %), as we predicted in our first hypothesis (*Estimate* = 0.46, *SE* = 0.18).

9.2. Reaction times

When analyzing reaction times, model comparisons indicated that there is a main effect of Age ($\chi^2(3) = 131.86$, $p < .001$), a main effect of Complexity ($\chi^2(1) = 30.97$, $p < .001$), and an Age by Complexity interaction ($\chi^2(3) = 26.45$, $p < .001$). The main effect of Age emerged because, not surprisingly, age 7 group responded 518 ms (*SE* = 87.47) slower than age 9 group, and 831 ms (*SE* = 87.51) slower than age 11 group. Undergraduate students were the fastest, with a difference of 1324 ms (SE = 87.43) between them and the age 7 group. The main effect of Complexity emerged because detecting complex graphemes took 219 ms (SE = 28.61) longer than detecting simple graphemes. The Age by Complexity interaction emerged because the differences between simple and complex

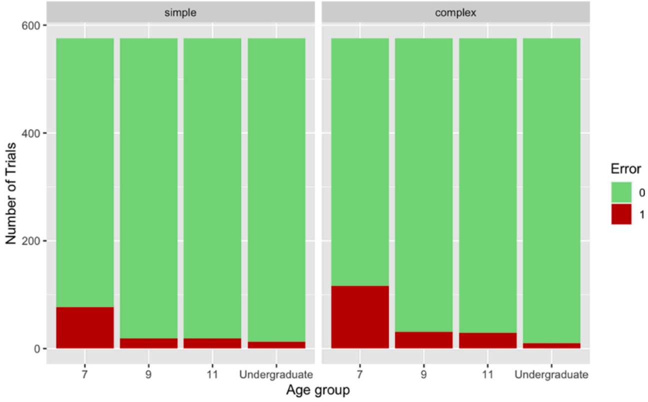

Fig. 6. Number of correct (green) and incorrect (red) trials for participants per age group (age 7, age 9, age 11 and undergraduate) responding to simple and complex graphemes. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

graphemes vary across age groups (see Fig. 7 and Table 2). Specifically, age 7 participants were most affected by grapheme complexity. Across all age groups, there is a significant difference between the Simple and the Complex condition (*Estimate* =219 ms, *SE* = 28.61, $t(625.36) = 7.68$, $p < .001$). This difference is larger for age 7 than for age 9 (*Estimate* = −168, *SE* = 38.18, $t(3968.46) = -4.41$, $p < .001$), age 11 (*Estimate* = −138, *SE* = 38.22, $t(3966.42) = -3.62$, $p < .001$), and undergraduates (*Estimate* = −173, *SE* = 37.92, $t(3970.29) = -4.56$, $p < .001$). Against our original prediction, the youngest (instead of the oldest) participants are the most affected by the complexity effect (show the biggest delay when processing complex graphemes).

9.3. Mouse trajectories

When considering the mouse position over time, model comparisons indicated that on the slope of the mouse trajectory there is a main effect of Age ($\chi^2(3) = 19.43$, $p < .001$), a main effect of Complexity ($\chi^2(1) = 16.11$, $p < .001$) and an Age by Complexity interaction ($\chi^2(7) = 460.51$, $p < .001$). The main effect of Age emerged because mouse trajectories were steeper (better performance) for undergraduates (*Estimate* = -0.35, *SE* = 1.12), followed by age 11 (*Estimate* = 3.71, *SE* = 1.12), age 9 (*Estimate* = 1.94, *SE* = 1.12) and age 7 (*Estimate* = 23.99, *SE* = 0.79) groups. The main effect of Complexity emerged because mouse trajectories were less steep (worse performance) with complex than simple graphemes across all the participants (*Estimate* = −2.98, *SE* = 0.18). The Age by

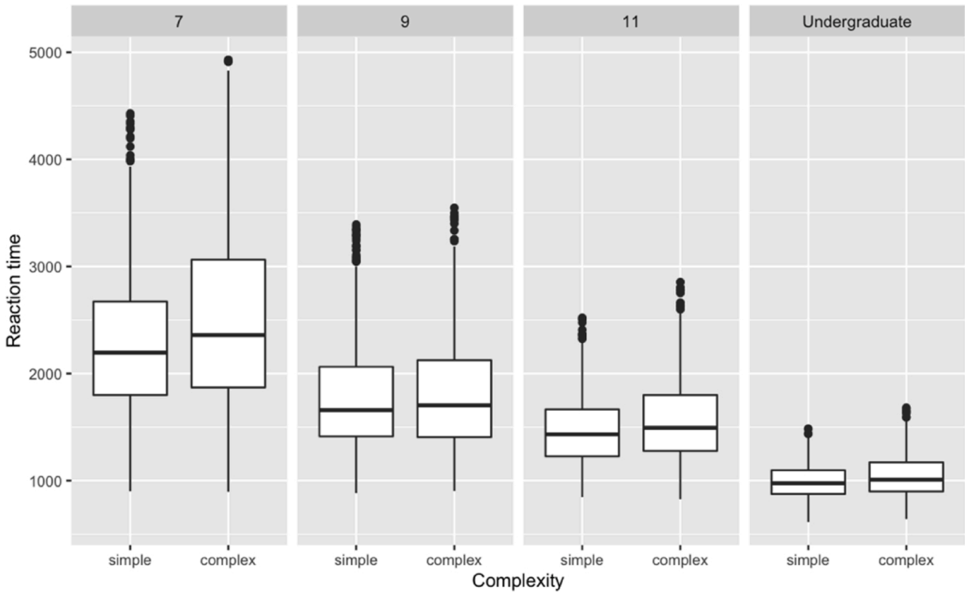

Fig. 7. Reaction times for participants per age group (age 7, age 9, age 11 and undergraduate) responding to simple and complex graphemes.

Table 2
Descriptive statistics (means and standard deviations) of reaction times for students per age group (age 7, age 9, age 11 and undergraduate) and condition.

Age group	Simple	Complex
Age 7	2,306 (687)	2,520 (846)
Age 9	1,782 (534)	1,827 (561)
Age 11	1,479 (333)	1,557 (389)
Undergraduate	998 (166)	1,043 (200)

Complexity interaction emerged because the effect of Complexity (better performance for simple graphemes) was larger for the age 7 group than the rest of the groups (see Fig. 8). The differences between the simple and complex slopes of the mouse trajectories were more pronounced in age 7 group (*Estimate* = −2.98, *SE* = 0.18), than age 9 group (*Estimate* = 2.47, *SE* = 0.24), age 11 group (*Estimate* = 2.54, *SE* = 0.24) and undergraduate students (*Estimate* = 3.85, *SE* = 0.24). Across all age groups, there is a significant difference between the Simple and the Complex condition (*Estimate* = −2.98, *SE* = 0.18, $t(409800) = -16.49$, $p < .001$). This difference is larger for age 7 than for age 9 (*Estimate* = 2.48, *SE* = 0.24, $t(409800) = 10.01$, $p < .001$), age 11 (*Estimate* = 2.54, *SE* = 0.24, $t(409800) = 10.24$, $p < .001$), and undergraduates (*Estimate* = 3.85, *SE* = 0.24, $t(409800) = 15.68$, $p < .001$).

10. Discussion

In Experiment 1 congruency of grapheme-to-phoneme mappings across languages was manipulated. We compared participants' performance with congruent (e.g., detect "a" in *park*) and incongruent (e.g., detect "a" in *name*) words –not predicted by Spanish orthographic rules. In this first experiment we wanted to assess if Spanish children process grapheme units differently, depending on whether the pronunciation of the graphemes is congruent across languages or not. Our hypothesis was that (in line with results from deep orthographies like English-French) graphemes that are congruent across Spanish and English would be detected faster than incongruent ones, and that younger students would be more affected by cross-linguistic interference, that is, the lack of congruency. The results of errors and reaction times were similar, in that age 7 group had the worst performance but no effect of congruency emerged. The results of the mouse trajectories point to an age by congruency interaction, as congruency effects only emerged in age 7 group. These null results were surprising to us, as we had predicted that all students would be affected by their native language when processing graphemes. The youngest children are the only ones who perform better when responding to congruent than incongruent graphemes. The congruency effect does not emerge in older children or undergraduates. In sum, grapheme congruency does not have an influence on errors nor reaction times. As it is possible to observe in Fig. 5, the effect of congruency is very small and only emerges relatively late in the mouse trajectories (after 1500 ms have passed). Thus, researchers should be cautious when making claims based on this interaction.

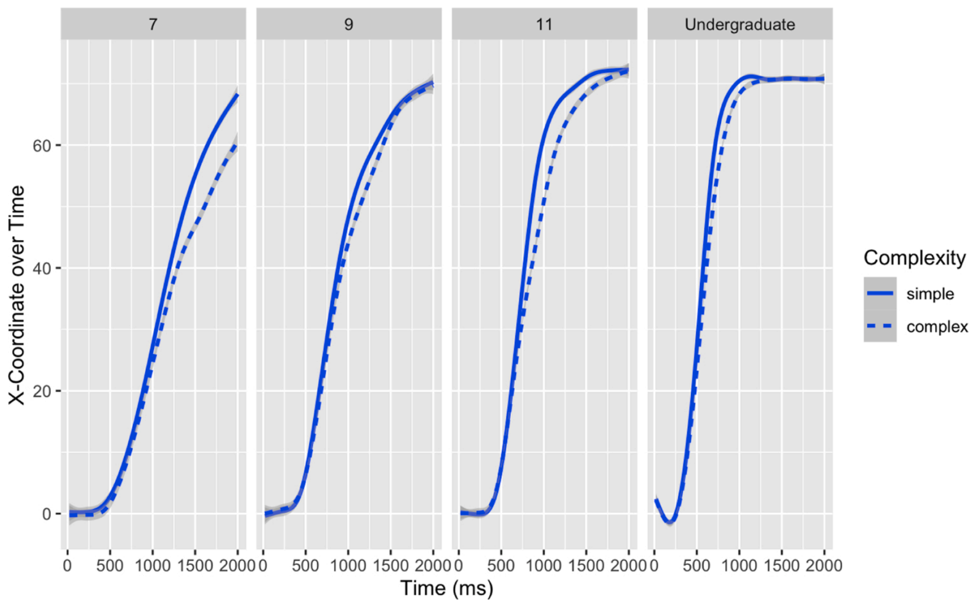

Fig. 8. The first two seconds of the mouse trajectories per age group (age 7, age 9, age 11 and undergraduate) responding to simple and complex graphemes.

In Experiment 2 grapheme complexity was manipulated. We compared simple (e.g., detect "a" in *park*) and complex and English-specific graphemes (e.g., detect "a" in *beach*). Congruency and complexity have an effect on orthography processing by monolingual speakers. Our aim with the second experiment was to assess if Spanish readers, speakers of a shallow language with nonequivalent complex graphemes, would be affected by complex English graphemes. Also, we investigated how L2 learners process sublexical units that do not exist in their native language. Participants across all age groups had less errors, lower reaction times, and steeper mouse trajectories when detecting a letter in a simple grapheme than when detecting a letter in a complex grapheme. Unsurprisingly, overall performance was better in the older participants; age 7 participants had more errors, as well as higher reaction times, and less efficient mouse trajectories than the rest of participants. Interestingly, the age by condition interaction emerged in the opposite direction as predicted. Instead of observing larger complexity effects in older participants (e.g., undergraduates), the differences between simple and complex graphemes in reaction times and mouse trajectories were largest for age 7 group.

In respect of our first experiment, our results do not support our initial hypothesis, as participants were barely affected by differences in congruency. The fact that the youngest students (age 7 group) were the only ones slightly affected by cross-linguistic interference point to the idea that as Spanish-English bilinguals grow older they are able to efficiently inhibit cross-linguistic interference. The lack of congruency effects in Spanish-English bilinguals emerges as a stark contrast to the congruency effects previously reported in French-English bilinguals (Commissaire et al., 2014). It is possible that cross-linguistic interference is more pronounced in bilinguals with two deep orthographies (French-English) than in bilinguals with one shallow and one deep orthography (Spanish-English). Nevertheless, we should also remark two main differences between their participants and our own sample that might account for the contradictory results. First, the instructional method followed by the French students is described as focused on written more than on oral skills. That is different from the instructional method of the school our participants attend, as this Spanish school focuses on oral communication in second language before the students learn to read in either language. Second, French students started their English instruction later on, when reading acquisition was completed. In contrast, our participants started their literacy acquisition in both languages at the same time. Furthermore, they were already exposed to English before reading learning; thus, our students are sequential bilinguals but simultaneous biliterates. Bearing in mind the described differences, we agree with the theoretical interpretation of Commissaire and colleagues. The influence of L1 sublexical phonology affects L2 learners in letter detection when graphemes are shared but not congruent. This is, when the orthographic mappings are not congruent across languages. Nevertheless, it only occurs during their first years of instruction. Our own findings point to a nonselective activation of both languages' phonology occurring at early stages of literacy acquisition. Younger children are more sensitive to cross-linguistic interference, as they have started their instruction recently and L1 inhibitory and L2 activatory connections are not well-established. The lack of congruency effects in our older participants might be interpreted as a stronger activation of L2 phonological codes, a result of the high exposure to the second language. Therefore, in line with the BIA-d model, once the students generate these connections (better inhibition of native language and stronger activation of second language) the congruency effect is no longer detectable.

Regarding complexity, we determined whether early knowledge of English is accompanied by the interiorization of English specific graphemes. If Spanish students were to process English-specific complex graphemes during reading, it would mean that they are able to adapt their processing strategies to the target language. Indeed, results showed that all participants performed better with simple than complex graphemes. In complex graphemes, performance was worsened due to the conflict produced by the letter and the grapheme units coactivation. These results supporting complexity effects are in line with those reported by Rey et al. (2000) and Marinus and de Jong (2011) in monolinguals, and Commissaire et al. (2014) in bilinguals.

A surprising result that warrants further consideration is the fact that the complexity interaction in Experiment 2 emerged in the opposite direction as predicted. While (in line with our predictions) complexity effects emerged, the effects were larger for younger instead of older participants. If complexity effects were due solely to proficiency levels (e.g., more proficient individuals having larger complexity effects because of their automatic processing of the English orthography) we should have seen a larger effect in the older participants. Instead, we observed larger complexity effects in the youngest group of participants (7-year-old children). Chetail (2020) found no evidence for a complex grapheme effect in undergraduate students and attributed the effects observed to a phonological confusion. Since our older participants were barely affected by congruency in Experiment 1, it seems unlikely that the origin of differences between simple and complex graphemes in older participants is phonology. One possibility, though, is that our younger participants were indeed affected by phonological confusion. The origin of this confusion is that participants would detect the "a" slower in beach than in park, because they activate the phoneme which corresponds with that grapheme (/biʧ/ compared to /pɑrk/). This type of phonological confusion could result in increased differences between simple and complex graphemes for the youngest children, as they were affected by congruency in Experiment 1. Nonetheless, another possible explanation is the issue of response time scaling. It is a known phenomenon that effects tend to increase when the scale increases. In this case, reaction times for younger participants were much larger and had a greater variability than reaction times for older participants. As age 7 participants have longer reaction times, the effect of complexity might appear larger. Last, but not least, the number of letters (more vowels to process) in the complex graphemes might have affected the younger (less expert) participants in a way that older participants were not affected. Although Marinus and de Jong (2011) discarded serial processing as the reason of the complexity effect found in their Dutch participants (children with and without dyslexia), we do not reject this possibility in Spanish-English bilinguals. Given the Spanish orthographic characteristics, sublexical serial processing is a more plausible explanation of our results with younger participants. Older students could be using a global lexical reading strategy joined to a strong knowledge of English complex graphemes, which contributed to reduce differences between simple and complex graphemes. In the case of younger participants, the appliance of a serial phonological recoding in word processing could be the origin of the increase in the complexity effect. One or several of these explanations could be behind our results in Experiment 2. In order to determine the root cause of these effects, further studies about this issue would be necessary.

Regarding bilingual processing, the results of both experiments are consistent with the BIA-d model and the non-selective hypothesis. Cross-linguistic interference is more likely to happen on children when they start biliteracy acquisition (Bialystok et al., 2005; Jared et al., 2012; Sun-Alperin & Wang, 2008). In the case of Experiment 1, our younger participants could be facing the challenge of dealing with overlapping activation of L1 and L2 phonology codes for shared graphemes. After getting experience with the second language, L2 excitatory and L1 inhibitory connections strengthen, hence the lack of congruency effect in older participants. In their case, L2 grapheme-to-phoneme correspondences were strongly activated and the inhibition of L1 phonology guaranteed a correct and impartial processing of the cross-linguistic incongruent grapheme.

Regarding Experiment 2, the fact that complex graphemes are found in English but not in Spanish leads to another consideration. Complex graphemes might be processed as orthographic markers, which activate the language node described in BIA-d model (Grainger et al., 2010), thus facilitating processing. Orthographic markers are letters or bigrams that can be found only in one language. This language specific orthography facilitates language membership recognition, as it has been demonstrated by several authors (Casaponsa, Carreiras, & Duñabeitia, 2014; Oganian, Conrad, Aryani, Heekeren, & Spalek, 2016; van Kesteren, Dijkstra, & de Smedt, 2012). In addition, the written introduction of the task in English indicated that English words would be appearing. This fact, joined to complex graphemes working as orthographic markers, could have made the participants activate their "English mode" (Grosjean, 1989, 2001). That is, an activation of the English connections while inhibiting the Spanish connections.

However, it seems plausible that sensitiveness to crosslinguistic interference among young children is not only a product of an immature language control mechanism, but the interaction of different reading strategies as well, as reading mechanisms are influenced by both the native and the second language (Bhide, 2015; Goswami, Gombert, & de Barrera, 1998; Lallier, Acha, & Carreiras, 2016). Indeed, transferences during reading are highly dependent on the linguistic features shared across both languages (Lallier & Carreiras, 2018), and bilinguals can use different strategies depending on the characteristics of each language orthography. Differences in processing between shallow and deep orthography languages are found in French-German (de León Rodríguez et al., 2016) or English-Welsh (Egan, Oppenheim, Saville, Moll, & Jones, 2019) bilinguals. These investigations reported an adjustment in reading strategies according to the language context. However, the mentioned studies samples were formed by adults. Indeed, after years of instruction and prolonged exposure, bilinguals process each orthography in a similar way to native speakers of the language in particular (Goodwin, August, & Calderon, 2015; Treutlein et al., 2017). The versatility observed in our undergraduate participants suggests that English-Spanish bilinguals also adapt to English orthography strategies after their first years of instruction. But what happens during foundation literacy acquisition? The transition from a sublexical to a lexical route, described in reading developmental models (Ehri, 1992; Share, 1995), was demonstrated in monolingual readers of shallow orthographies like Italian (Orsolini, Fanari, Tosi, De Nigris, & Carrieri, 2006; Zoccolotti, de Luca, Di Filippo, Judica, & Martelli, 2009) and Spanish (Cuetos & Suárez-Coalla, 2009). Bhide (2015) suggested that early literacy experience with a shallow orthography leads to a higher reliance on phonological recoding and sublexical processing in a second language. Our results from younger participants evidenced this, being consistent with other studies in French-Spanish (Lallier, Valdois, Lassus-Sangosse, Prado, & Kandel, 2014) and French-Basque (Lallier et al., 2016) bilinguals. Further studies should assess the potential advantages or disadvantages of this, but van Daal and Wass (2017) have demonstrated a positive effect of knowing a shallow orthography when learning a second deeper orthography (English).

Considering our results for both experiments, just before middle-childhood seems to be a key period in literacy acquisition. This stage of clear improvement was already evidenced in monolinguals (Seymour et al., 2003), but also in bilingual children, as Howard et al. (2012) found in their study about errors in spelling. A specific comparison of first stages of reading acquisition (6–10 years old) would shed light on L2 orthography processing in this crucial period. Specifically, it would confirm the degree in which children learning to read in a shallow orthography rely on the same strategies when learning a deeper orthography. It would also be interesting to compare children with different level of exposure to their second language, as it influences cross-linguistic interference (Brysbaert, Lagrou, & Stevens, 2017). Language exposure is likely to be involved in how bilinguals learn to process language specific features. These results will inform current instructional methods, collecting evidence about the most indicated approach to teach bilingual children to read and write in both languages. As suggested by Murray and colleagues (Murray, McIlwain, Wang, Murray, & Finley, 2019), reassessing our current instructional methods is necessary because of their importance for literacy acquisition. Furthermore, different techniques and tasks should be compared in order to compile more information about the variables that affect second language orthographic learning, as their impact on language processing depend on the task demands (Fischer-Baum, Dickson, & Federmeier, 2014). In this sense, our results stand for the advantages of using the mouse-tracking paradigm (Freeman & Ambady, 2010; Spivey et al., 2005) to record the unfolding of participants' responses. There were effects that emerged in the sensitive mouse trajectories despite not emerging in overall measures like errors or reaction times. Reaction times are useful and give information about how difficult it is to process a written word. Mouse trajectories give information about how this item is processed (and therefore, why would it be difficult to be processed). The mouse-tracking paradigm broadens the information that can be obtained from the same task (Marinus & de Jong, 2011; Rey et al., 2000), as it gives information about what happens during the processing and not only the outcomes.

One of the limitations of the study is that we did not collect individual socioeconomic status data from our participants. Future studies should do so, as this aspect can have a potential impact on dual language development. Regarding the generalizability of these results, our participants were selected from a particular school, therefore, our results might be only suitable to children attending bilingual schools with similar instructional methods. Also, different reading strategies applied by bilingual children should be confirmed through other tasks to determine to what extent these results emerge across cognitive processes.

In summary, this investigation provides information about how Spanish children learning English process sublexical units. Furthermore, it contributes to the discussion of how speakers of a shallow-orthography language learn to read in a deep-orthography language. The weak congruency effect, only evidenced in the mouse trajectories of the age 7 group, points to a strong activation of L2 and a strong inhibition of L1 phonology since very early on. Cross-linguistic interference might still affect more proficient children, but the language node is likely to be activated enough to avoid processing differences. Moreover, students learn to process language specific graphemes, as it was reflected by the complexity effect during letter detection. Interestingly, younger participants performance showed more differences between simple and complex graphemes, which seen from a developmental perspective could indicate a greater reliance in a serial processing strategy at early stages. The reading strategies that children apply during literacy acquisition in languages with a shallow orthography are likely to influence how they process second languages with deep orthographies. The complexity of written language processing, the differences in orthography between languages, the variety of instructional methods and the diversity of the bilingual experience make this area of research an exciting topic of investigation full of potential discoveries. Broaden knowledge about reading development (specifically focused on second language literacy acquisition) will lead to a better understanding of the challenges that children must face in bilingual education. Certainly, helping children become proficient readers across languages will have a positive impact on their lives and on society at large. As Stephen Krashen put it: "*We acquire language when we understand messages, when we understand what people tell us and when we understand what we read*."

Declaration of Competing Interest

We have no known conflict of interest to disclose.

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See Tables A1 and A2

Table A1
Graphemes by congruent and incongruent condition used in Experiment 1.

Congruent		Incongruent	
Target letter "a"	Target letter "i"	Target letter "a"	Target letter "i"
Card	Pink	Game	Five
Farm	Give	Name	Rice
Half	Hill	Late	Nine
Hard	Kiss	Wake	Bike
Past	Milk	Cake	Bird
Path	Sick	Tall	Dirt
Bark	Wish	Salt	Girl
Dark	Gift	Talk	Wife
Fast	Kill	Walk	First
Bath	Miss	Wall	Birth

Table A2
Graphemes by simple and complex condition used in Experiment 2.

Simple			Complex		
Target letter "a"	Target letter "e"	Target letter "o"	Target letter "a"	Target letter "e"	Target letter "o"
Bath	Best	Corn	Bread	Beach	Board
Black	Desk	Frog	Clean	Head	Boat
Glad	Dress	Shop	Coat	Learn	Coal
Lamp	Guess	Soft	Dead	Meal	Coast
Plant	Left	Song	Dream	Leaf	Float
Sand	Neck	Storm	Read	Speak	Goat
Star	Send	Torch	Toad	Teach	Load
Yard	Spell	Word	Toast	Team	Road

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Estudio II

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ORIGINAL RESEARCH
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Influences of First and Second Language Phonology on Spanish Children Learning to Read in English

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Children learning to read in two different orthographic systems are exposed to cross-linguistic interferences. We explored the effects of school (Monolingual, Bilingual) and grade (2nd, 4th, and 6th) on phonological activation during a visual word recognition task. Elementary school children from Spain completed a lexical decision task in English. The task included real words and pseudohomophones following Spanish or English phonological rules. Using the mouse-tracking paradigm, we analyzed errors, reaction times, and computer mouse movements. Children in the bilingual school performed better than children in the monolingual school. Children in higher grades performed better than children in lower grades. The interference effect of Spanish phonology was weak and became weaker in higher grades. Spanish children differentiate between first and second language grapheme-to-phoneme correspondences since early on in the educational process. In 6th grade, children from the bilingual school responded better to words and Spanish pseudohomophones, while children from the monolingual school were less distracted by the English pseudohomophones. Children in the bilingual school had stronger inhibition of Spanish (L1) phonology and stronger activation of English (L2) phonology. Instructional method plays an important role on the processing strategies Spanish children rely on when reading in English. School and grade influence the link between orthographic and phonological representations.

Keywords: orthography, phonology, bilingual reading, pseudohomophones, mouse-tracking

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INTRODUCTION

Learning to read is a key foundation for education, and much effort is invested in ensuring all children are able to read properly. Learning a second language is also important, as it allows worldwide communication and it improves professional development. Thus, how children learn to read in a second language is an important topic to investigate.

Speaking more than one language is an important skill highly valued within the European educational systems (Council of Europe, 2001). In Spain, studying a foreign language at school is compulsory for all children. English is by far the most popular, and the number of schools implementing Spanish–English bilingual programs is increasing. Many bilingual education programs are being developed, but English as a second language instructional methods vary across schools (Hélot and Cavalli, 2017). The consequences of this variety of educational approaches have not been fully investigated, but these different techniques could be influencing how children learn to read in a second language. For instance, it has been demonstrated that being more exposed to second language impacts positively on language learning (Farukh and Vulchanova, 2015). Thus, it is essential to determine the role of school and to ensure teachers know how to help students read in their second language. Despite the undeniable benefits of being exposed to a second language since early stages (Winsler et al., 1999; Larson-Hall, 2008; Olulade et al., 2016), children face the challenge of simultaneously learning to read and write in two different orthographies. The purpose of this study is to determine how Spanish children learn to read in English. In particular, we examine the effect of school and grade on word processing during second language reading.

When children learn to read in their native language, they learn a specific set of grapheme-to-phoneme correspondences. The goal is to connect a grapheme (the letter "a") to its correspondent phoneme (the sound/ʌ/). For instance, in order to form the word cat, the letters c - a - t are processed and connected to the sound each is related to. In languages like English, it may also be necessary to learn correspondences between larger segments of writing, like syllables or rhymes, and their phonological representations. Regardless of the size of the processing units (as long as it is not the whole word) this serial rule-based procedure is known as sublexical decoding (Rau et al., 2014). A stage of sublexical decoding is included in some reading developmental models (Frith, 1985; Ehri, 2005). In later stages, readers transit from this sublexical to a lexical strategy, which improves fluency and efficiency. However, as Share (1995) states in the self-teaching hypothesis, this developmental transition can be different for each word and strategies may overlap. Every time a word is successfully decoded, children acquire specific orthographic information. The orthographic representation of the word will be formed through a self-teaching mechanism after repeated exposures. The coexistence of phonological and lexical processing continues along the reader's life. This highlights the relevance of print-to-sound correspondence knowledge, which is specific to the orthography of each language (Goswami et al., 2001). Children learning to read are influenced by orthographic depth of their native language—the extent to which the orthography is a phonetic representation of speech (Katz and Feldman, 2017). This reliability of print-to-sound correspondences is based on the complexity and unpredictability of the orthography (Schmalz et al., 2015; De Simone et al., 2021). In more shallow orthographies (e.g., Spanish), each grapheme is associated with a single phoneme; there is a one-to-one correspondence with relatively few exceptions. However, in deeper orthographies (e.g., English) each grapheme can be associated with multiple phonemes. In these cases, the formation of strong orthographic representations and the transition from a sublexical to a lexical strategy will be more likely than in shallower orthographies.

Orthographic depth determines the main route (phonological or lexical) children rely on most during literacy acquisition (Ziegler and Goswami, 2005). For instance, children learning to read in a shallower orthography language like Spanish rely heavily on the phonological route and use more frequently grapheme–phoneme decoding strategies (Bhide, 2015). This facilitates code learning, allowing Spanish children to reach accuracy in reading sooner than their counterparts who learn to read in deeper orthography languages like English (Seymour et al., 2003). On the contrary, children learning to read in a deeper orthography like English rely more frequently on the lexical route (Defior and Serrano, 2005). Because not all graphemes correspond to a unique phoneme in English, children's sublexical decoding is based on units bigger than graphemes (e.g., syllables). The orthographic context, as well as other sublexical elements like syllables or rhymes, must be taken into consideration in more deep orthographies. This makes decoding a more complex task for English than for Spanish readers, which results in children who are learning to read in English reaching reading accuracy about a year later than their Spanish counterparts.

In bilingual programs children are exposed to another language and must learn an additional set of grapheme-to-phoneme mappings. While English and Spanish share the same alphabet, the grapheme–phoneme equivalences are not the same. For instance, the sound /i/ is represented with i in Spanish and ee or ea in English. This sound is perceived in English as a long vowel, but vowel length is not a relevant aspect in Spanish (Fox et al., 1995). Furthermore, other phonemes may be perceived as two separate sounds in English but a single sound for Spanish speakers. For instance, the /ʤ/ in jeans (which is not contrastive with the /j/ in yellow) or the /i/ and /ɪ/, which are both perceived and represented as the same grapheme i. This substitution of the spelling of an English specific phoneme (like /i:/ or /ʌ/) for the spelling of the closest phoneme in Spanish (like/i/ or/a/) has been frequently reported (Cronnell, 1985; Zutell and Allen, 1988; Fashola et al., 1996; Sun-Alperin and Wang, 2008; Howard et al., 2012). In the case of cheese, for example, its transcription following Spanish rules would be chis. This lack of discrimination affects not only the vowel sound, but the final/z/ phoneme as well. This voice alveolar fricative does not exist in Spanish, and its closest phoneme is a voiceless alveolar fricative (/s/). Moreover, in Spanish the letter "z" represents the sound/θ/, which is normally spelled as "th" in English. These inconsistencies help illustrate the incongruences that Spanish children encounter when learning to read in English.

While understanding the orthography of each language is essential to learn how to read, the corresponding phonology also plays an important role in literacy acquisition. For instance, the triangle model (Seidenberg and McClelland, 1989; Harm and Seidenberg, 2004) suggests a cooperation between orthography and phonology to read words. Nevertheless, exposure to the phonology of both languages can lead to cross-linguistic interferences between first language (L1) and second language (L2; Akamatsu, 2003; Lemhöfer et al., 2008; Sun-Alperin and Wang, 2008; Deacon et al., 2009; Ota et al., 2010; Howard et al., 2012; Bhide, 2015). As posited by the language non-selective lexical access hypothesis (Dijkstra and van Heuven, 2002), lexical and sublexical information from both languages is coactivated during word reading. The strength of these influences depend on variables like exposure (Brysbaert et al., 2017), amount of use (Flege et al., 1997; Luk and Bialystok, 2013), proficiency in L1, L2, or both languages (Haigh and Jared, 2007; Van Hell and Tanner, 2012), age (Howard et al., 2012), and the specific orthography (Beauvillain, 1992; Bialystok et al., 2005a; Hamada and Koda, 2008; Lemhöfer et al., 2008; Sun-Alperin and Wang, 2008; Ota et al., 2010; Lallier and Carreiras, 2018) and phonology (Sun-Alperin and Wang, 2008; Ota et al., 2009, 2010) of the L1 and L2 languages. Confusion between decoding rules (e.g., reading an English word by applying Spanish phonological rules) is likely to influence bilingual readers when the languages differ in terms of orthographic depth (Goswami et al., 1998). Many authors suggest that early phonological activation of both L1 and L2 phonological codes overlap during reading (Jared and Szucs, 2002; Duyck, 2005; Jared et al., 2012). This overlap of the two languages happens even in skilled readers that rely on lexical strategies (Perfetti and Bell, 1991; Grainger et al., 2005; Braun et al., 2009).

The pseudohomophone effect provides consistent evidence of phonological activation during reading. Pseudohomophones are non-words that sound like real words (e.g., pseudohomophones of the real English word cheese would be /chease/ or /chis/). Pseudohomophones are orthographically different from words, but phonologically equivalent. In native speakers, pseudohomophones yield faster responses in naming, which reflects a facilitating effect of familiar pronunciations (McCann and Besner, 1987; Seidenberg et al., 1996; Goswami et al., 2001). In addition, pseudohomophones delay responses in lexical decision tasks; since they sound like real words it is more difficult to discard them efficiently (McCann et al., 1988; Seidenberg et al., 1996; Goswami et al., 2001; Pexman et al., 2001; Ziegler et al., 2001; Briesemeister et al., 2009).

The pseudohomophone effect can be explained by computational models of visual word recognition like the multiple read-out model (MROM-p; Jacobs et al., 1998) or the dual-route cascaded model (DRC; Coltheart et al., 2001). In the MROM-p, a stimulus is rejected as a non-word when a threshold is not reached within a certain amount of time. During the processing of a pseudohomophone, there is a mismatch in the activation of the phonological and orthographical nodes, which requires a readjustment that results in delays in the response. The DRC, implemented with the MROM-p, is based on the double-route model (Coltheart, 1978). According to this model, activation in early modules flows to later modules, which receives excitation or inhibition from feedback pathways. In this model, a pseudohomophone activates a lexical entry in the phonological lexicon that does not match with any input in the orthographical lexicon, producing an incongruity. Both models describe a conflict between the "real word" phonological information and the "non-word" orthographical information. Readers are able to resolve this conflict, but the time needed to do so results in delayed responses.

As it happens in monolinguals, the pseudohomophone effect also results in a processing advantage (naming) or disadvantage (lexical decision) in second language readers. In lexical decision tasks, cross-lingual pseudohomophones rely on phonological transference across languages (Duyck, 2005). The phonological activation of a real word in either language competes with the orthographical activation of a non-word. In the case of bilinguals, the coactivation of L1 and L2 phonologies must be handled by activating the target language and inhibiting the non-target language (Grainger and Dijkstra, 1992; van Heuven et al., 1998). Thus, pseudohomophones can have the phonology-to-orthography correspondences of the target (/dreem/ for dream) or the non-target (/drim/for dream) language of the bilingual.

To date, research about pseudohomophone interference effects in second language learners of English has focused mainly on native speakers of orthographies like Dutch or French (Nas, 1983; Duyck, 2005; Haigh and Jared, 2007; Jared et al., 2012; Commissaire et al., 2019). These authors describe pseudohomophone effects as a result of the coactivation of both languages. However, Dutch and French orthographies are not as shallow as Spanish (Seymour et al., 2003), so there is no information about how readers of more shallow orthographies behave when learning to read using a deeper orthography. The present investigation is designed to provide new insights on this topic.

Furthermore, most of the research of pseudohomophones in second language learners has been conducted in adult populations (Nas, 1983; Haigh and Jared, 2007), with a smaller number investigating teenagers (Commissaire et al., 2019) or children (Jared et al., 2012). These studies did not systematically evaluate the developmental evolution of bilingual reading acquisition. Pseudohomophone effects might not emerge in beginner readers because their orthographic representations are not formed yet. In those without orthographic representations, the conflict between phonological and orthographical information would not exist, and therefore, the incongruity that leads to a delayed response would not emerge. Changes across grades in literacy patterns have been documented in Spanish children learning English as a second language (Howard et al., 2012; Hevia-Tuero et al., 2021), and just before middle-childhood, there is a key period in which children are proficient enough to rely on lexical retrieval and they depend less on sublexical decoding (Rau et al., 2014). Nevertheless, there is no information about how this pattern may affect performance in a pseudohomophone task.

Differences between languages may lead to different reading strategies during literacy acquisition, especially when native language orthography is shallower (Spanish), and second language orthography is deeper (English). A better understanding of the factors that affect word recognition across languages with different orthographies will lead to better approaches to reading instruction in second language learners. The present investigation contributes to the literature by measuring the effect of phonological cross-linguistic interferences in Spanish children learning English (a deeper orthography language). Studies that have investigated how Spanish influences English in second language learners have focused on vocabulary, morphological awareness, reading-aloud, or spelling (Zutell and Allen, 1988; Fashola et al., 1996; Sun-Alperin and Wang, 2008; Howard et al., 2012; Goodwin et al., 2015). To our knowledge, this is the first study to investigate the effects of L1 and L2 phonology in Spanish children learning to read in English.

This research has numerous educational implications. Instructional methods influence bilingual children reading abilities (Bialystok et al., 2005b). Depending on the school's characteristics, instructional methods expose children to different amounts of oral and written input in their different languages. For instance, reading skills in first language are important (Cummins, 1979; Maurer et al., 2021), but the amount of input received in second language also has a strong impact on reading proficiency (Matusevych et al., 2017; Mahmoud Al-Zoubi, 2018). Increased exposure to a language would mean more opportunities to process words, which may facilitate the formation of orthographic representations, as well as consolidate grapheme-to-phoneme correspondences. In Spain, there are different approaches to help children become proficient in English; however, not all of them seem to be successful (Martínez Agudo, 2019). Developing empirically validated instructional methods that are effective at teaching children to understand and read English are essential (Freeman and Freeman, 2006).

A novelty of the present study is that we measured participants responses using the computer software MouseTracker (J. Freeman and Ambady, 2010). The mouse-tracking paradigm has been extensively used in psycholinguistics research (Spivey et al., 2005; Barca and Pezzulo, 2015; Incera and McLennan, 2016; Incera, 2018). In line with previous research, the mouse-tracking paradigm measures errors and reaction times, so direct comparisons with other studies can be performed. In addition, it measures mouse trajectories (i.e., participant's computer mouse movements as they respond to the task), which provide detailed information about the online decision-making processes taking place. Through the analysis of x-coordinates over time (how close the mouse is from the correct response) it is possible to visualize the slope of the mouse trajectory. Steeper mouse trajectories mean that responses are more efficient (the computer mouse moves faster/straighter toward the correct response). Less steep mouse trajectories mean that responses are less efficient (the computer mouse moves slower/deviates more when moving toward the correct responses).

In the present investigation, children responded to a visual lexical decision task that included English words (dream), pseudohomophones following Spanish (L1) phonological rules (drim), and pseudohomophones following English (L2) phonological rules (dreem). Children were asked to click on the green tick when reading a real word and to click on the red cross when reading a string of letters that was not an English word. Clicking on the red cross (non-word) when reading a pseudohomophone is likely to take additional time, as children would be activating the real word phonology and the incorrect orthography. Thus, using the mouse-tracking paradigm we expect responses to pseudohomophones to result in more errors, slower reaction times, and less efficient mouse trajectories for children with less English proficiency (younger children, children attending the monolingual school). We want to determine the extent to which school (monolingual, bilingual) and grade (2nd, 4th, and 6th) influence second language reading.

The present study is the first to investigate the combine effects that grade and school have on the phonological development of Spanish children learning to read in English. Grade is an important factor to consider, as reading processes quickly evolve during the elementary school years. Furthermore, instructional method is likely to have a big impact on the ability of Spanish children to read in English. While all children in Spain are required to learn English, those in schools with bilingual instructional methods are likely to be exposed to English more often than those in other schools. For each of the three types of stimuli (English Words, Pseudohomophones following Spanish phonological rules, and Pseudohomophones following English phonological rules), our predictions are:

1. Children in higher grades will perform better than children in lower grades (Main effect of Grade).
2. Children in the bilingual school will perform better than children in the monolingual school (Main effect of School).
3. The effect of school (better performance in the bilingual school) will be larger for children in higher grades (Grade by School Interaction).

MATERIALS AND METHODS

Participants

Spanish native children from second, fourth, and sixth grade who attended two different types of schools participated in the study. All the schools that agreed to participate in the experiment were located in Spain, and they declared having a Spanish–English bilingual learning program. They were similar in terms of educational approaches during lessons taking place in Spanish. However, distinct instructional methods with respect to English were applied, and the hours per week that children were exposed to English differed. Henceforward, we will refer to them as monolingual (with less exposure to English) and bilingual (with more exposure to English) schools.

Monolingual School

In the monolingual school type, all the staff are Spanish native speakers. Children attend 4 h of English lessons per week and follow a Content and Language Integrated Learning methodology (CLIL; Martínez Agudo, 2019). Lessons of two other subjects, which vary depending on the grade (e.g., arts or science), also take place in English. Children are exposed to oral English during kindergarten stages through songs and letter names learning, but English instruction begins to place value on grammar and written vocabulary at Elementary levels. No specific reading instructional method is followed for English.

Bilingual School

The bilingual school type has some native English speakers as staff members. Lessons are taught 50% of the time in Spanish and 50% of the time in English. The instructional method emphasizes oral communication during English lessons. During kindergarten stages, children learn phonics, with explicit

TABLE 1 | Age and sex per school and grade.

School	Grade	Age Mean (SD)	Sex
Monolingual	Second	7.74 (0.29)	15 F/14 M
	Fourth	9.61 (0.28)	13 F/16 M
	Sixth	11.63 (0.28)	14 F/14 M
Bilingual	Second	7.67 (0.30)	12 F/15 M
	Fourth	9.61 (0.27)	15 F/14 M
	Sixth	11.63 (0.28)	14 F/14 M

instruction of phonological correspondences and decoding skills. Teaching of foundation skills of reading continues in later stages, where reading and writing is combined with oral communication.

The sample included 168 participants between 7 and 12 years old ($M_{age} = 9.60$; $SD_{age} = 1.60$). Children were randomly recruited from both types of school, and samples were equivalent −84 from the monolingual and 84 from the bilingual school. Across both types of school, the sample included 54 children from second grade (27 males and 27 females), 58 children from fourth grade (30 males, 28 females), and 56 children from sixth grade (28 males and 28 females; see **Table 1**). All of them had Spanish as their native language, and they had been studying English for at least 4 years by the time of data collection. None of the participants had cognitive or behavioral impairments. Children from both types of school were socio-economically equivalent.

Materials

A total of 24 words were selected, avoiding cognates and words that could be similar in Spanish and English. The mean length was 4.54 ($SD = 0.72$) characters and the mean frequency was 55,722 according to the Subtlex-UK database (van Heuven et al., 2014). Each word (e.g., *cheese*) was manipulated in order to create a pseudohomophone with a transcription that followed Spanish phonological rules (e.g., *chis*), and a pseudohomophone with a transcription that followed English phonological rules (e.g., *chease*). Four different versions of the experiment were created in order to counterbalance the stimuli across conditions. Every participant answered to all words, but within each version of the experiment, each word appeared only in one format (word, Spanish pseudohomophone, English pseudohomophone, illegal non-word). Furthermore, stimuli were randomly presented and the position of the response options was counterbalanced. For half the participants, the "it is a word" response (green tick image) was placed on the top left corner of the screen, while for the other half the correct response was placed on the top right corner of the screen (see **Figure 1**). Each participant responded to 42 trials (six baseline trials, six words, six English pseudohomophones, six Spanish pseudohomophones, six illegal non-words, and 12 filler words) for a total of 7,056 observations. The illegal version of each word and other English words were included as fillers. This was necessary to balance the amount of trial types answered by each participant (same amount of real word/non-word trials).

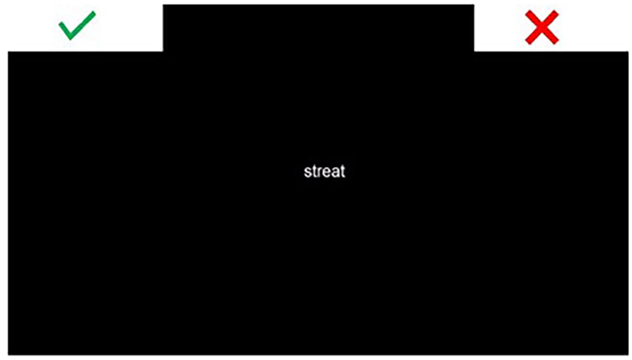

FIGURE 1 | Screenshot of the participants' view of the lexical decision task.

Procedure

The task was created with the computer software MouseTracker (Freeman and Ambady, 2010). An HP x360 Stream laptop was used to present the stimuli to the participants. Participants were asked to answer using a computer mouse and a large mouse pad (17.8 by 15.5 inches). Participants were tested individually, and performance feedback was not provided. Testing took place in a room free of noise and distracting elements to ensure the accuracy of the results. Each participant was randomly assigned to one of the eight versions of the experiment (to counterbalance the stimuli type and the response position).

Before the experiment, children were asked to complete a baseline task (Incera and McLennan, 2018; Hevia-Tuero et al., 2021). Non-linguistic trials (click on the smiley face on the top right or left corners of the screen) were included as a baseline motor task to measure the basic mouse movement abilities of the children. Furthermore, training trials were presented with the purpose of familiarizing the children with the computer program and the task before presenting the target trials.

At the beginning of each trial, START appeared at the bottom-center of the screen and the response options appeared on the top left and right corners. The written word or non-word was displayed in the center of the screen as soon as participants clicked START. The stimuli remained on the screen until participants clicked on one of the two response alternatives (green tick for real words, red cross for non-words). Children were told to click on one of the two response options as quickly and accurately as possible. Once they answered, the START button appeared and they had to click on it to initiate the next trial. If participants took more than 750 milliseconds to initiate a mouse movement, a warning appeared instructing them to start moving the mouse earlier on in future trials.

Analysis Plan

R-software (version 4.0.2) was used to run the mixed model analyses using the lme4 package (version 1.1–21; Bates et al., 2015). To analyze number of errors, we combined the advantages of ordinary logit models with the ability to account for random subject and item effects (Jaeger, 2008). The independent variables included in the analyses were grade (2nd, 4th, and 6th) and school (monolingual, bilingual). We performed separate analyses for each of the three types of stimuli in the lexical decision task: Words, Pseudohomophones following Spanish phonological rules, and Pseudohomophones following English phonological rules. The dependent variables included in the analyses were number of errors, reaction times, and mouse trajectory (x-coordinates over time).

The MouseTracker program measures participants' mouse positions over time, which includes three variables: *y*-coordinates, *x*-coordinates, and time (in milliseconds). Since three-dimensional graphs are hard to visualize, the standard in the field is to report *x*-coordinates over time [see (Incera, 2018), for a detailed discussion of methodological concerns and practical recommendations when using the mouse-tracking paradigm with bilingual populations]. While all participants move the mouse upwards (START is at the bottom and the response options are at the top of the screen) the way in which the task is set up results in the manipulation influencing whether participants move right or left (toward the response options on the right or left corner). Thus, we report mouse trajectories as *x*-coordinates over time.

Outliers were filtered, deleting correct responses with reaction times over and under 2 SD for each school, grade, and type of stimuli. First, we performed the Grade by School analysis on the baseline, in order to determine whether children in both schools are equivalent at the motor level. The baseline analysis does not include the random effect of items because all trials are the same (at baseline there is no item variability to account for). Second, we performed the Grade by School analysis on words, pseudohomophones following Spanish rules, and pseudohomophones following English rules. The goal was to test the effect of Grade (children in higher grades perform better), the effect of School (children in the bilingual school perform better), and the Grade by School interaction (the effect of school—bilingual better—is larger in higher grades). Random effects of participants and items were included crossed in all models testing Words, Spanish Pseudohomophones, and English Pseudohomophones. Models were compared using the Chi-square test; only factors that significantly contributed to model fit, as determined by a significant value of *p* in the chi-square test, were included in the final model. The estimate (effect size) and standard error of each effect was reported for all factors included in the final model for each dependent variable.

RESULTS

The data and the R Notebook with the analyses can be found at the Open Science Framework.

Errors

Errors are calculated by counting the number of times children clicked on the incorrect response (red cross for words, green tick for pseudohomophones). Error analyses cannot be conducted for the baseline task since there are no errors; all children were able to click on the smiley face at the top right/left corner of the screen without making any mistakes.

When analyzing number of errors for *words*, model comparisons indicated that there was a main effect of Grade [$\chi^2_{(2)} = 80.44$, $p < 0.001$] and a main effect of School [$\chi^2_{(1)} = 13.32$, $p < 0.001$], in line with our first and second hypotheses. Furthermore, the Grade by School interaction [$\chi^2_{(2)} = 11.56$, $p = 0.003$] also improved model fit, in line with our third hypothesis. The final model for errors for words as modeled in R is as follows: Error ~ Grade*School + (1|Participant) + (1|Stimuli). The effect of Grade emerged because second graders had more errors than fourth (*Estimate* = −0.84, *SE* = 0.33) and sixth (*Estimate* = −2.24, *SE* = 0.39) graders. The interaction emerged because, while the number of errors in words was equivalent for monolingual and bilingual children in second grade (second grade monolinguals 42.59%; second grade bilinguals 41.97%), the monolingual children had more errors than the bilingual children in fourth (fourth grade monolinguals 28.16%; fourth grade bilinguals 9.19%; *Estimate* = −1.70, *SE* = 0.52) and sixth (sixth grade monolinguals 11.90%; sixth grade bilinguals 4.16%; *Estimate* = −1.28, *SE* = 0.62) grades (**Figure 2**).

In the *Spanish pseudohomophones* analysis, model comparisons indicated that there was a main effect of Grade [$\chi^2_{(2)} = 40.41$, $p < 0.001$]. However, there was no effect of School [$\chi^2_{(1)} = 0.04$, $p = 0.841$] and there was no Grade by School interaction [$\chi^2_{(2)} = 2.38$, $p = 0.303$]. The final model for errors for Spanish pseudohomophones as modeled in R is as follows: Error ~ Grade + (1|Participant) + (1|Stimuli). The effect of Grade emerged because children in second grade had more errors than children in fourth (*Estimate* = −0.90, *SE* = 0.26) and sixth (*Estimate* = −1.92, *SE* = 0.31) grades. In the *English pseudohomophones* analysis, model comparisons indicated that there was a main effect of Grade [$\chi^2_{(2)} = 11.13$, $p = 0.003$]. However, the effect of School [$\chi^2_{(1)} = 1.58$, $p = 0.208$] and the Grade by School interaction [$\chi^2_{(2)} = 0.917$, $p = 0.631$] did not emerge. The final model for errors for English pseudohomophones as modeled in R is as follows: Error ~ Grade + (1|Participant) + (1|Stimuli). While there were no differences between children in second and fourth grade (*Estimate* = −0.24, *SE* = 0.22), the effect of Grade emerged because there were differences between children in second and sixth grade (*Estimate* = −0.74, *SE* = 0.22), the older children had less errors (see **Figure 3**).

In sum, error analyses for Words supported Hypothesis 1 (Effect of Grade), Hypothesis 2 (Effect of School), and Hypothesis 3 (Grade by School Interaction). Furthermore, error analyses for Pseudohomophones supported Hypothesis 1 (Effect of Grade). However, the effect of School (Hypothesis 2) and the Grade by School Interaction (Hypothesis 3) did not emerge in error analyses for pseudohomophones. Children from both schools (monolingual, bilingual) were equally likely to consider the pseudohomophones incorrect.

Reaction Times

Reaction times were measured from the moment the stimulus appeared on the screen to the moment participants clicked

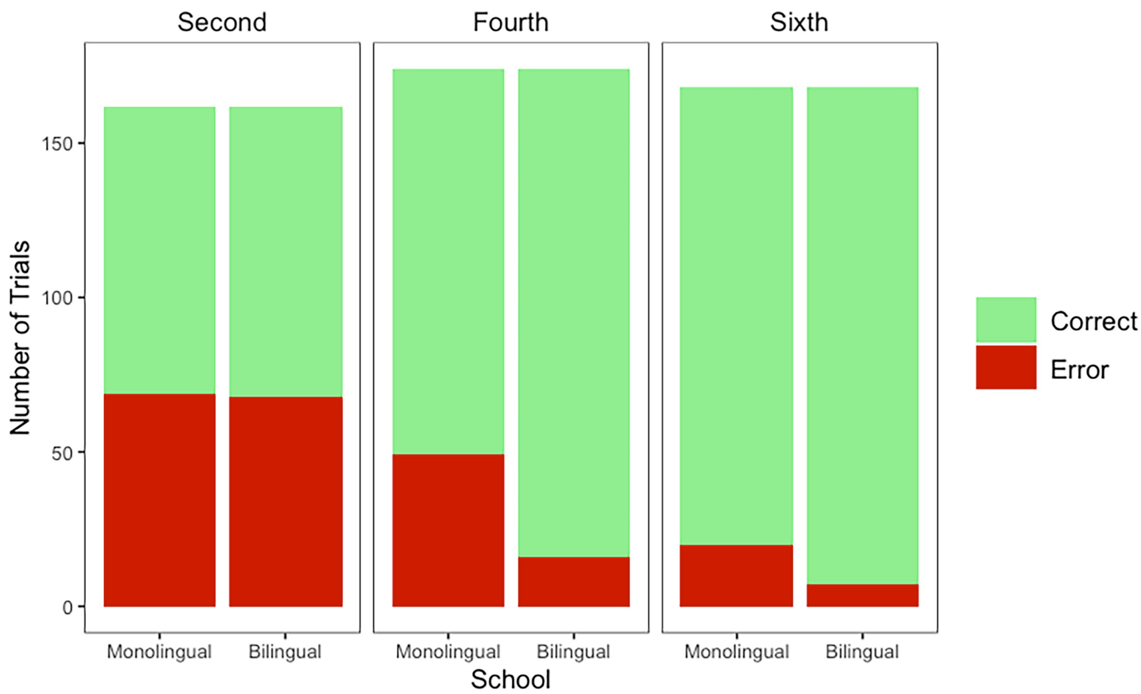

FIGURE 2 | Correct answers (green) and errors (red) per grade and school for words.

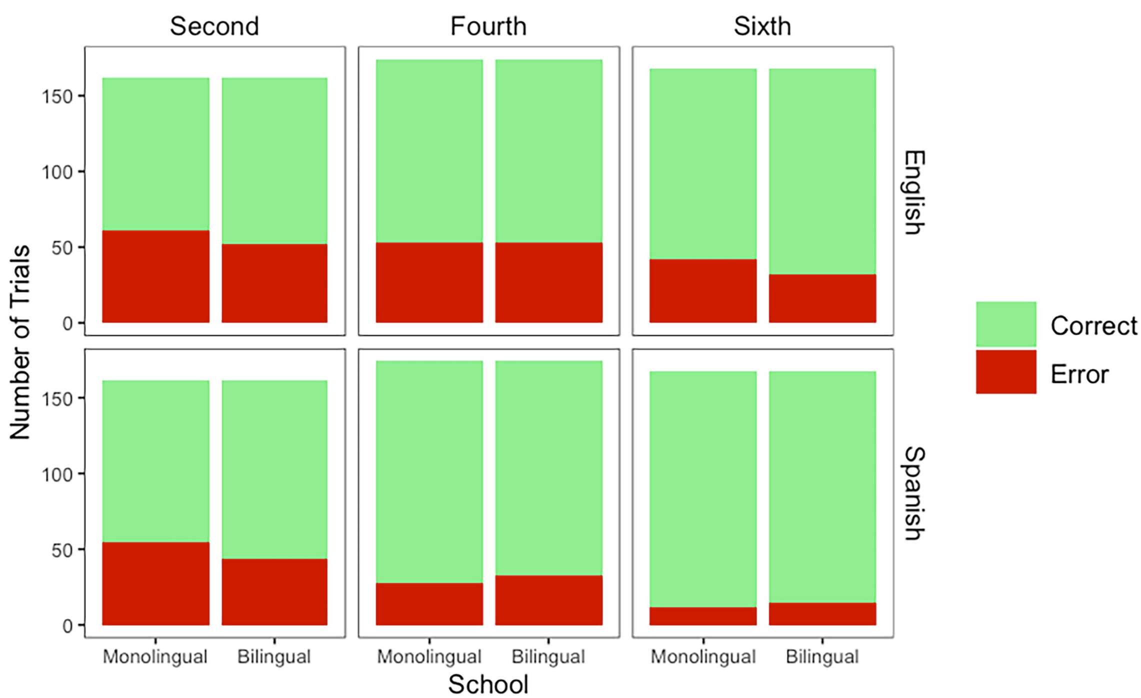

FIGURE 3 | Correct answers (green) and errors (red) per grade and school for Spanish and English pseudohomophones.

on the response. When analyzing the *baseline*, model comparisons indicated that there was a main effect of Grade [$\chi^2_{(2)} = 73.01$, $p < 0.001$] and a main effect of School [$\chi^2_{(1)} = 4.61$, $p = 0.031$]. The Grade by School interaction did not emerge [$\chi^2_{(2)} = 1.49$, $p = 0.472$]. The final model for reaction times for baseline as modeled in R is as follows: RT ~ Grade + School + (1|Participant).

TABLE 2 | Descriptive statistics (means and standard deviations) for reaction times responding to each condition (English Words, Spanish Pseudohomophones, English Pseudohomophones) per grade and school.

School	Grade	Baseline	Word	Spanish	English
Monolingual	Second	2,177 (886)	3,161 (1147)	3,441 (1203)	3,760 (1350)
	Fourth	1,579 (652)	2,484 (962)	2,619 (884)	2,698 (919)
	Sixth	1,293 (406)	1,942 (528)	2,133 (609)	2,293 (705)
Bilingual	Second	1,912 (679)	2,750 (1111)	3,256 (1303)	3,559 (1376)
	Fourth	1,510 (1016)	1,977 (546)	2,497 (881)	2,438 (718)
	Sixth	1,179 (450)	1,710 (433)	1,870 (452)	2,019 (519)

The effect of Grade emerged because second graders responded 499 ms ($SE = 83$) slower than fourth graders, and 808 ms ($SE = 84$) slower than sixth graders. The effect of School emerged because children from the bilingual school responded 147 ms ($SE = 68$) faster than children from monolingual school (see **Table 2**).

When analyzing *words*, model comparisons indicated that there was a main effect of Grade [$\chi^2_{(2)} = 86.60$, $p < 0.001$] and a main effect of School [$\chi^2_{(1)} = 17.61$, $p < 0.001$]. However, the Grade by School interaction did not emerge [$\chi^2_{(2)} = 1.91$, $p = 0.385$]. The final model for reaction times for words as modeled in R is as follows: RT ~ Grade + School + (1|Participant) + (1|Stimuli). The effect of Grade emerged because second graders responded 782 ms ($SE = 109$) slower than fourth graders, and 1,208 ms ($SE = 108$) slower than sixth graders. The effect of School emerged because children from bilingual school responded 374 ms ($SE = 86$) faster than children from monolingual school (see **Table 2**).

When analyzing *Spanish pseudohomophones*, there was a main effect of Grade [$\chi^2_{(2)} = 88.03$, $p < 0.001$]. The main effect of School [$\chi^2_{(1)} = 3.78$, $p = 0.051$] and the Grade by School interaction did not emerge [$\chi^2_{(2)} = 0.28$, $p = 0.868$]. The final model for reaction times for Spanish pseudohomophones as modeled in R is as follows: RT ~ Grade + (1|Participant) + (1|Stimuli). Overall, children took more than 3,000 ms to respond (*Estimate* = 3,400, $SE = 96$). Second graders were 780 ms slower than fourth graders ($SE = 129$) and 1,389 ms slower than sixth graders ($SE = 129$). When analyzing *English pseudohomophones*, there was a main effect of Grade [$\chi^2_{(2)} = 105.85$, $p < 0.001$] and a main effect of School [$\chi^2_{(1)} = 7.46$, $p = 0.006$]. The Grade by School interaction [$\chi^2_{(2)} = 0.03$, $p = 0.984$] did not emerge. The final model for reaction times for English pseudohomophones as modeled in R is as follows: RT ~ Grade + School + (1|Participant) + (1|Stimuli). Overall, children took more than 3,500 ms to respond (*Estimate* = 3,869, $SE = 111$). Second graders were 1,111 ms ($SE = 129$) slower than fourth graders and 1,555 ms ($SE = 128$) slower than sixth graders. Children attending a bilingual school were 286 ms ($SE = 103$) faster than children attending a monolingual school (see **Table 2**).

In sum, reaction time analyses for Words supported Hypothesis 1 (Effect of Grade) and Hypothesis 2 (Effect of School), but not Hypothesis 3 (Grade by School Interaction). Furthermore, reaction time analyses for Pseudohomophones supported Hypothesis 1 (Effect of Grade). Interestingly, the reaction time effect of School (Hypothesis 2) emerged in English but not in Spanish Pseudohomophones. Finally, the Grade by School Interaction (Hypothesis 3) did not emerge for Pseudohomophones.

Mouse Trajectories

Mouse trajectories are measured with *x*-coordinates over time. When analyzing the *baseline*, model comparisons indicated that on the slope of the mouse trajectory there was a main effect of Grade [$\chi^2_{(2)} = 48.10$, $p < 0.001$]. However, the main effect of School [$\chi^2_{(1)} = 1.53$, $p = 0.215$] and the Grade by School [$\chi^2_{(5)} = 2.26$, $p = 0.811$] interaction did not emerge. The final model for mouse trajectories for baseline as modeled in R is as follows: X100 ~ Time*Grade + (Time|Participant). The effect of Grade emerged on the slope of the mouse trajectories (Time*Grade) because, when compared to children in second grade, the mouse trajectories were steeper (better performance) for children in fourth (*Estimate* = −2.14, $SE = 0.68$) and sixth grade (*Estimate* = −5.09, $SE = 0.68$).

In *words*, model comparisons indicated that on the slope of the mouse trajectory there was a main effect of Grade [$\chi^2_{(2)} = 38.97$, $p < 0.001$] and a Grade by School [$\chi^2_{(5)} = 15.03$, $p = 0.010$] interaction. The main effect of School [$\chi^2_{(1)} = 1.43$, $p = 0.231$] did not emerge. The final model for mouse trajectories for words as modeled in R is as follows: X100 ~ Time*Grade*School + (Time|Participant) + (1|Stimuli). The effect of Grade emerged on the slope of the mouse trajectories (Time*Grade) because—compared to children in second grade—the mouse trajectories were steeper (better performance) for children in fourth (*Estimate* = 4.24, $SE = 2.28$) and sixth grade (*Estimate* = 12.30, $SE = 2.27$). The Grade by School interaction emerged on the slope of the mouse trajectories (Time*Grade*School) because the difference between the children attending the monolingual and the bilingual school was larger in fourth than second grade (*Estimate* = 4.56, $SE = 3.19$). However, the difference was smaller in sixth than second grade (*Estimate* = −2.74, $SE = 3.20$). While in sixth grade the children attending the bilingual school still outperformed the children attending the monolingual school (see **Figure 4**), this difference—the effect of school—was not as large in sixth as in fourth grade.

In *Spanish pseudohomophones*, model comparisons indicated that on the slope of the mouse trajectory there was a main effect of Grade [$\chi^2_{(2)} = 47.85$, $p < 0.001$]. However, the main effect of School [$\chi^2_{(1)} = 0$, $p = 0.994$] and the Grade by School [$\chi^2_{(5)} = 6.70$, $p = 0.243$] interaction did not emerge. The final model for mouse trajectories for Spanish pseudohomophones as modeled in R is as follows: X100 ~ Time*Grade + (Time|Participant) + (1|Stimuli). When responding to Spanish pseudohomophones, mouse trajectories were steeper for children in fourth (*Estimate* = 5.39, $SE = 1.78$) and sixth (*Estimate* = 13.23, $SE = 1.79$) grades. In *English pseudohomophones*, there was a main effect of Grade [$\chi^2_{(2)} = 46.27$, $p < 0.001$]. However, the main effect of School [$\chi^2_{(1)} = 0.02$, $p = 0.864$] or the Grade by School [$\chi^2_{(5)} = 3.18$, $p = 0.67$] interaction did not emerge. The final model for mouse trajectories for English pseudohomophones as modeled in R is as follows: X100 ~ Time*Grade + (Time|Participant) + (1|Stimuli). When responding to English pseudohomophones, mouse trajectories were steeper for children in fourth (*Estimate* = 9.27, $SE = 1.94$) and sixth (*Estimate* = 14.12, $SE = 1.96$) grades (see **Figure 5**).

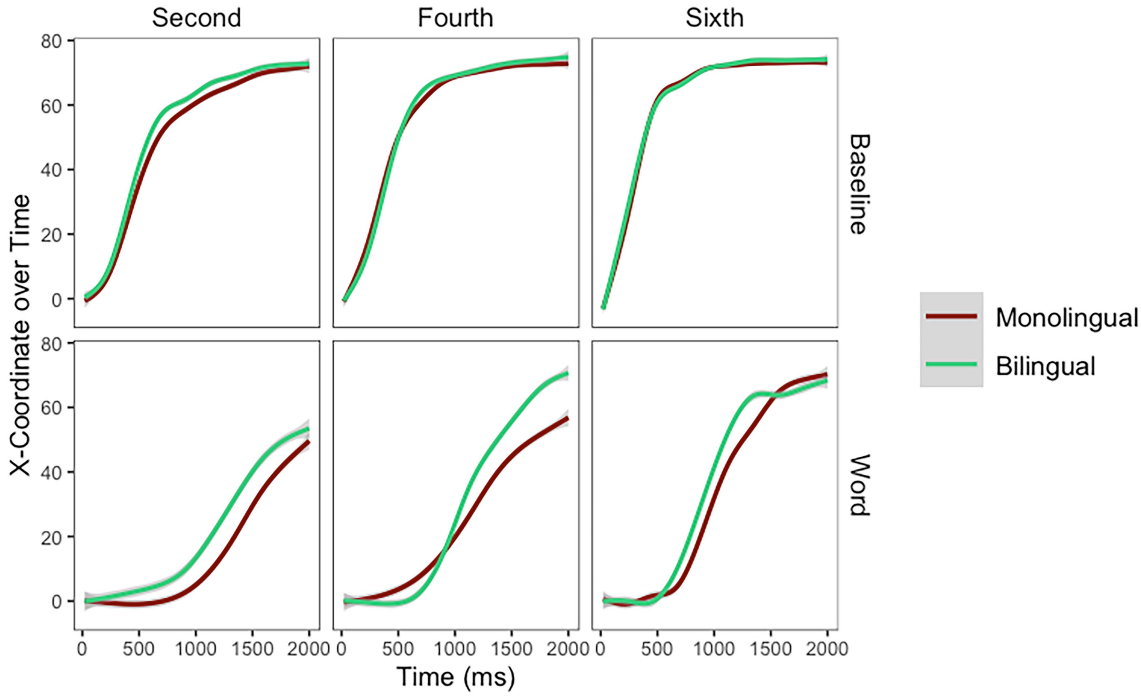

FIGURE 4 | Mouse trajectories for baseline and words per grade and school.

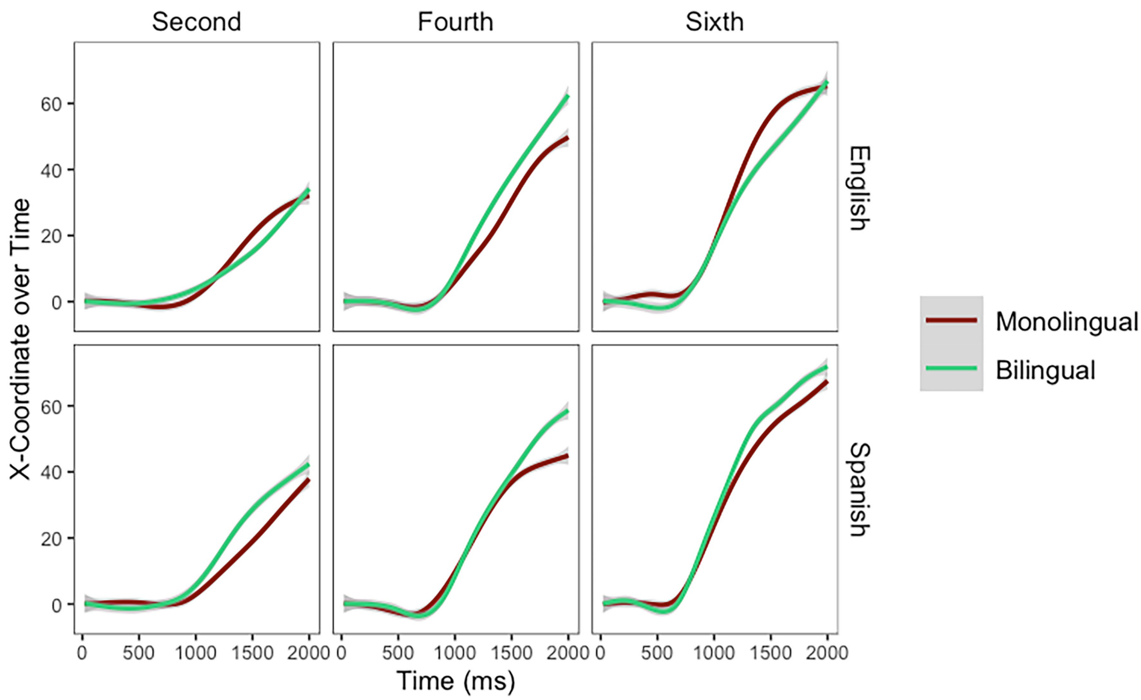

FIGURE 5 | Mouse trajectories for Spanish and English pseudohomophones per grade and school.

In sum, all analyses performed on the Mouse Trajectories supported Hypothesis 1 (Effect of Grade). However, Hypothesis 2 (Effect of School) did not emerge for words or pseudohomophones. Finally, results from Words support Hypothesis 3 (Grade by School interaction), but fourth grade (as opposed to sixth) is where the effect of School is largest.

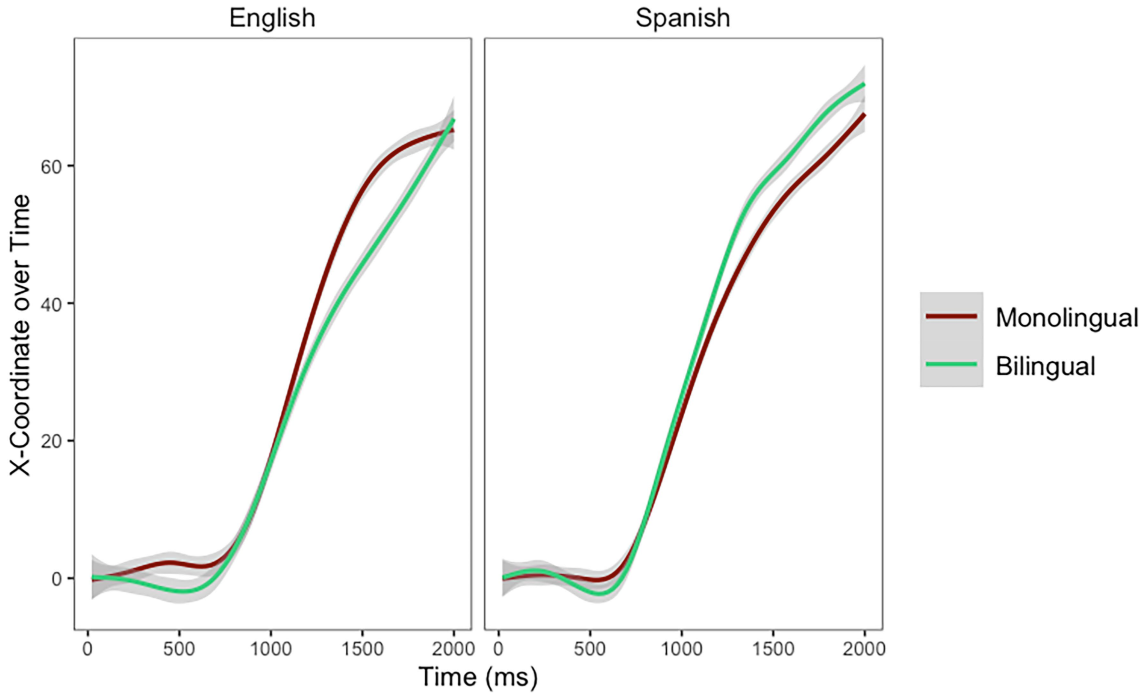

FIGURE 6 | Mouse trajectories for Spanish and English pseudohomophones per school in sixth grade.

Exploratory Analysis

The intriguing pattern of results for sixth graders in **Figure 5** (the children from the monolingual school seem to outperform the children from the bilingual school) led to an *exploratory analysis* performed on the slope of the mouse trajectories. This analysis focuses exclusively on children in sixth grade (the group where this interaction seems to emerge). The goal is to explore the potential Pseudohomophone (Spanish, English) by School (Monolingual, Bilingual) interaction in these skilled children. When sixth graders responded to the pseudohomophones, there was a main effect of Pseudohomophone [$\chi^2_{(1)} = 67.36$, $p < 0.001$] and a Pseudohomophone by School interaction [$\chi^2_{(3)} = 215.87$, $p < 0.001$]. The final model for this exploratory analysis as modeled in R is as follows: X100 ~ Time*Condition*School + (Time|Participant) + (1|Stimuli). The main effect of Pseudohomophone emerged because for all students English pseudohomophones were more distracting than Spanish pseudohomophones (*Estimate* = 0.28, *SE* = 0.39). However, the main effect of School [$\chi^2_{(1)} = 0.06$, $p = 0.805$] did not emerge. The cross-over interaction (see **Figure 6**) emerged because children from the bilingual school outperformed children in the monolingual school when responding to Spanish Pseudohomophones, while children in the monolingual school outperformed children in the bilingual school when responding to English pseudohomophones (*Estimate* = 4.99, *SE* = 0.55).

Close inspection of **Figure 6** indicates that early in the trajectory (around 500 ms after stimulus onset) children in the bilingual school are more distracted by both types of pseudohomophones than children in the monolingual school. Once participants start moving toward the correct response, the interaction emerges. Children in the bilingual school are able to outperform their counterparts in Spanish pseudohomophones, but children in the monolingual school outperform their counterparts in English pseudohomophones.

DISCUSSION

The aim of this study is to determine how native language (i.e., Spanish) interferes with second language reading (i.e., English); especially when L1 is shallower (phonemes and graphemes are more consistently linked) than L2. Importantly, we explored the extent to which grade (2nd, 4th, and 6th) and type of school (Bilingual, Monolingual) play a role in the acquisition of L2 grapheme-to-phoneme correspondence rules.

Words

In line with Hypothesis 1, older children performed better than younger children. Sixth graders had less errors, faster reaction times, and straighter mouse trajectories than fourth and second graders. In line with Hypothesis 2, children attending a bilingual school performed better (less errors, faster reaction times) than children attending a monolingual school. In line with Hypothesis 3, the effect of school (Spanish children attending a bilingual school having less errors) was larger in higher grades. In second grade, children attending the bilingual and the monolingual schools had similar number of errors (close to 40%) when recognizing English words. While students in the second grade performed above chance (60% accuracy), performance substantially improved in higher grades, especially for the children attending the bilingual school.

Our results from number of errors in words point to the conclusion that early on children in both schools perform equally, but as time passes children in the bilingual school outperform those in the monolingual school. Considering the MROM-p (Jacobs et al., 1998), word nodes are strongly activated in children attending a bilingual school, facilitating their responses in the lexical decision task and increasing processing speed in visual word recognition. The fact that the differences between bilinguals and monolinguals are larger in older children indicates that the effect of type of school is cumulative. Those in the bilingual school continue gaining advantages until at least sixth grade, as they are likely to have a higher level of English exposure (in particular, oral exposure).

Regarding the development of the orthography, higher exposure to English among bilingual children could have benefited their formation of strong orthographic representations along their schooling experience. These strong representations could have made their visual word recognition more accurate. An increase of English instructional time, especially the increase in oral instructional time, could have aided the bilingual children in consolidating the grapheme-to-phoneme correspondences. In addition, more opportunities to form orthographic representations are gained with more exposure to written words, which allows for a more efficient transition from serial phonological decoding to lexical processing (Share, 1995). This would be especially relevant for English reading acquisition due to the opacity of the English orthography. In English, phonological decoding is not enough to process words (Cunningham et al., 2002; Ziegler and Goswami, 2005). Finally, having more vocabulary is likely to facilitate recognition of a higher number of words, which makes readers more confident at rejecting non-words. This last possibility is supported by our results as children attending the monolingual school were less confident at rejecting non-words. The number of errors suggests that real English words were not recognized as such by the children in the monolingual school, likely because these children do not know these words yet.

Reaction times indicated that children from the bilingual school were faster than children from the monolingual school. A caveat to claim an advantage is that children in the bilingual school were also faster at baseline. In order to conclude that there are cognitive effects at play, the effect needs to be above and beyond that of the baseline. Indeed, the time difference between children attending the monolingual and bilingual school when responding to English words (374 ms) was more than double that the difference between these two groups at baseline (147 ms). Even though this effect needs to be considered cautiously—the two groups were not equivalent at baseline so the difference could be due (at least in part) to motor influences—the results indicate that the bilingual school has a positive effect on reading performance.

While baseline differences emerged in reaction times they did not emerge in mouse trajectories. Mouse trajectories showed that children were equivalent in terms of baseline mouse movements. When looking at the effect of school on the mouse trajectory, those attending the bilingual school were better at processing English words than those attending the monolingual school. Interestingly, this effect was largest in fourth grade. This is an important finding as it points to a time in development when the effect of School might be maximal (at least when measuring performance using a Lexical Decision task). Alternatively, it is possible that the task was too easy for the older children, thus the difference does not emerge because the sixth graders are performing at ceiling.

Pseudohomophones

In line with Hypothesis 1, when responding to pseudohomophones older children performed better than younger children. Second graders were more affected by the pseudohomophones than older students, probably because they do not have strong English orthographic representations. Second graders had recently started English literacy learning, and correspondence rules might not have been well established at this stage. Additionally, less expertise in L1 inhibition, joined to a lack of reading proficiency, are likely to result in less efficient reading performance. As Hamada (2017) observed, the influence of the native language phonology decreases when learners become more proficient in second language. A difference in knowledge of English phonological rules between children in the bilingual and the monolingual school could also explain these effects. There were no differences between schools with respect to errors in pseudohomophones. The nature of the cognitive processes at play (rejecting a non-word vs. accepting a word) is likely to have influenced these results. All children, even those in the bilingual school, took time and had doubts when rejecting the pseudowords and accidentally accepted some pseudowords as real words. Further research is necessary to determine what additional variables (e.g., oral versus written exposure) are influencing pseudohomophone effects in bilinguals.

While the main effect of school—children in the bilingual school outperforming children in the monolingual school—did not emerge in mouse trajectories, we observed a cross-over interaction. In line with Hypothesis 3, when responding to Spanish pseudohomophones children in the bilingual school outperformed children in the monolingual school. However, against Hypothesis 3, when responding to English pseudohomophones, children in the monolingual school outperformed their peers attending the bilingual school. In sixth grade, children attending a bilingual school are very efficient at rejecting Spanish pseudohomophones, but they get more distracted by the English pseudohomophones than children attending a monolingual school (**Figure 6**). The fact that children in the bilingual school are more confident discarding non-words that clearly follow Spanish rules than children in the monolingual school, support the idea that children in the bilingual school have more experience/practice inhibiting Spanish. The fact that children in the monolingual school get less distracted by the English pseudohomophones than children in the bilingual school indicate that their English phonology might not be as strongly developed.

Implications

Children learning a second language automatically activate L2-specific rules during word reading. All participants had more errors when responding to English than Spanish pseudohomophones (see **Figure 3**). When responding to an English task (in English mode), native speakers of Spanish were more distracted by the English than the Spanish phonology. This pseudohomophone effect is equivalent in other languages (Nas, 1983; Commissaire et al., 2019). In line with other studies, Spanish children develop knowledge of English phonology relatively early during development (Hevia-Tuero et al., 2021). In our study, the pseudohomophone effect emerged even in second grade, and not only in advanced L2 learners like Commissaire and colleagues had previously reported (2019). An emerging knowledge of English orthography is acquired at early stages, with relatively few years of instruction. These results support the idea that phonological information is activated in visual word recognition (Goswami et al., 2001; Ziegler et al., 2001).

The type of school children attend to (bilingual, monolingual) influences word processing. This effect could be due to higher levels of exposure to the second language or to a different approach to reading instruction. Different instructional methods might lead to different ways of processing, altering the orthography–phonology relationship. Indeed, instructional methods and native language characteristics influence reading strategies in both native and second language (Bhide, 2015). Furthermore, phonics instruction facilitates successful learning of relationships between letters and sounds, a requirement for learning to read (Castles et al., 2018). Not having been explicitly taught about English phonics, children in monolingual schools could be building orthographic representations without developing English phonological representations. These children could be relying on the lexical route or on Spanish phonological representations. In this way, they could be processing a whole word unit and rejecting a non-word based on orthographical characteristics. Results from the monolingual school coincide with what Pitts and Hanley (2010) found in their study: Spanish-speaking adults were less reliant on phonology than native speakers, despite knowing well the English grapheme-to-phoneme rules. These findings support the triangle model of cooperation between phonology and orthography to read words (Seidenberg and McClelland, 1989; Harm and Seidenberg, 2004). For those with less knowledge of phonology, a development of a direct orthography-to-semantics pathway would be reasonable (and advantageous in this task). Children attending a bilingual school have a foundation of phonic knowledge, and they are more familiar with English phonology. Therefore, they are likely to have a balanced division of labor. This approach is efficient in some situations (when phonology is helpful). However, the activation of the English phonology makes these bilingual children more sensitive to pseudohomophone effects. The type of school children attend influence their processing strategies during word recognition. There is a shift in the division of labor between the orthographic and the phonological component, which is likely to be influenced by how much written and oral exposure they have in their second language.

The more plausible explanation for our results is that English phonology plays a major role in the way that children in bilingual schools learn. When processing English pseudohomophones, the conflict between the existence of phonological information and the lack of orthographical information of a real word makes them move toward the correct response (rejecting the pseudohomophone) less efficiently. Although they have developed a better "rejection of Spanish" mechanism than children in the monolingual schools, they are still more distracted by the English phonology. These results connect to an increase on the activation of the English language node as described in BIA model (van Heuven et al., 1998) in children attending a bilingual school. Being aware of the stimuli language membership activates the language node. Moreover, for the children attending a bilingual school the higher level of exposure to English is likely to intensify language node activation.

The performance differences found between these instructional methods are remarkable. These results open the possibility for new research in L2 literacy instruction. The goal would be to better understand how instructional methods influence reading proficiency in each language, as authors like Rolla San Francisco et al. (2006) have suggested. Attending a bilingual school may strengthen English phonology activation. While this might constitute a disadvantage in a lexical decision task involving pseudohomophones, this is likely to be helpful when reading. This way of processing written text is closer to the "native" way of processing English words, which speaks to the good job bilingual schools are doing.

The current study is one of the few studies that have investigated L1 and L2 phonology interferences in Spanish children learning English. Moreover, this is the first study to use a pseudohomophone lexical decision task for this purpose. These findings support and complement previous research about phonological activation in second language learners during reading tasks. Furthermore, the present experiment adds to the literature on pseudohomophone effects in orthographic systems with different orthographic depths (shallower, like Spanish and Dutch; or deeper, like French and English). Our results are in line with those reported by Commissaire et al. (2019) and Nas (1983). Nas (1983) focused on adult Dutch L2 learners who had reach a proficient level of reading in their native language. Commissaire et al. (2019) studied adolescent French L2 learners of sixth and eighth grades. The novelty of our study is that participants started English instruction at an early age, and they learnt to read in both languages (L1 and L2) at the same time. In fact, the ages of the children participating in this study match the age for literacy foundation, which is another important contribution of the present investigation. Evaluating children across different grades allowed us to investigate the evolution of L1 and L2 during simultaneous reading learning, shedding light on the processes of literacy acquisition of English learners. However, we do not know to what extent our findings can be extrapolated to other populations of English learners, like Chinese or Hebrew speakers. Spanish and English share the same alphabet, which may have facilitated orthographic rule learning (Pasquarella et al., 2015). Future studies should address this issue, as cross-linguistic transfer is likely to be influenced by the proximity of L1 and L2 orthographies (Geva and Siegel, 2000; Chung et al., 2019).

The mouse-tracking paradigm allowed us to explore children's responses as they unfold over time. This methodology could be used in future studies to investigate automatic phonological activation during reading in tasks like visual masked priming using pseudohomophones (see Duyck, 2005; Ziegler et al., 2013; Sauval et al., 2017). Additionally, it would be interesting to focus on the effect of linguistic variables in order to broaden our knowledge of visual word recognition in L2 learners. Data focused on Spanish speakers learning English are scarce, despite the fact that English and Spanish are the first and fourth most commonly spoken languages in the world (Eberhard et al., 2020). Further investigations are needed to explore how reading mechanisms from the native language interfere with how children learn to read in their second language.

There are additional variables that could be taken into account when investigating these effects. Teachers were asked to select children with average reading skills, and children with difficulties were not included. This study did not assess Spanish and English reading skills, nor did it take into account domain-general abilities like inhibitory control (Bartolotti et al., 2011), which likely influence children's performance. The practical concerns of creating a study short enough for young children, while assessing a wide range of linguistic and cognitive skills, is a real challenge. Furthermore, data were collected during school hours, so students could not be absent from class too long. Additional variables related to the school are likely to influence children's performance. Some examples are the amount of time (only at school, also outside of school) and the type of exposure (oral versus written) to the language, the presence or absence of native speaker teachers, and the instructional methods used during pre-literacy stages. Together, these are factors that may be relevant for Spanish children learning English. It would be interesting to assess the specific weight of these variables in future studies, building on previous research (De Wilde et al., 2020).

CONCLUSION

In conclusion, the aim of this experiment was to understand how Spanish children learn to read in English. We found that Spanish children are able to recognize English orthography independently of their grade and the type of school they attend (monolingual, bilingual). Interestingly, differences in teaching methodologies—like an oral emphasis in bilingual schools versus a written emphasis in monolingual schools, as well as explicit phonics instruction—influence how L2 learners read. Spanish children in the bilingual school are more efficient at recognizing English words and discarding Spanish pseudohomophones, but get more distracted by English pseudohomophones. These results are in line with the idea that children in the bilingual school have better oral English (better English phonological representations) which makes them perform similar to the way in which native English speakers perform. The way in which learners are exposed to a second language determines how they process the orthography and phonology of their languages. Instructional methods influence the strength of the L1 and L2 inhibition processes.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary materials, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Comité de Ética de la Investigación del Principado de Asturias. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

CH-T made contributions to the collection, analysis, interpretation of data for the work, and drafted the manuscript. SI and PS-C supervised the study and revised it critically for important intellectual content. All authors contributed to the article and approved the submitted version.

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Estudio III

How Country of Origin and Stimuli Language Influence Visual Word Recognition in Bilingual Children

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Abstract

We used mouse tracking to determine how country of origin and stimuli language influence visual word recognition in bilingual children. Children attending bilingual schools in Spain and USA completed a lexical decision task in English. The task included real English words (e.g. *true*), and pseudohomophones following Spanish (e.g. *tru*) and English (e.g. *troo*) orthographical rules. Bilingual children from both countries performed worse when responding to English pseudohomophones (within-language interference) than Spanish pseudohomophones (between-language interference). The children from USA outperformed the children from Spain in almost every measure. Interestingly, their mouse trajectories followed a different pattern. When responding to pseudohomophones, children from USA showed a pronounced initial deviation towards the incorrect response (likely due to a strong activation of the phonology of the real English word) followed by a very effective corrective movement (likely due to an orthographic verification mechanism). Mouse tracking provides novel insights regarding language activation in bilingual readers.

Keywords: Bilingual word recognition, orthography, phonology, pseudohomophones, mouse tracking

The experiment, the data, and the scripts to reproduce the analyses are available at the Open Science Framework:

https://osf.io/gdtzh/?view_only=bd6de63140b946a48f6676dd428df098

How Country of Origin and Stimuli Language Influence Visual Word Recognition in Bilingual Children

Literacy rates are at or near 100% around the world, with certain regions as exceptions (UNESCO, 2017). At the same time, it is estimated that half the world's population speaks two or more languages (Grosjean, 2010). Therefore, bilingual reading is a topic relevant to billions of people. Learning to read in two or more languages requires different processes than learning to read in one. It is important to uncover how bilingual people are able to read in their different languages. Biliteracy (being able to read in two or more languages) is becoming very popular due to the increasing number of students learning a second language at school.

When bilingual children process written words they face the challenge of having lexical and sub-lexical information from both languages coactivated (Commissaire, Audusseau, et al., 2019; Kroll & Groot, 2005; Marian & Spivey, 2003). The purpose of the current investigation is to examine the influence that country of origin (Spain, USA) and stimuli language (Spanish, English) has on visual word recognition in bilingual children. The variable country of origin is a proxy for language dominance, as the majority language in each country –Spanish in Spain and English in USA– is usually the dominant language for those living in that country. In the present study, children have to correctly identify English words (e.g. *true*), while discarding Spanish (e.g. *tru*) and English (e.g. *troo*) pseudohomophones –stimuli that sound like English homophones but are not real English words. Our goal is to understand how the two languages of a bilingual reader interact.

Linguistic Interference

Within-language interference refers to the competition between words in a particular language. For example, “candle” and “candy” need to be distinguished when processing English (Spivey et al., 2005). Between-language interference (or cross-language interference) refers to the competition between words across two or more languages (Kroll & Groot, 2005). For example, “chandelier” and “candelabro” need to be distinguished when English-Spanish bilinguals recognize words. The way in which a person reads a word (the activation of its phonology, orthography, meaning…) can be influenced by variables such as characteristics of the reader (e.g., country of origin) and characteristics of the task (e.g., stimuli language). These variables affect how active each of the languages of a bilingual is at any given time and within a particular context. Language non-selectivity refers to the simultaneous activation of the two (or more) languages of a bilingual.

Researchers have argued that the bilingual system is fundamentally language nonselective (Dimitropoulou et al., 2011; Kroll & Groot, 2005; Marian & Spivey, 2003), although the two languages of a bilingual are often activated to a different degree (Incera & McLennan, 2018b; Kroll & Groot, 2005). Furthermore, orthographic markedness –spelling characteristics associated to a particular language– can influence the extent to which a particular language is activated (Casaponsa et al., 2014; Commissaire, Audusseau, et al., 2019; van Kesteren et al., 2012). It is important to determine how stimuli language influences word recognition in bilingual children learning to read in two languages.

Differences in L2 proficiency modulate co-activation during lexical access (van Hell & Tanner, 2012). Higher proficiency in a language typically translates into higher levels of activation and automaticity. This indicates that children reading in their native language (e.g., children from USA reading in English) will have higher levels of activation than children reading in their second language (e.g., children from Spain reading in English). However, lower-proficiency languages can also capture attention due to the fact that participants have relatively less control –are less able to efficiently inhibit their second language (Hayakawa et al., 2020). It is important to determine how language dominance influences word recognition in bilingual children learning to read in two languages.

Pseudohomophones

Pseudohomophone effects refer to the distraction caused by nonwords that are pronounced like real words but are written differently. For instance, *dreem* is a pseudohomophone of the real English word *dream*. Underlying the pseudohomophone effect there is an orthography-phonology conflict (Briesemeister et al., 2009). The conflict emerges between the existence of phonological information that matches the real word and the lack of the orthographical information required to be the real word. Because of this conflict, the reader needs to ignore the real word activated through the phonology and focus on the incorrect orthography to appropriately conclude that the pseudohomophone is not a real word. The existence of pseudohomophone effects highlights the importance of phonology when reading silently. Researchers have found that pseudohomophone effects remain constant across different word lengths (Ziegler et al., 2001), a finding that points to the possibility of an orthographic verification mechanism playing a role in visual word recognition. This orthographic verification mechanism (Ziegler et al., 2001) might occur when readers process written words as a whole, thus being unaffected by the specific word length.

In bilinguals, phonological activation can be triggered by the orthography of the first (L1) or the second (L2) language of the reader. Thus, bilingual pseudohomophone effects can be within-languages (*troo* activates *true*) or between-languages (*tru* activates *true*). The Orthographic Depth Hypothesis (Katzt & Frostt, 1992) and the Psycholinguistic Grain Size Theory (Ziegler & Goswami, 2005) have been proposed as a way to describe these effects. The size of the processing units that readers rely on depends on linguistic characteristics. For instance, transparent orthographies like Spanish or German allow the processing of smaller units, since grapheme-to-phoneme correspondences are usually constant. However, due to the opaque nature of the English orthography, English readers are likely to rely more on bigger units, like whole syllables, rhymes, or even full words. The lexical processing of words reduces the pseudohomophone effect, as readers do not apply sublexical processing to decode the stimuli. Thus, pseudohomophone effects are likely to be stronger in transparent languages. Researchers reported pseudohomophone effects in a lexical decision task for German children but not for English children (Goswami et al., 2001). This is likely due to German being a more transparent language with more consistent grapheme-to-phoneme relations.

Researchers have reported significant pseudohomophone effects in developing bilingual readers (Commissaire, Duncan, et al., 2019; Sauval et al., 2017). Sauval and colleagues (2017) used a priming task and concluded that phonological representations are activated during bilingual reading as early as third grade. Furthermore, their data support the idea that the bilingual system is fundamentally language nonselective even in developing readers. Commissaire and colleagues (2019) replicated these findings using a lexical decision task. These authors reported that L2 learners automatically activate the phonology of both languages during L2 silent reading. Across different tasks, researchers have found pseudohomophone effects and language nonselective activation in developing bilingual readers.

In addition to characteristics of the language, characteristics of the reader (L1, L2) can influence the magnitude of the pseudohomophone effect (Commissaire, Duncan, et al., 2019; Hevia-Tuero et al., 2022). Hevia-Tuero and collaborators (2022) reported that Spanish children learning English in bilingual schools (with more oral exposure) are more distracted by English pseudohomophones than Spanish children learning English in monolingual schools. These results point to the conclusion that the pseudohomophone effect becomes larger as oral proficiency increases. Since phonological representations become stronger with experience, readers with very strong phonological representations are particularly distracted by pseudohomophones. In the present study we compare L1 (children from USA reading in English) and L2 (children from Spain reading in English) bilingual readers. We expect L1 readers to activate the phonology to a greater degree than L2 readers; thus, larger pseudohomophone effects in children from USA.

Interactive Activation

The Bilingual Interactive Activation model (Dijkstra et al., 1998) was created as a theoretical representation of how bilinguals process words. In the BIA model, language membership is represented with a language level: a language node. A revised version of the model, the Bilingual Interactive Activation Plus (BIA+), extends the old version by adding phonological and semantic lexical representations to the orthographic ones and by changing the role of the language nodes (Dijkstra & van Heuven, 2002). In the BIA+ model, language nodes are influenced by orthography and phonology, as well as context (e.g., the task influences the level of activation of each language).

According to BIA+, orthography and phonology can interact and alter the language nodes. This assumption is supported by research on language recognition (Vaid & Frenck-Mestre, 2002) and orthographic markedness (van Kesteren et al., 2012).

In bilingual readers, the orthography and phonology of a particular word can increase the activation of a specific language. The BIA+ model can account for effects within- and between-languages through the manipulation of resting-level activations of targets and neighbors (Lam & Dijkstra, 2010). In the present study, the language of the words and the phonology of the stimuli are in English, thus we expect English to be the most strongly activated language. However, the orthography of half of the pseudohomophones follows Spanish orthographical rules, allowing us to explore between-language orthographic influences.

The effect of language dominance on crosslinguistic effects is contemplated in the BIA+ model with the so-called temporal delay assumption. It refers to a delay in the activation of the second language (L2) when compared to the first language (L1). Even if bilingual processing is nonselective, different degrees of activation of each language lead to differences during word processing. Research has shown that within-language interference has a bigger impact than between-language interference (Dyer, 1971; Incera & McLennan, 2018b; MacLeod, 1991; Marian & Spivey, 2003), as the degree of activation of the target language is larger. Incera and M^c^Lennan (2018b) observed that between-language interference emerges later than within-language interference. Thus, the weaker language (i.e., nondominant language for the reader, non-target language in the task) is less activated, takes more time to be processed, and causes less interference.

Another extension of the bilingual interactive-activation model is the BIA-d that considers these processes from a developmental perspective (Grainger et al., 2010). The BIA-d combines an initial language non-selective mechanism with emergent inhibitory control mechanisms that limit cross-language interference. Determining when and how these inhibitory control mechanisms emerge in bilingual readers is an important empirical question. More recently, the Multilink model (Dijkstra et al., 2019) has been proposed as a localist-connectionist model that integrates the basic assumptions of previous models.

The present investigation focuses on elementary school children that are simultaneous bilinguals. Even though bilingual children are likely to have a dominant language (i.e., the majority language spoken in their corresponding countries), their situation is unique because they are learning to read simultaneously in both languages. These children speak both languages in school before they start learning how to read. Their reading acquisition process is likely to be influenced by the demands that require to keep two systems in mind at the same time. This is an important reason to focus on a young sample of bilingual children who are in the process of learning to read in two languages. While investigating young children has its own set of difficulties (e.g., tasks need to be shorter) we believe it is important to explore the early stages of reading acquisition and the emergence of these effects. Researchers have found that reading strategies in second language are strongly influenced by experiences in first language (Bhide, 2015). In line with this idea, simultaneous bilinguals might need to spend extra time learning how to differentiate between the rules of each language. The challenge of connecting a single grapheme to different phonemes (a common situation in opaque languages like English) might be particularly difficult for readers of transparent languages like Spanish.

Researchers have used the mouse-tracking paradigm to investigate bilingual processing (Bartolotti & Marian, 2012; Incera & McLennan, 2018b, 2018a). In the next section we describe this methodological innovation and discuss how the way in which participants move their computer mouse can shed light on the questions discussed above.

Mouse Tracking

A strength of the present experiment is that participants' responses are collected using the mouse-tracking paradigm (Freeman & Ambady, 2010; Spivey et al., 2005). The advantage of using mouse tracking is that –in addition to accuracy and reaction times– computer mouse movements are recorded over time. Mouse tracking was first introduced by Spivey and collaborators (2005), who reported that participants respond to words with control competitors (candle/jacket) with straighter mouse trajectories than to words with phonological competitors (candle/candy). In this spoken word recognition task, participants took more time to move towards the correct response "candle" when the alternative response was a phonological competitor "candy." Soon after this initial investigation, the introduction of the open source software MouseTracker (Freeman & Ambady, 2010) resulted in an explosion of research using the mouse-tracking paradigm.

Mouse tracking is particularly useful to explore the timing of the cognitive processes underlying participants' responses to linguistic tasks. For example, researchers have used mouse tracking to determine that conceptual representations influence participants 60 milliseconds earlier than grammatical information (Incera et al., 2018). Furthermore, implementing the mouse-tracking paradigm with a sample of bilingual participants, researchers have found that within-language interference influences participants 80 milliseconds earlier than between-language interference (Incera & McLennan, 2018b). In this bilingual activation study by Incera and McLennan, English-Spanish bilinguals responded to a Stroop task where the stimuli language was either congruent (English) or incongruent (Spanish) with the language in the response options (English). The results of this investigation indicated that participants mouse trajectories deviated 80 milliseconds earlier towards the incorrect response in the within (BLUE) than in the between (AZUL) language incongruent condition (Incera & McLennan, 2018b). Researchers using mouse-tracking data have also concluded that bilinguals overcome competitor interference by increasing the activation of target items (Bartolotti & Marian, 2012).

More recently researchers have used the mouse-tracking paradigm to investigate reading processes in bilingual children (Hevia-Tuero et al., 2021, 2022). Using a letter detection task, Hevia-Tuero and collaborators observed that mouse trajectories are more efficient when children identify simple than complex graphemes (Hevia-Tuero et al., 2021). Using a lexical decision task, researchers observed that mouse trajectories are more efficient for children enrolled in bilingual than monolingual schools (Hevia-Tuero et al., 2022). The present study expands on previous mouse-tracking research by exploring how bilingual children from USA (for whom English is their L1) respond to pseudohomophones in relation to the responses of bilingual children from Spain (for whom English is their L2). Using the mouse tracking paradigm to determine how country of origin and stimuli language influence visual word recognition in bilingual children is an approach that is likely to result in novel insights with important implications for models of bilingual word recognition.

The present study

In the present study we used a lexical decision task with English and Spanish pseudohomophones that sound like English words (see Appendix). English and Spanish pseudohomophones were created by manipulating real English words. To do so, the phonological representation of each word was transcribed with an alternative spelling following English and Spanish orthographic rules. The new spellings were piloted by native English and Spanish speakers. While in Spanish there are only five vowels, in English there are over 15 different vowel sounds. We manipulated the orthography in the following ways: “ee” became “i” in Spanish and “ea” in English, “ea” became “i” in

Spanish and "ee" in English, "ue" became "u" in Spanish and "oo" in English, "a" became "ei" in Spanish and "ai" in English. In order to respect the orthographic rules of each language, certain consonants had to be modified as well, as some phonemes do not have a grapheme representation in Spanish. Therefore, the closest grapheme available was used (for instance, *jeans* and *yins*). The rationale behind these manipulations is that, using analysis of errors (Cronnell, 1985; Fashola et al., 1996; Howard et al., 2012; Moore & Marzano, 1979; Sun-Alperin & Wang, 2008), researchers have identified these changes as common spelling mistakes that emerge when analyzing writing samples from English-Spanish bilinguals.

We determined the role of *country of origin* by comparing Spanish-English bilinguals from Spain and English-Spanish bilinguals from USA. While both groups of children attend bilingual schools, the underlying assumption is that children from Spain are more proficient in Spanish and children from USA are more proficient in English. We argue that children who live in a country where the majority language is English are likely to be more proficient in English than children who live in a country where the majority language is Spanish. Given that the task is in English, we predict that children from USA will outperform children from Spain (see below Prediction 1: Main Effect of Country).

We determined the role of *stimuli language* by comparing English pseudohomophones (within-language interference) and Spanish pseudohomophones (between-language interference) in a task with English words as the target. The key difference between the Spanish and the English pseudohomophones is whether the stimuli followed Spanish (e.g., *tru*) or English (e.g., *troo*) orthographical rules. In line with the temporal delay assumption of the BIA+ model, and the results of previous research (Incera & McLennan, 2018b), we expect within-language competition (*troo* activates *true*) to be stronger than between-language competition (*tru* activates *true*). Thus, English pseudohomophones will be more distracting than Spanish pseudohomophones (see below Prediction 2: Main Effect of Language).

When considering the *combined effects* of the reader and the stimuli, it is possible to visualize at least two different scenarios. On the one hand, if the reader is the most important influence, Spanish pseudohomophones (dominant language) should distract children from Spain to a larger degree than English pseudohomophones (Prediction 3A). Alternative, if the stimuli language is the most important influence, English pseudohomophones (within-language interference) should distract all children more, even those from Spain (see below Prediction 3B: Country by Language Interaction).

Predictions

1. Main Effect of Country: Given that the task is in English, children from USA (English dominant) will outperform children from Spain (Spanish dominant).
2. Main Effect of Language: Given that the task is in English, English pseudohomophones (within-language interference) will be more distracting than Spanish pseudohomophones (between-language interference).
3. Country by Language Interaction:

    Children from USA…

        Will be more distracted by English than Spanish pseudohomophones (for this group both country of origin and stimuli language activate English).

    Children from Spain…

a. Will be more distracted by Spanish than English pseudohomophones if *country of origin* is most important (for this group country of origin activates Spanish).
b. Will be more distracted by English than Spanish pseudohomophones if *stimuli language* is most important (for both groups stimuli language activates English).

Method

Participants

The sample included 156 children (78 from Spain and 78 from the United States) between 7 and 11 years old (M_{age} = 9.38; SD_{age} = 1.20). The children from Spain (M = 9.38, SD = 1.43) and USA (M = 9.38, SD = 0.91) were carefully matched in age (t = 0.01, p = .991). Participants were recruited from two English/Spanish bilingual Elementary schools. The Spanish school is in [Blind Version], while the USA school is in [Blind Version]. Lessons in both schools are taught 50% of the time in Spanish and 50% of the time in English by native teachers. Most families whose children attend these bilingual schools are native speakers of the dominant language of the country (Spanish for the [Blind Version] and English for the [Blind Version]). Learning a second language is an important skill in an increasingly globalized world; thus, many parents who are not bilingual themselves are still invested in ensuring that their children are able to speak other languages. None of the participants (84 males, 72 females) had cognitive or behavioral impairments.

Materials

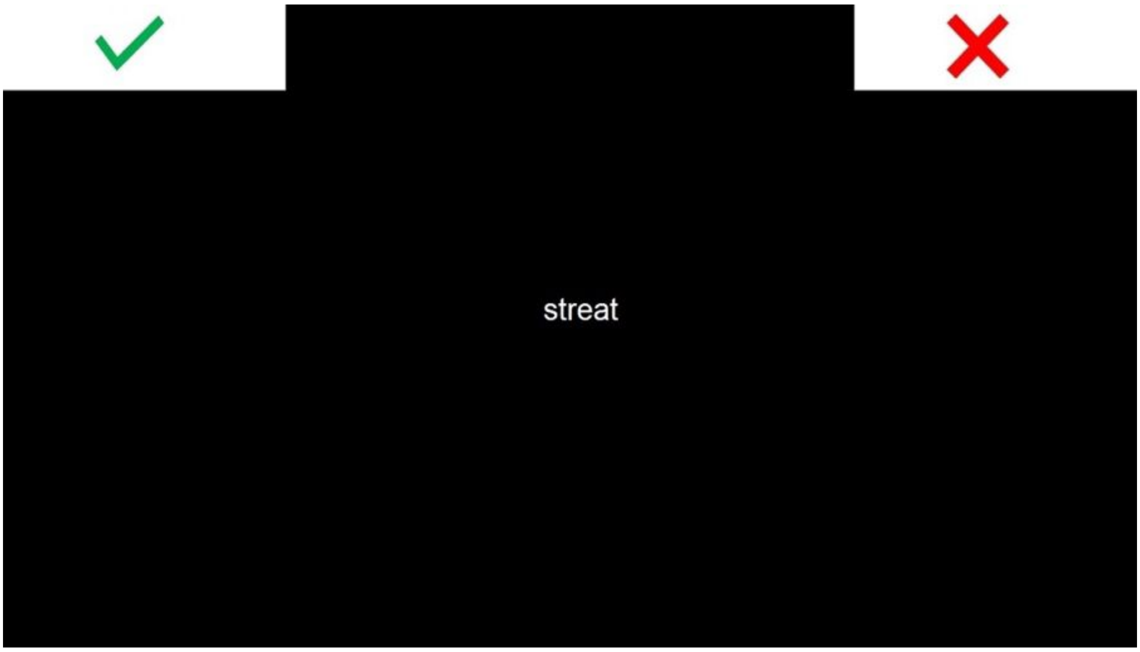
We used the same materials as [Blind Version]. There was a total of 108 stimuli (see Appendix) with 24 target words, 24 Spanish pseudohomophones, 24 English pseudohomophones, 24 illegal nonwords, and 12 filler words. We used illegal nonwords in this experiment even though most researchers use legal pseudowords. It is easier and faster to reject illegal nonwords than legal pseudowords because discrimination tends to be based on letter string legality, this approach makes the pseudohomophones look more similar to words. In the present study we selected illegal nonwords in order to induce more errors in the pseudohomophones.

The mean length was 4.54 (*SD* = 0.72) characters for words, and 4.26 (*SD* = 0.78) for pseudohomophones, while the mean frequency was 55,722 for words according to the Subtlex-UK database (van Heuven et al., 2014). For every word (e.g., *true*) we created two different pseudohomophones: one whose transcription followed Spanish orthographical rules (e.g., *tru*), and one whose transcription followed English orthographical rules (e.g., *troo*). Researchers analyzing errors (Howard et al., 2012; Moore & Marzano, 1979) have identified these changes as common spelling errors that emerge when analyzing writing samples from English-Spanish bilinguals. The orthographical overlap –the number of equivalent graphemes between the pseudohomophone and the original word– was larger ($t = 2.07$, $p < .001$) for the English pseudohomophones ($M = 3.38$) than for the Spanish pseudohomophones ($M = 2.62$). This is to be expected given that the original words were in English and the English pseudohomophones were created to follow English orthographical rules. Furthermore, we added a condition with illegal nonwords created with the same graphemes as the words (e.g., *uetr*). These illegal nonwords were easy to discard because they violated the rules of both languages. The filler English words (12 in total) were included in order to have an equivalent number of words and nonwords in each version of the task (see Appendix).

To counterbalance the words across conditions it was necessary to create four different versions of the experiment. Each stimulus only appeared in one format (word, Spanish pseudohomophone, English pseudohomophone, illegal nonword) in each version of the experiment. The English filler words were the same across all versions of the experiment. We also counterbalanced the position of the response options. For half of the participants the correct response (green tick: ✓) was placed on the top left corner of the screen, while for the other half the correct response was placed on the top right corner of the screen (see Figure 1).

Figure 1

Participants' View of the Task.



Procedure

We followed the same procedure as [Blind Version]. The task was created with the computer software MouseTracker (Freeman & Ambady, 2010). Equivalent laptops were used to present the stimuli to the participants from both countries, who were asked to answer using a computer mouse. Participants were tested individually in their schools, and performance feedback was not provided. Testing took place in a room free of noise and distracting elements to ensure the accuracy of the results. Each participant was randomly assigned to one of the eight versions of the experiment (four versions to counterbalance the type of stimuli, each with two possible positions for the response options).

Before starting the lexical decision task, nonlinguistic trials (see Figure 2) were included as a baseline motor task to measure the basic response speed of the children. Previous research has highlighted the need of a baseline task when comparing different groups (Incera & McLennan, 2018a). After clicking the START button, participants had to click on a smiley face, which randomly appeared on the top left or right corners of the screen. Once the children completed the baseline task, the instructions for the lexical decision task appeared on the screen. At the beginning of the lexical decision task, six practice trials were presented in order to familiarize the children with the task. An example trial would proceed as follows: As soon as participants clicked START at the beginning of each trial, a string of letters (words or nonwords) was randomly displayed in the center of the screen. Children were told to click on one of the two response options (green tick ✓ for real words, red cross X for nonwords) as quickly and accurately as possible. The experimental protocol was approved by the Ethics Committee of Research of [Blind Version] and by the Institutional Review Board (IRB) at [Blind Version]. Informed consent was obtained from all participants.

Figure 2

Baseline Task with a Smiley Face.

Results

R-software (version 4.0.4) was used to run the mixed model analyses using the lme4 package (version 1.1-226) (Bates et al., 2015). We performed two separate analyses. The dependent variables in both analyses were number of errors, reaction times, and mouse trajectories (*x*-coordinates over time). First, we compared the two groups (children from Spain / USA) on words (including fillers to counterbalance yes/no answers) and nonwords (including pseudohomophones and illegal nonwords). The independent variables included in the first analysis were lexicality (word, nonword) and country (Spain, USA). The lexicality analysis was performed as a baseline to establish the paradigm and the task. Given the novelty of applying the mouse-tracking paradigm to pseudohomophone effects, we believe it is important to determine how children respond to the lexical decision task. Second, we compared the two groups (children from Spain / USA) on English and Spanish pseudohomophones. The independent variables included in the second analysis were condition (pseudohomophones following Spanish rules, pseudohomophones following English rules) and country (Spain, USA). The pseudohomophones analysis was performed to determine how phonology influences visual word recognition in bilingual children.

The random effects of participants and trials were included crossed in all models. Models were compared using the Chi Square test; only factors that significantly contributed to model fit –as determined by a significant *p* value in the Chi square test– were included in the final model. The estimate and standard error for each effect was reported for the factors included in the final model. Each participant responded to 36 trials across five different conditions (6 words, 6 English pseudohomophones, 6 Spanish pseudohomophones, 6 illegal nonwords, and 12 filler words) for a total of 5,616 observations. For the analyses of reaction times and mouse trajectories, we excluded incorrect responses (620 trials – 11% of total) and responses with reaction times over and under two standard deviations for each country/condition (see Table 1).

Table 1

Percentage of Trials per Group/Condition Excluded for the Reaction Times and Mouse Trajectories Analyses.

Country	Lexicality	Condition	Excluded
Spain	Words	Words	2.11%
		Filler words	2.00%
	Nonwords	Spanish	5.01%
		English	4.17%
		Illegal	2.86%
USA	Words	Words	2.15%
		Filler words	3.22%

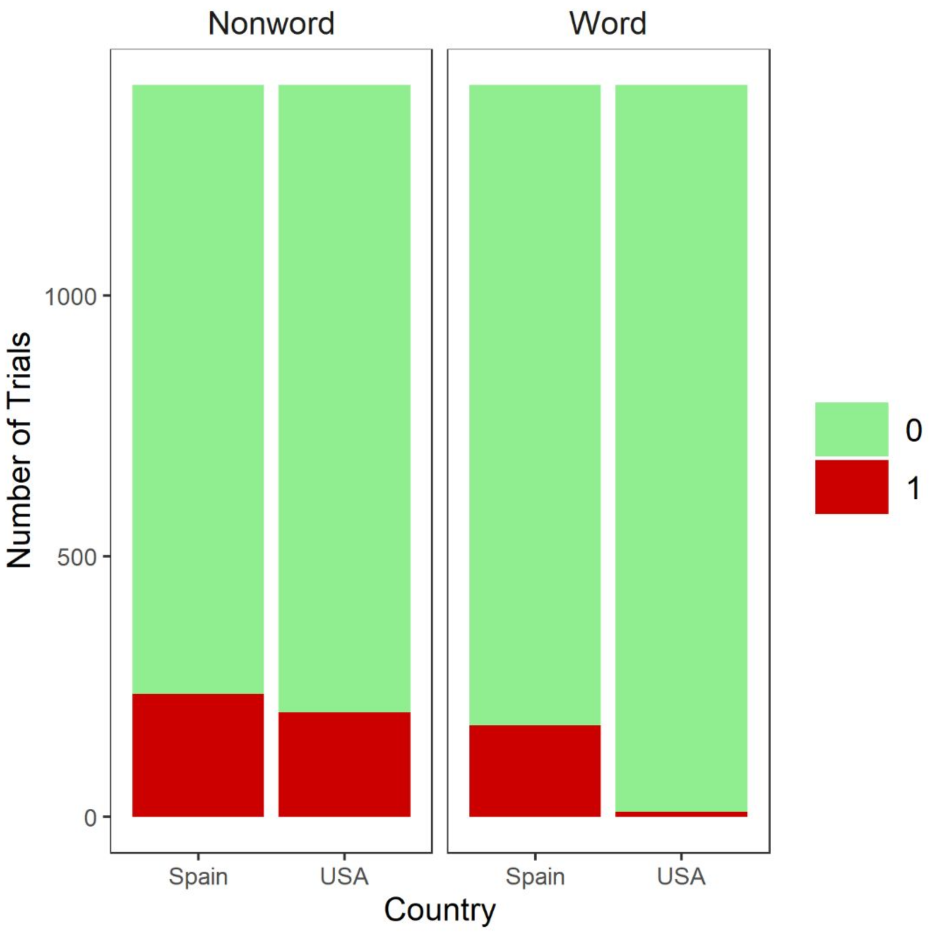
Nonwords	Spanish	2.08%
	English	4.27%
	Illegal	4.02%

Lexicality (Words and Nonwords)

In number of errors, model comparisons indicated that there was a main effect of Lexicality ($\chi^2_{(1)} = 9.88$, $p = .001$), a main effect of Country ($\chi^2_{(1)} = 23.59$, $p < .001$), and a Lexicality by Country interaction ($\chi^2_{(1)} = 72.01$, $p < .001$). The effect of Lexicality emerged (*Estimate* = -0.09, *SE* = 0.33) because children had more errors in nonwords (436/1808 - 24.11%) than words (184/1808 - 10.17%). The effect of Country emerged (*Estimate* = -0.41, *SE* = 0.21) because children from Spain (411/1808 - 22.73%) had more errors than children from USA (209/1808 - 11.55%). The Lexicality by Country interaction emerged (*Estimate* = -3.35, *SE* = 0.47) because children from USA did much better than children from Spain in words (9/1404 - 0.64% USA errors; 175/1404 - 12.46% Spain errors), but only slightly better in nonwords (200/1404 – 14.24% USA errors; 236/1404 - 16.81% Spain errors). Thus, the effect of country –children from USA outperforming children from Spain– was larger for words than nonwords. The interaction is driven by the fact that bilingual children from USA had virtually no errors when responding to English words (see Figure 3). In line with Prediction 1, children from USA had less errors than children from Spain.

Figure 3

Number of Right (Green) and Wrong (Red) Answers per Country (Spain, USA) for Words and Nonwords.



In reaction times, model comparisons indicated that there was a main effect of Lexicality ($\chi^2_{(1)} = 72.25$, $p < .001$) and a main effect of Country ($\chi^2_{(1)} = 53.87$, $p < .001$). However, the Lexicality by Country interaction did not emerge in reaction times ($\chi^2_{(1)} = 0.47$, $p = .492$). Overall, children took more than two seconds to respond (*Estimate* = 2,670 ms, *SE* = 67 ms). The Lexicality effect emerged because children responded 394 ms (*SE* = 40) faster to words than to nonwords. The Country effect emerged because children from USA responded 713 ms (*SE* = 89) faster than children from Spain (see Table 2). In line with Prediction 1, children from USA responded faster than children from Spain.

Table 2

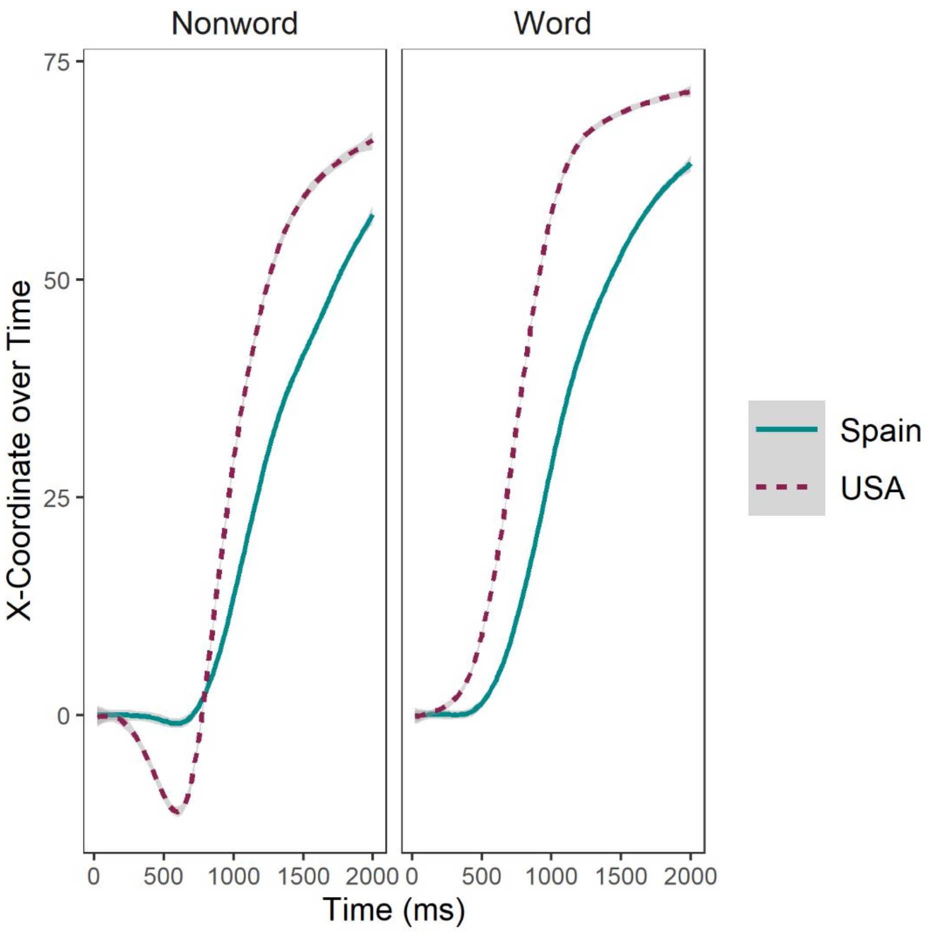
Mean (Standard Deviation) of the Reaction Times (in milliseconds) for Words and Nonwords for the Children in each Country

Lexicality	Country: Spain	Country: USA
Words	2196 (972)	1516 (432)
Nonwords	2558 (1096)	1928 (737)

In mouse trajectories, model comparisons indicated that there was a main effect of Lexicality ($\chi^2_{(1)} = 149.01$, $p < .001$), a main effect of Country ($\chi^2_{(1)} = 19.14$, $p < .001$) and a Lexicality by Country interaction ($\chi^2_{(3)} = 746.69$, $p < .001$). The effect of Lexicality emerged (*Estimate* = 3.05, *SE* = 0.13) because mouse trajectories were steeper (more efficient) for words than for nonwords. The effect of Country emerged because the slope of the mouse trajectory was steeper (more efficient) for children from USA (*Estimate* = 7.94, *SE* = 0.91) than children from Spain. Regarding the significant interaction (*Estimate* = -3.82, *SE* = 0.17), the effect of country –children from USA outperforming children from Spain– was larger for words than nonwords. In line with the analysis of errors, the interaction is driven by the fact that bilingual children from USA responded extremely efficiently to English words (see Figure 4). In line with Prediction 1, children from USA had steeper trajectories than children from Spain.

Figure 4

First Two Seconds of the Mouse Trajectories per Country (Spain, USA) for Words and Nonwords.



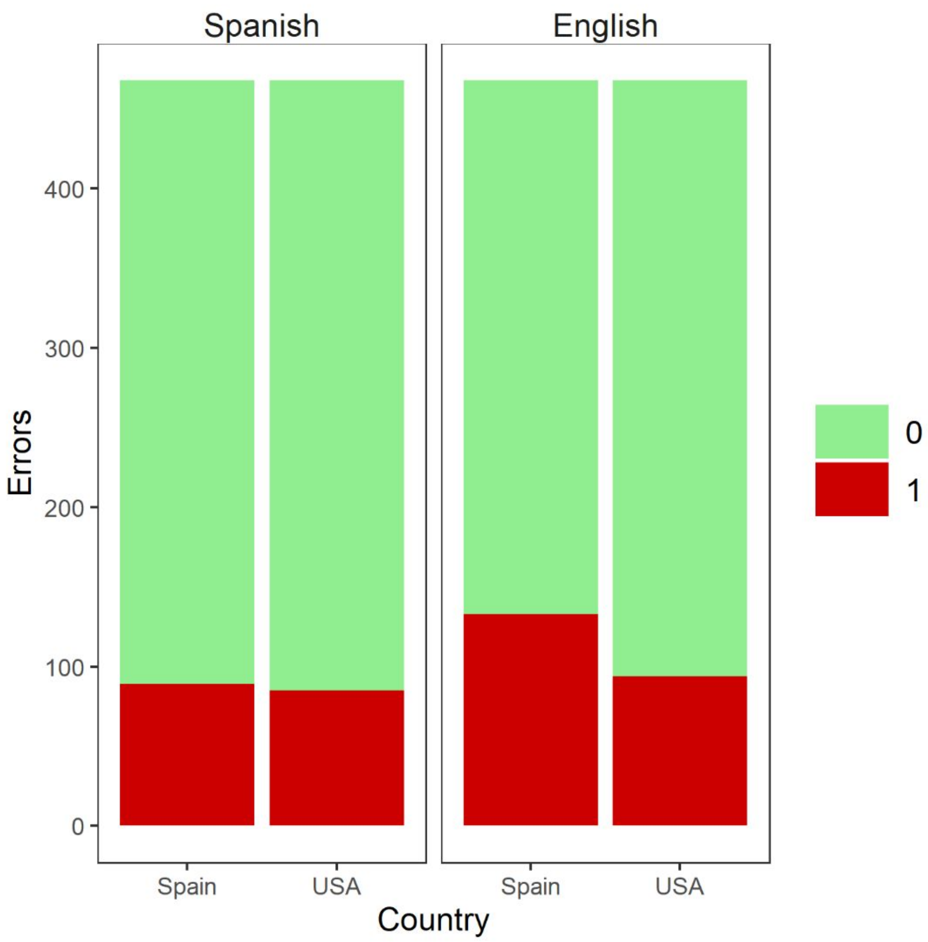
When observing Figure 4, it is possible to determine that children from both countries moved straight towards the correct response when responding to words. However, the pattern is different for nonwords. During the first 500 milliseconds of the mouse trajectory, children from USA had strong deviations towards the incorrect response. Later, they efficiently corrected these deviations moving towards the correct response at a much faster pace. This faster pace allowed children from USA to outperform the children from Spain within the first 1,000 milliseconds of the mouse trajectory.

Pseudohomophones (Spanish and English)

In number of errors, model comparisons indicated that there was a Pseudohomophones by Country interaction ($\chi^2_{(1)} = 12.69$, $p < .001$). However, the main effect of Pseudohomophones ($\chi^2_{(1)} = 2.03$, $p = .154$) and the main effect of Country ($\chi^2_{(1)} = 3.49$, $p = .061$) did not emerge. The Pseudohomophones by Country interaction emerged (*Estimate* = -1.13, *SE* = 0.31) because English pseudohomophones were particularly challenging to discard for children from Spain. Children from Spain had more errors in English pseudohomophones (133/468 – 28.41%) than in Spanish pseudohomophones (89/468 – 19.01%), while children from USA had similar number of errors in both English (94/468 – 20.08%) and Spanish (85/468 – 18. 16%) pseudohomophones (se Figure 5). The effect of country –children from USA outperforming children from Spain– emerged for English pseudohomophones but not for Spanish pseudohomophones. Children from Spain were able to discard Spanish pseudohomophones as efficiently as children from USA, but children from Spain had more difficulties discarding the English pseudohomophones. In line with Prediction 3B, children from Spain had more errors in English than Spanish pseudohomophones.

Figure 5

Number of Right (Green) and Wrong (Red) Answers per Country (Spain, USA) for Spanish and English Pseudohomophones.



In reaction times, model comparison indicated that there was a main effect of Country ($\chi^2_{(1)} = 27.06$, $p < .001$). However, the main effect of Pseudohomophones ($\chi^2_{(1)} = 3.70$, $p = .054$) and the Pseudohomophones by Country interaction did not emerge ($\chi^2_{(1)} = 0.12$, $p = 0.723$). Overall, children took more than two seconds to respond (*Estimate* = 2,671, *SE* = 89). The main effect of Country emerged because children from USA responded to pseudohomophones 613 ms (*SE* = 113) faster than children from Spain (see Table 3).[1] In line with Prediction 1, children from USA responded faster than children from Spain.

Table 3

Mean and Standard Deviations of the Reaction Times for Spanish and English Pseudohomophones for the Children in each Country.

Pseudohomophones	Country: Spain	Country: USA
Stimuli: Spanish	2558 (1084)	1991 (811)
Stimuli: English	2725 (1143)	2129 (812)

In mouse trajectories, model comparisons indicated that there was a main effect of Pseudohomophones ($\chi^2_{(1)} = 106.15$, $p < .001$), and a Pseudohomophones by Country interaction ($\chi^2_{(3)} = 101.70$, $p < .001$). The main effect of Country did not emerge. The effect of Pseudohomophones emerged (*Estimate* = -0.12, *SE* = 0.01) because mouse trajectories were steeper (more efficient) for Spanish than English pseudohomophones. Although the effect of Country was not significant, the Pseudohomophones by Country interaction emerged (*Estimate* = 1.10, *SE* = 0.01) because of a steeper slope in English pseudohomophones by children from USA (see Figure 6). In line with Prediction 2, English pseudohomophones were more distracting than Spanish pseudohomophones.

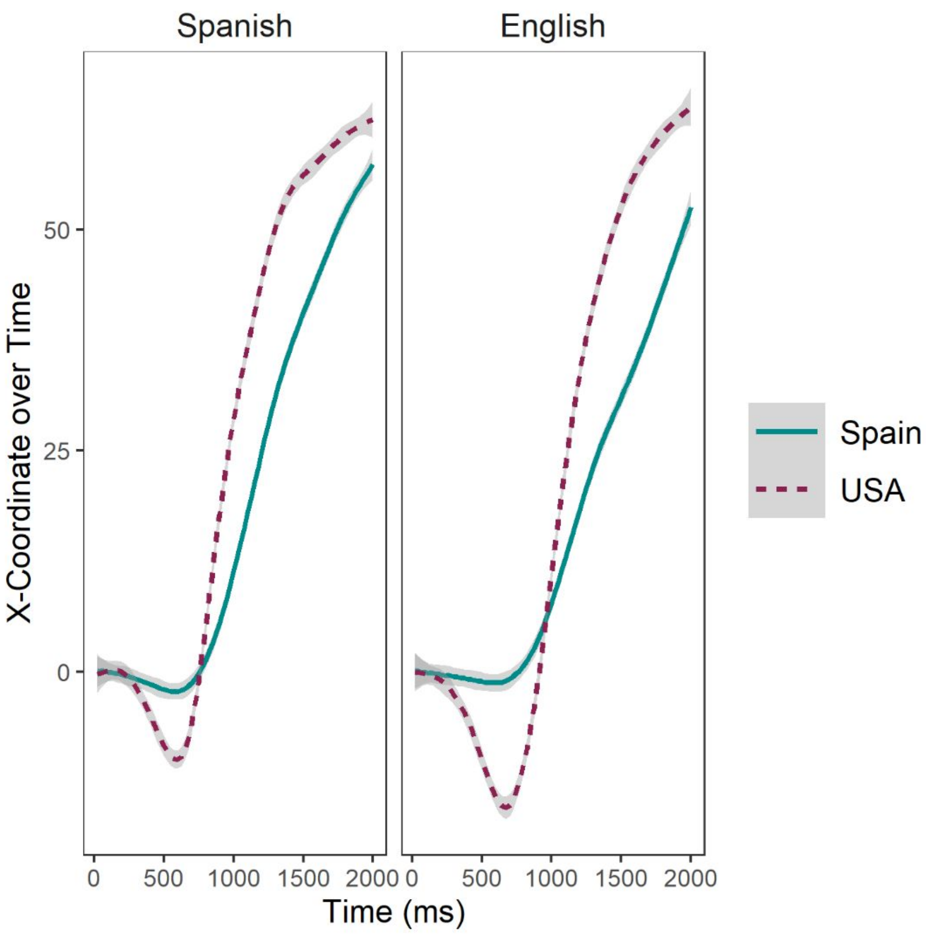
In line with the results of Figure 4 (see above), when exposed to pseudohomophones (that followed Spanish/English phonological rules) USA children deviated to a greater degree towards the incorrect response and then corrected their trajectory by moving faster towards the correct response than children from Spain (see

[1] While following convention *p* less than .05 was deemed non-significant, the curious reader might be interested in knowing that the difference between the Spanish and the English pseudohomophones (*p* = .054) corresponds to an estimate of 133 ms (SE = 65 ms).

Figure 6). This deviation was particularly pronounced for English pseudohomophones when compared to the Spanish pseudohomophones. While the deviation is strong for the children from USA (dotted line), upon close inspection of Figure 6 it is possible to observe a small deviation towards the incorrect response in the mouse trajectories of the children from Spain (solid line).

Figure 6

First Two Seconds of the Mouse Trajectories per Country (Spain, USA) for Spanish and English Pseudohomophones.



Taken together, these results indicate that (1) children from USA had less errors when responding to the English pseudohomophones, (2) children from USA were faster when responding to both Spanish and English pseudohomophones, and (3) the mouse trajectories of children from USA had a more pronounced deviation when responding to pseudohomophones. When exposed to both Spanish and English pseudohomophones, children from USA initially moved towards the incorrect response to a greater degree and later on corrected their mouse trajectory moving towards the correct response more efficiently. Even though children from USA outperformed children from Spain (they had less errors, responded faster, and their trajectories were steeper), when observing the beginning of their mouse trajectories (Figures 4 and 6), it is possible to observe that children from USA were more distracted by the pseudohomophones than children from Spain. When responding to pseudohomophones, children from USA were more attracted to the incorrect response at the beginning of the trajectory (likely due to a stronger activation of the English phonology of the real word) but were also faster and more efficient at moving towards the correct response at the end of the trajectory (likely due to a stronger activation of the English orthography of the real word).

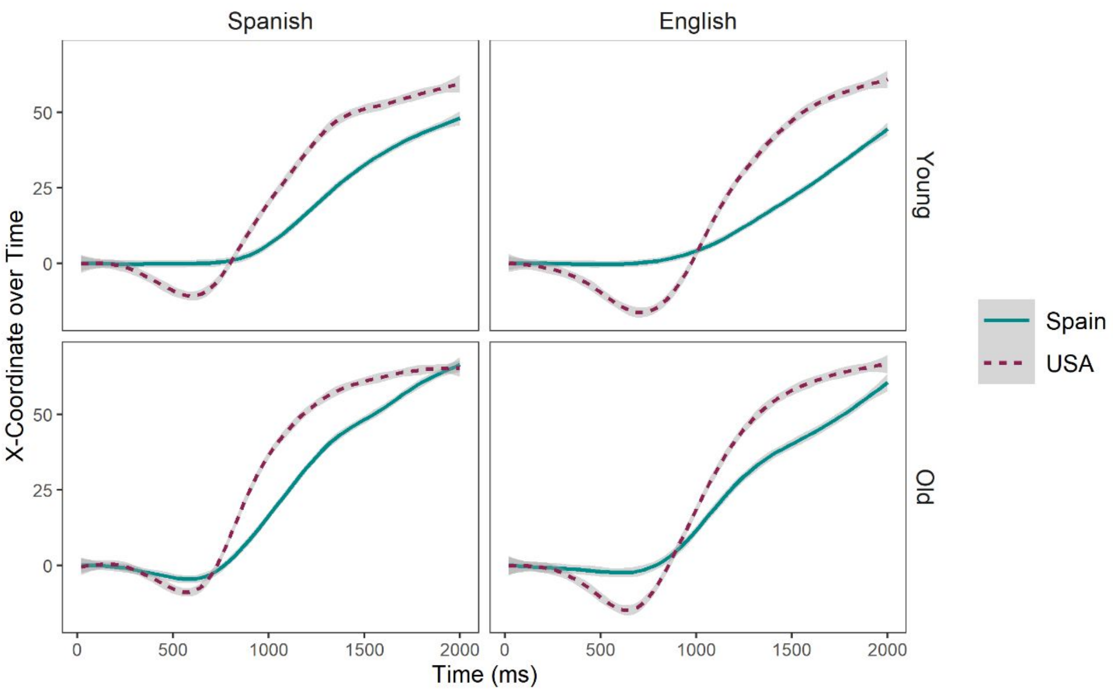
Exploratory Analyses (Age)

Given that numerous processes develop during the first few years of reading acquisition (Landerl et al., 2022; Sauval et al., 2017; Verhoeven & Perfetti, 2021), we performed an exploratory analysis to determine whether age (in our sample 7-11 years old) interacts with the pseudohomophone effect observed in the mouse trajectories. We included age as a continuous variable in the statistical model; however, we transformed age into a categorical variable (Young 7-9: n = 78, Old 10-11: n = 78) in order to visually represent these effects in Figure 7. In mouse trajectories, model comparisons indicated that there was a Pseudohomophones by Country by Age interaction ($\chi^2_{(7)}$ = 79.72, $p < .001$). The Pseudohomophones by Country by Age interaction emerged (*Estimate* = 1.50, *SE* = 0.04) because the pseudohomophone effect in the Spanish pseudohomophone condition was reduced for the older children from USA (see Figure

7 – bottom left quadrant). Children from USA showed larger pseudohomophone effects across conditions, but older children from USA were better at reducing this phonological activation in the Spanish pseudohomophone condition.

Figure 7

First Two Seconds of the Mouse Trajectories per Country (Spain, USA) for Spanish and English Pseudohomophones, for Young (7-9) and Old (10-11) children.



Discussion

It is important to highlight that all bilingual children were able to complete the task (in English) without difficulties. First, we analyzed the *lexicality*, the comparisons between words and nonwords. Bilingual children from both countries performed better with words than nonwords, and children from USA –who completed the task in their dominant language– performed better than children from Spain (Prediction 1). The lexicality effect –better performance for words than nonwords– emerged in both groups of children. The fact that this effect emerged in the group of children from Spain is important. Even though the Spanish group was overall less efficient at processing English, they were still better at recognizing English words than at discarding nonwords. Differences between countries were especially large in words because children from USA performed extremely well when recognizing English words. These results provide additional evidence that the English-Spanish bilinguals from USA were dominant in English, and the Spanish-English bilinguals from Spain were dominant in Spanish.

Second, we analyzed the *pseudohomophones*, the comparisons between the pseudohomophones that followed Spanish and English orthographical rules. Both types of pseudohomophones activated the same phonology –the phonology of the English word (e.g., *true*)– but each type of pseudohomophone activated a different orthography. Children discarded the between-language pseudohomophones that followed the Spanish orthography (e.g., *tru*) more efficiently than the within-language pseudohomophones that followed the English orthography (e.g., *troo*). The fact that even the children from Spain were more distracted by the English (within) than the Spanish (between) pseudohomophones, highlights the powerful effect of stimuli language (within-language interference) when processing orthography (Prediction 2).

For the Spanish children, the within-language orthographic interference was stronger than the influence of their own dominant language (Prediction 3B). We had predicted two alternative possibilities for the results of the children from Spain. First, Spanish pseudohomophones could be more distracting if country of origin (language dominance) was most important for performance (Hypothesis 3A). Second, English pseudohomophones could be more distracting if stimuli language (within-language interference) was most important for performance (Hypothesis 3B). Our results support Hypothesis 3B, the language of the stimuli seems to be more relevant than the dominant language of the child. These results show that within-language orthographic interference is stronger than between-language orthographic interference independently of the dominant language of the reader. Our results indicate that the language of the stimuli has a stronger influence on participants' orthographic processing than country of origin.

There are different possibilities that can explain why all children found the English pseudohomophones more challenging to process than the Spanish pseudohomophones. First, this effect might be due to the fact that the English pseudohomophones had a larger orthographical overlap with the real English words than the Spanish pseudohomophones. This confound is by design, the original words were in English so the English pseudohomophones were created to follow English orthographical rules. Second, it is possible that all children were in English mode, given that the target words were in English. Having English strongly activated might make rejecting English pseudohomophones particularly difficult. Third, it is possible that the English pseudohomophones are more problematic for all participants because of the spelling characteristics of the language (e.g., more complex graphemes). Fourth, it is possible that the fact that the English language is less transparent made the English pseudohomophones more difficult to process for all children. While performing the same task in Spanish could help tease apart some of these possibilities, it is not possible to create within-languages Spanish pseudohomophones that follow Spanish orthographic rules. Spanish is a very transparent language, so words are already written following the phonology. Future studies should test these possibilities using other languages, in order to better tease apart the specific mechanisms at the root of these effects.

Even though –across almost every measure– the children from USA outperformed the children from Spain, it is important to note that when responding to pseudohomophones their mouse trajectories showed a different pattern. Specifically, children from USA had stronger initial deviations towards the incorrect response (moving towards the green tick/word ✓ when initially seeing "*troo*") and efficient corrective movements towards the right response (moving towards the red cross/nonword X soon after seeing "*troo*"). These corrective movements were so efficient that the children from USA outperformed the children from Spain in the second half of the mouse trajectory, despite their initial deviation in the wrong direction. Children from USA showed a pronounced deviation towards the incorrect response (likely due to a strong activation of the phonology of the real English word) followed by a very effective corrective movement (likely due to an orthographic verification mechanism). Despite the initial deviation, children from USA quickly overturned their movement and eventually outperformed the children from Spain (see Figure 6).

An important innovation of the present investigation is that using the mouse-tracking paradigm we observed a different pattern of responses between the children from USA and Spain. Specifically, the children for whom English was their dominant language had stronger phonological activation at the beginning of the mouse trajectory followed by a stronger orthographical correction at the end of the mouse trajectory. Studies that only record end-point measures (e.g., errors, reaction times) might be missing these nuanced effects. Different processes (phonology, orthography) seem to influence the mouse trajectories at different points in time. While by the end of the trajectory children from USA clearly outperformed children from Spain, during the unfolding of their responses the pattern was different. Language dominance resulted in both, a stronger phonological activation (more deviation toward the incorrect response at the beginning of the mouse trajectory) and a stronger orthographical activation (faster movements towards the correct response at the end of the mouse trajectory). The timing of the cognitive processes at play when recognizing pseudohomophones are likely to inform models of bilingual word recognition.

The "crossing" of the mouse trajectories (see Figure 6) indicates that the children from USA are engaging in different cognitive processes than the children from Spain. Previous mouse-tracking research has shown similar trade-off patterns. In a Stroop task, bilingual participants took longer to begin moving the mouse but then moved more efficiently towards the correct response than monolingual participants (Incera & McLennan, 2016). We argue that, when responding to pseudohomophones, the deviation in the mouse trajectories is due to the fact that children from USA activate the phonology of the English words to a larger degree than children from Spain. The activation of the phonology initially makes them move towards the incorrect response, but soon after they correct their mistake. Despite the initial deviation, children from USA are much more efficient at recognizing English words than children from Spain.

Support for the idea that children from USA are activating the English phonology in the pseudohomophone condition emerges from the fact that the deviation does not appear in words, and that the effect is more pronounced in English pseudohomophones (within-language interference) than Spanish pseudohomophones (between-language interference). Importantly, these effects are not due to motor movement artifacts because equivalent patterns of results emerged for the versions of the task with the green tick on the top right and left corners of the screen. Taken together, these results point to the idea that the pronounced deviation in the mouse trajectory that emerges when children from USA are responding to pseudohomophones, is due to the stronger activation of the phonology of the English words. Thus, higher levels of English proficiency results in increased activation of English phonology.

Using mouse tracking it is possible to observe the strength of this phonological activation.

In the exploratory analysis we performed to determine the effect age (see Figure 7), we observed that the older children from USA had a reduced pseudohomophone effect in the Spanish condition[2], while the effect of the Spanish pseudohomophones was strong in the younger children from USA. In bilingual reading, the inhibitory mechanism discussed in the BIA-d model (Grainger et al., 2010), the orthographical activation of the target language (or the orthographical inhibition of the second language), might be emerging around 10 years old. In line with the results of Hayakawa and colleagues (2020) the lower-proficiency language can capture attention due to the fact that participants have relatively less control –are less able to efficiently inhibit their second language. In our study, the younger children from USA were less able to inhibit the Spanish orthography than their older counterparts. Future studies should explore these developmental effects in more detail.

Ziegler and colleagues (2001) discussed the possibility of an orthographic verification mechanism playing a role in word reading. The corrective movement that children from USA perform soon after deviating towards the incorrect response supports the existence of this orthographic mechanism. Furthermore, the fact that the deviation in the mouse trajectory for the children from USA is less pronounced for the Spanish than the English pseudohomophones supports the idea that this orthographic verification mechanism is faster between- than within-languages (likely due to a weaker activation of the other language). It is easier to discard *tru* than *troo* as a nonword when the target words are in English. It is possible that the "turn of the trajectory" – the

[2] It is also possible that the difference between the older children from Spain and the older children from USA in the Spanish pseudohomophone condition was reduced because the pseudohomophones that followed the Spanish orthography influenced the older children from Spain to a larger degree.

moment at which the children from USA move from incorrectly going towards the green tick ✓ to correctly going towards the red cross X – is the moment at which this verification mechanism takes place. If so, future studies could develop specific tasks targeted to test this orthographic mechanism and see whether the magnitude and timing of the turning point can be altered as a result of experimental manipulations.

A limitation of the present study is that the number of trials was relatively low. Even though we had a good sample size (156 children) a higher number of trials per condition would have been beneficial. When doing research with children is necessary to balance statistical power with practical concerns. More trials are always better from a statistical point of view, but long studies are difficult to execute when working with young children. Children (in our study we recruited children as young as seven years old) can get tired if the study is too long. In addition, to collect these data we had to take the children out of their classrooms, so taking too much time would be challenging. While studies with young children are necessary to establish the developmental patterns of literacy acquisition, future studies should investigate the reliability of these patterns by using longer tasks with older children.

Another limitation of the study refers to the characteristics of the stimuli. We created the stimuli by identifying common spelling errors that emerge when analyzing writing samples from English-Spanish bilinguals. However, this approach (an emphasis on external as opposed to internal validity) resulted in pseudohomophones that were not matched on English bigram frequency. Future studies should carefully control the characteristics of the stimuli (e.g., create pseudohomophones that allow for a dissociation between orthographic and phonological influences) in order to determine what influences the pseudohomophone effect. In the current investigation it is difficult to distinguish between phonological and orthographical influences at the stimuli level, instead, we make this distinction by comparing the response patterns of different populations (bilinguals from Spain, bilinguals from USA).

As discussed in the Introduction, researchers have reported that Spanish children in a monolingual school were less distracted by the English pseudohomophones than Spanish children in a bilingual school (Hevia-Tuero et al., 2022). In the monolingual school much of the instruction occurs with written materials so children are less exposed to oral English (weaker phonological representations of English words). In the bilingual school much of the instruction is provided by native speakers so children are more exposed to oral English (stronger phonological representations of English words). These results point to the conclusion that phonological representations are driving the pseudohomophone effect. In this study, we found that children from USA are more distracted at first but outperformed Spanish children soon after that. Taken together, these findings point to the conclusion that phonological activation is influencing the beginning of the mouse trajectory, while orthographic activation is influencing the later parts of the mouse trajectory. This nuanced argument can be made thanks to the use of the mouse-tracking paradigm, that allows researchers to explore how different factors (phonology, orthography) influence participants responses at different points in time.

Future studies should measure the characteristics of the bilingual children included in the sample because bilingualism is a complex construct composed of multiple related dimensions (Luk & Biaylstok, 2013). Variables like age of language acquisition, amount of exposure to each language, and current proficiency, are likely to play a role in visual word recognition. Our experience with these bilingual schools, and the results of the lexical decision task, support the idea that the bilingual children residing in the USA are more proficient in English and the bilingual children residing in Spain are more proficient in Spanish. However, it is important to consider the possibility of a few children in each sample deviating from this norm. It is likely that there is a range of dominance profiles in both groups, with some children in Spain or USA falling into a balanced profile. Bilingualism is a complex construct that needs to be properly quantified.

In conclusion, this study determined how country of origin and stimuli language influence visual word recognition in bilingual children. First, stimuli language (within-language interference) determined children's processing of pseudohomophones to a greater extent than country of origin. Second, being dominant in the task language (children from USA answering in English) made the effects stronger. Third, the country of origin and the stimuli language interacted as children from USA were extremely efficient at processing English words and particularly distracted by the English pseudohomophones. The mouse trajectories exposed an interesting pattern of results; children from USA showed a pronounced deviation towards the incorrect response early in the trajectory (likely due to a strong activation of the phonology of the real English word) followed by a very effective corrective movement (likely due to an orthographic verification mechanism). These findings indicate that orthography is closely connected to the activation of a particular language since a relatively early age. Models of bilingual reading need to consider the impact of phonology and orthography, as well as the timing of these effects.

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Appendix: Stimuli

Words	Spanish rules	English rules	Illegal	Fillers
cheese	chis	chease	echsee	end
feel	fil	feal	eefl	film
free	fri	frea	eerf	fish
green	grin*	grean	nrgee	dog
keep	kip	keap	eekp	fast
need	nid	nead	eedn	park
street	estrit	streat	tsrtee	car
clean	clin	cleen	nlcea	song
dream	drim	dreem	mrdea	sand
jeans	yins	jeens	snjea	lamp
lead	lid*	leed	ldea	pink
mean	min	meen	nmae	work
please	plis	pleese	plseae	
read	rid*	reed	rdae	
speak	espik	speek	pksea	
team	tim	teem	tmea	
blue	blu	bloo	uebl	
clue	clu	cloo	uecl	
glue	glu	gloo	uegl	
true	tru	troo	uetr	
cake	keik	caik	kcae	
shape	seip	shaep	aepsh	
snake	esneik	sneik	aekns	
take	teik	taik	tkea	

*A limitation of this list of stimuli is that three of the Spanish pseudohomophones are in fact real English words. Future experiments should not consider these stimuli as nonwords. A reanalysis of the data after excluding these three stimuli yielded the same results/conclusions as the analyses reported in the Results/Discussion sections.

Estudio IV

Reading and Writing
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Spelling errors by Spanish children when writing in English as a foreign language

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Abstract

English orthography differs from that of other European languages in terms of complexity and regularity. This difference may impact the development of accurate spelling in English, especially when it is learned as a foreign language in school. In this study we wanted to explore spelling development patterns of Spanish speaking children learning English at school. To do so, we analyzed spelling errors from a free narrative task from 136 children in fourth, fifth and sixth grades. We classified errors following a two-level procedure based on the Triple Word Form theory (Phonology, Orthography and Morphology) and the POMAS (Phonological, Orthographic, and Morphological Assessment of Spelling) system. While results showed almost no change in accuracy across grades, there was evidence of more errors related to orthography as compared to phonology and morphology. This points to an incomplete knowledge of English orthography. This study sheds light on the spelling development of foreign language learners, and illustrates the interference that the native language may have when the two orthographies of the speller are linguistically distant. Considering the findings, educational implications to improve foreign language spelling instruction at school are offered.

Keywords Spanish · English · EFL · Spelling · Writing

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Introduction

English is used as a lingua franca in many places (MacKenzie, 2014). It is one of the most common additional languages to be learned in many countries around the world, including Spain (Council of Europe, 2001). And yet, children face a challenge when they learn it as a foreign language, partly because of English orthographic depth and inconsistency. Consistency refers to how regular grapheme-phoneme and phoneme-grapheme translation rules are (Alegría & Carrillo, 2014). Orthographic depth is the extent to which the orthography is a phonetic representation of speech (Katz & Feldman, 2017). The more complex and unpredictable an orthographic system is, the less reliable its print-to-sound correspondences are (De Simone et al., 2021; Schmalz et al., 2015). In the case of English, the orthography differs from that of many other European languages (like Italian or Spanish) in terms of syllable complexity and orthographic regularity (Seymour et al., 2003). For instance, Spanish orthography is transparent and highly consistent, as it is characterized by one-to-one correspondences between graphemes and phonemes (with few exceptions). English orthography is more opaque, as more than one grapheme corresponds to a single phoneme (e.g., /i/ can be spelled *ee* like in *see*, or *ea* like in *sea*). Additionally, graphemes can represent different phonemes depending on the orthographic context (e.g., *th* may represent /ð/ like in *brother*, or /θ/ like in *thing*). The depth of the English orthography also influences other linguistic aspects, apart from grapheme-phoneme correspondences. Some spellings preserve their morphological identity at the expense of phoneme-grapheme consistency (Chomsky & Halle, 1968; Cummings, 1988), as in the case of *sign* and *signature*, which exemplifies how the appearance of the root morpheme is conserved (it is also spelled with *i*), despite different pronunciation (/aɪ/ in *sign*, and /ɪ/ in *signature*). Moreover, not only the pronunciation of the vowel varies, but also that of the consonant (/g/ in *signature*). Additional examples of this double inconsistency in pronunciation (despite preserving the same root morpheme) include *signal (/sɪgnəl/)* and *design (/dɪzaɪn/)*.

These differences between languages may have an influence on decoding strategies used by foreign language learners (Bhide, 2015; Rau et al., 2015; Ziegler & Goswami, 2005), and may also impact spelling (Watcharapunyawong & Usaha, 2013). The aim of this study was to explore the characteristics of the spelling errors that Spanish children produce in English when it is learned as a foreign language in order to understand the strategies that children rely on, and the effect that a native language background from a script with a transparent orthography may have on English spelling development.

Spelling

Spelling is a cognitive process fundamental to writing (Bourassa & Treiman, 2009). Solid orthographic retrieval skills (that is, being a good speller) allows more cognitive resources to be dedicated to other processes of writing (McMurray, 2006). During spelling acquisition, children rely on different types of information, and different skills support the spelling process. At first, phonological skills are one of the most relevant, especially phonological awareness and knowledge of phoneme-to-grapheme correspondences (Blachman, 2000; Ziegler & Goswami, 2005). Novel words are decoded through a sublexical route by applying these phoneme-to-grapheme correspondences (Coltheart et al., 2001). This demonstrates how important phonology is for literacy acquisition. But it is not a fully efficient route, and it is not sufficient for processing words with an irregular orthographic form (Moats, 2010, 2016). Since sublexical processing is serial, applying phoneme-grapheme correspondences takes time and cognitive resources. The retrieval of a word is faster once its orthographic representation is stored in the lexicon, especially for long or irregular words (Barton et al, 2014). Thus, strong orthographic representations for words is essential to save cognitive resources, which can then be dedicated to other processes, like semantic or syntactic processing. Moreover, advanced orthographic skills are required in languages with complex orthographies like English, for example, grasping which letter sequences are legal or illegal, comprehending context-dependent spelling, and processing different patterns like digraphs and clusters (Cassar & Treiman, 1997). Lastly, morphological awareness is also relevant (Carlisle, 2000; Carlisle & Feldman, 1995). Morphology is a source of valuable information for correct spelling, especially for English due to its depth (Chomsky & Halle, 1968) and its morphophonemic orthography (Nunes et al., 2006; Venezky, 1999, 2011). For instance, pronunciation of certain graphemes in base words may change after inflection or derivation (*magic, magician*), but knowing the forms (suffixes) facilitates spelling (Bourassa & Treiman, 2008; Garcia et al., 2010).

Triple word form theory

Three linguistic elements (phonology, orthography, and morphology) comprise the Triple Word Form theory (Bahr et al., 2009; Berninger et al., 2009; Garcia et al., 2010). According to this theory, these three types of knowledge about spelling and word structure are stored and coordinated with each other in order to construct the written form of language. The interrelationship between sounds (phonology) and letters (orthography), and the relationships between base words and affixes (morphology) contribute to spelling. Studies focused on the analysis of spelling errors reveal how children rely on these sources of knowledge along with the processes that they activate during spelling (Bahr et al., 2009; Garcia et al., 2010). They also shed light on the non-linearity of spelling development since error patterns change across grades. For instance, Bahr and colleagues (2012) found a shift in linguistic error distribution. While phonological errors were more frequent than morphological errors among younger children, they found an increase of morphological errors in grades four and five. These authors attributed the shift to children's vocabulary growth leading to the use of more complex words, whose written formation may not be mastered yet. At the same time, growth in the orthographic lexicon after years of reading experience leads to less reliance on phonological information alone and thus a reduction in phonological errors that are also found in grades four and five. Given the transfer between spelling and reading (Conrad, 2008), the formation of strong orthographic representations through a self-teaching mechanism facilitates spelling (Shahar-Yames & Share, 2008; Share, 1995).

Error analysis

There are a variety of error collection and analysis methods. Spelling errors obtained from word dictation tasks (Caravolas et al., 2001; Dixon et al., 2012; Fashola et al., 1996; Howard et al., 2012; Raynolds & Uhry, 2010; Russak & Kahn-Horwitz, 2015; Sun-Alperin & Wang, 2008) guarantee the same number of words for all the participants, as well as control for the different orthographic features being targeted. Nevertheless, dictation tasks could artificially inflate the rate of errors and would limit the knowledge that the students can activate, if they do not recognize the target words. Collecting data in a more natural environment, like using narrative writing tasks (Bahr et al., 2012, 2015; Quick & Erickson, 2018), has greater face validity, as it approximates the natural writing process more closely. Although narrative writing can lead to avoidance of certain words which the speller may find difficult to spell, this form also prevents the possibility of encountering words that a student is not familiar with or mis-hears. Narrative writing tasks may allow the use of a wider range of a participant's vocabulary, avoiding the constraints of researchers' words selection. Since students will write different numbers of words, the scoring and spelling comparisons must be made by calculating percentages using the total number of words produced, and the total number of errors (Moats et al., 2006).

Regarding error analysis methods, some standardized tests assess spelling accuracy by quantifying errors through a binary measure of correct/incorrect (e.g., *Test of Written Spelling-5*, by Larsen and colleagues, 2013), but there are researchers who have proposed different scoring systems. Constrained approaches (Caravolas et al., 2001; Treiman & Bourassa, 2000) do not consider acceptable orthographic productions (*rane* for *rain*) as errors, as long as phonology is represented through a legal sequence. On the contrary, the aim of unconstrained approaches is to identify the type of information that children rely on during spelling: phonology, orthography, or morphology. Inaccurate spellings are analyzed, even when the result is phonetically plausible, in order to identify the contributions of these three features (Bahr et al., 2012). This latter system considers multiple linguistic sources, which give information about underlying knowledge. Furthermore, the unconstrained approach is useful for measuring students' spelling ability (Daffern & Ramful, 2020), and the differences before and after intervention (Apel & Masterson, 2001). In foreign language learners, this method also allows for a better understanding of the type of errors that students produce, and thus instructional targets that teachers should focus on (Bahr et al., 2015; Joshi et al., 2008).

Spelling error studies in English as a foreign language learners include speakers from different linguistic backgrounds, like Arabic (Al-Bereiki & Al-Mekhlafi, 2015; Allaith & Joshi, 2011; Russak, 2022), Chinese (Dixon et al., 2012), Hebrew (Kahn-Horwitz et al., 2012; Russak, 2020; Russak & Kahn-Horwitz, 2015), Italian (Palladino et al., 2016) or Spanish (Bahr et al., 2015; Fashola et al., 1996; Howard et al., 2012) (see Figueredo, 2006, for a review). In the case of Spanish, research is relevant because it is the first language of more than 580 million speakers around the world (Fernández Vítores, 2019).

Spanish and English spelling

One of the key interests in exploring spelling errors in foreign language learners is the presence of native language influence. Certain aspects may be transferred across languages (Chung et al., 2019), although this depends on many factors, such as the linguistic proximity between languages (Geva & Siegel, 2000; Kahn-Horwitz et al., 2011). In the case of English and Spanish, both languages use the same alphabet. Despite the use of a similar alphabet, there are English spelling elements that differ from Spanish, and that have been found to present a challenge for Spanish speakers, leading to misspellings that Fashola and colleagues (1996) call “predicted errors” (see Table 1). These spelling errors have been widely described in Spanish-speaking populations (Bahr et al., 2015; Cronnell, 1985; Fashola et al., 1996; Howard et al., 2006, 2012; Lindner et al., 2022; Raynolds & Uhry, 2010; Rolla San Francisco et al., 2006; Sun-Alperin & Wang, 2008; Zutell & Allen, 1988). In what follows, these error types will be described in greater detail.

Phonology

The origin of some of these errors lies in differences in phonological inventories across languages. For instance, there are certain graphemes that are shared across languages, which lead to confusion if their pronunciation is not the same (Howard et al., 2012). One example is the letter *j*, which represents the sound /x/ in Spanish (e.g., *jarrón*) but the sound /ʤ/ in English (e.g., *jelly*). In other cases, some phonemes exist in the foreign language but not in the native language phonemic inventory (novel phonemes), so they may be more difficult to process. This idea was explained in the *Linguistic Affiliation* hypothesis (Russak & Saiegh-Haddad, 2011; Saiegh-Haddad et al., 2010), and it was also evidenced in English as a foreign language (EFL) learners from other linguistic backgrounds (Allaith & Joshi, 2011; Russak & Kahn-Horwitz, 2015). Furthermore, certain English consonants do not contrast in Spanish (e.g., /ð/ and /d/), and therefore, speakers fail to discriminate between them (Howard et al., 2012; Zutell & Allen, 1988). This also happens with voiced and unvoiced stop consonants (*p/b*, *t/d* and *k/g*), which are usually confused (Raynolds & Uhry, 2010). Errors with allophones (confusing *v* and *b*, which have the same pronunciation in Spanish) are very typical as well and have been described by Fashola and colleagues (1996) and Cronnell (1985). Vowels also represent a challenge for Spanish speakers. Spanish has five vowels sounds while English has between fifteen and twenty, depending on the variety (Deterding, 2004; Moats, 2009). As a result of this difference, many errors consist of the substitution of an English-specific phoneme (like /iː/ or /æ/) for spelling of the closest phoneme in Spanish (like /ɪ/ or /ɛ/) (Cronnell, 1985; Fashola et al., 1996; Howard et al., 2012; Sun-Alperin & Wang, 2008; Zutell & Allen, 1988). Additionally, vowel length is not distinctive in Spanish, while it is an important variable in English and has an influence on spelling

Table 1 English spelling features which are challenging for Spanish speakers with examples

Origin	Feature	Process	Target	Error
Novel phoneme	/h/	Misspelling because of novel phoneme (/h/) Addition of a letter which is silent in Spanish (*h*)	Hospital	Jospital
			Hair	Ger
			Ice cream	Hice creem
			About	Havaut
	/ð/	Misspelling because of lack of voicing features discrimination between /ð/ and /d/	Brother	Broder
			Bathroom	Badroom
			Bedroom	Beathroom
	Allophones /b/ /v/	Misspelling because of lack of discrimination between Spanish allophones /b/ and /v/	About	Avout
			Have	Habe
			Favorite	Faborite
			Rabbit	Ravit
	Novel vowels	Misspelling because of using the closest phoneme available in Spanish	Name	Neme
			Birthday	Berday
			Study	Stady
	Long vowels	Misspelling because of representing long vowels with diphthongs	Eyes	Ais
			Music	Miusic
			Old	Oul
Novel spelling patterns	Clusters	Misspelling produced in a cluster	Christmas	Crismas
			Twelve	Toelf
			School	Shool
	Digraphs	Misspelling produced in a digraph	With	Wiht
			Spanish	Sphanis
			Lucky	Luky
	Grapheme doubling	Misspelling because of wrong appliance of grapheme doubling rules	Rabbit	Ravit
			Funny	Funyy
			Prefer	Preffer
	Silent letters	Misspelling because of silent letter omission	Knock	Nock
			Excited	Exaited
			Kitchen	Kichen
			Subject	Subjet

(Fox et al., 1995). The pronunciation of some long vowels, like *a* /ei/ and *i* /ai/, are perceived and spelled as diphthongs by Spanish speakers (Fashola et al., 1996; Rolla San Francisco et al., 2006). Finally, confusion between the phonemes /θ/ and /s/ has been considered before (Bahr, 2015), as in South America and certain parts of the south of Spain there is no phonological contrast between these phonemes (Canfield, 1981; Lipski, 2012). However, both phonemes are discriminated in northern Spain oral Spanish.

Orthography

Apart from the difficulties stemming from phonological differences, some English orthographic patterns are challenging for Spanish speakers. Differences between English and Spanish orthography affect the size of the processing units (see the Psycholinguistic Grain Size theory by Ziegler & Goswami, 2005, 2006). English processing requires larger units, like syllables or rimes, beyond graphemes, which are enough for Spanish. As a result, there are English-specific orthographic features that do not exist in Spanish, and therefore may present difficulties in processing by Spanish speakers. Although consonant clusters exist in both languages, they are rarely formed by more than two letters in Spanish, and they never occur at the end of a word (only Latin words like *bíceps* are an exception). In English, however, tri-consonantal clusters are more common, both in starting and final positions (*street, tasks).* Digraphs are also elements that exist in English and Spanish, but their number is more limited in Spanish (*rr, ch, ll, qu* and *gu*) and not all digraphs are shared between both languages. Moreover, Spanish digraphs contain at least one consonant, while there are English digraphs formed exclusively by vowels (*ea, ee, oo…*). A particular case is grapheme doubling: in Spanish this occurs with few consonants, and they are usually associated with a change in pronunciation (*caro* and *carro* are pronounced differently). English grapheme doubling depends on rules, and more consonants and vowels are affected. Finally, the letter *h* is the only silent letter in Spanish. In English, many letters (including consonants and vowels) can be silent (*sword, name, castle*), and the letter *h* corresponds to the phoneme /h/ (which does not exist in Spanish). The existence of these unfamiliar new patterns (see Table 1) may explain spelling errors in English as well (Fashola et al., 1996; Howard et al., 2012; Sun-Alperin & Wang, 2008).

Our study

In this study we wanted to explore the type of spelling errors that are most frequent in Spanish-speaking children spelling in English. In particular, we wondered if there were differences in phonological, orthographic, and morphological errors across grades, and to what extent the native language (Spanish) may influence spelling in English as a foreign language (EFL). The majority of studies to date have been carried out in the United States, due to the number of Spanish speakers in the American Educational System (Hussar et al., 2020). Little research has been done in Spain, where English is mainly limited to educational environments, and the language of instruction in English classes is usually divided between Spanish and English. Moreover, English acquisition occurs during foundation stages of learning reading and writing in Spanish, producing a unique situation of sequential oral bilingualism and simultaneous biliteracy acquisition. In addition, some pronunciation differences between Spanish varieties (like /θ/ and /s/ phonemes) may have not been considered in previous studies. To our knowledge, in this country only Lahuerta (2015, 2018) has assessed the type of errors that students in Spain produce when spelling in English. Nevertheless, these studies focused on other aspects, like fluency or grammatical and lexical complexity, spelling remained in the background. Furthermore, the participants were adolescents, who are likely to have less errors due to the fact that they have had more exposure to the written language than young children (Lindner et al., 2022). Therefore, a gap exists in the literature regarding spelling errors among younger Spanish children learning to write in EFL. The present study attempts to fill this gap, in order to glean information about the influence of linguistic variables involved in English spelling. Moreover, studying literacy acquisition by children learning EFL allows a comparison with other studies focusing on native children. This, together with previous research with Spanish-speaking populations, gives us the opportunity to distinguish between the influence of developmental and linguistic factors. Specifically, we explore spelling development patterns of primary school students with the aim of answering the following research questions:

- To what extent do Spanish children learning EFL rely on their knowledge of phonology, orthography and/or morphology when spelling in English?
- Does the pattern of reliance on linguistic categories (phonology, orthography, morphology) change across grades?
- What type of linguistic features will be most apparent in spelling errors in Spanish children learning EFL?

Based on previous findings, we hypothesize that:

- In line with Triple Word Theory (Bahr et al., 2009; Berninger et al., 2009; Garcia et al., 2010), spelling errors in EFL among Spanish speakers will be evident in phonological, orthographic, and morphological categories.
- Morphological errors will increase while phonological errors will decrease across grades, following the previously observed developmental pattern.
- Spelling errors will reflect linguistic features that are challenging for L1 Spanish speakers when spelling in EFL, specifically doubling graphemes, long vowels and vowel digraphs, clusters, and novel phonemes.

Method

Participants

Demographic data

Participants were Primary Education students who attended fourth, fifth and sixth grades in a semi-private school in *blinded location* (Spain), a region in which a Northern Spain Spanish variety is spoken. Semi-private schools are present in other regions in Spain as well as in other European countries. These schools are partially funded by the Government, and they receive around 25–30% of the Spanish student population (Ministry of Education, 2021). The region is also representative of the Spanish population, with a per capita income similar to the Spanish average (National Statistics

Institute, 2021). Contrary to the Spanish-speaking population in the United States, our participants live in a country where Spanish is the official and dominant language (although there are dialects and co-official languages in certain territories). English is acquired as a foreign language at schools. Being proficient in English is highly valued. Nonetheless, its use is mainly relegated to educational or high-profile professional contexts (like business or academic pursuits).

The sample was comprised of 136 participants. Forty-four students were approximately 9 years old (M = 9.7 years; SD = 3 months), 47 were approximately 10 years old (M = 10.7 years; SD = 3 months) and 45 were approximately 11 years old (M = 11.8 years; SD = 3 months). All of the participants were native speakers of Spanish. None of the participants had cognitive, learning, or behavioral impairments. Furthermore, the socioeconomic status of the students who attend this school was generally middle. All the children's guardians provided written consent and agreed to participate. The procedure of the study was approved by the Ethics Committee of Research of the Principality of Asturias.

English language learning context

Children attended English lessons for four hours a week. Furthermore, some classes (like arts and science) were given in English in order to increase exposure to the language since the school follows a Content and Language Integrated Learning methodology (CLIL; Martínez Agudo, 2019), frequently used in Spanish schools. English instruction began in kindergarten, focusing primarily on oral communication during the first years, and integrating written content in the following grades. Although teachers were Spanish native speakers, they were proficient in English. Selected grades were chosen in order to explore literacy development stages, but also to allow students to have some experience with English writing prior to testing.

Procedure

Writing samples

Samples of a narrative task were collected, one per student. A template with instructions was printed and it was given to the students by the classroom teachers, who were responsible for administering the task. Students had 12 min to produce a handwritten composition. Instructions consisted of the following sentence: "Write about yourself, your family, your house… be creative!". Samples were transcribed by a bilingual Spanish–English speaker, who identified every misspelled word. One of the researchers reviewed the samples in order to detect any missing errors. The number of words and errors per sample were counted, and the percentage of misspelled words was calculated.

Classification system

Errors were classified on two different levels.

Categories

The first and more general level used the POMAS (Phonological, Orthographic, and Morphological Assessment of Spelling) categories (Bahr et al., 2012; Silliman et al., 2006). POMAS is an unconstrained, qualitative scoring system which embodies the Triple Word Form theory. As an unconstrained system, it considers all misspellings, even those in which the phonology of a word is preserved by an acceptable orthographic representation. In this first level, errors were classified in general categories: Phonological, Orthographic, Phonological-Orthographic, Morphological or Morphological-Orthographic. Errors affecting phonology were those that did not preserve the phonological skeleton (Bourassa & Treiman, 2003) (*pay* for *play*). Orthographic errors were those that, despite representing all the phonological elements of the word, did not demonstrate appropriate orthographic notation (*rabit* for *rabbit*). Morphological errors implied errors during the processes of derivation or composition, like misspelled prefixes (*andemployed* for *unemployed*). Phonological-Orthographic and Morphological-Orthographic categories were for those errors that overlapped between two areas of development. For instance, a Phonological-Orthographic error would be a misspelling affecting the orthography, which at the same time causes a change in the phonological representation of the word (*whit* for *with*, or *yuo* for *you*). An example of Morphological-Orthographic error would be a word root spelled phonologically with an accurate suffix spelling (*recepcionist* for *receptionist*).

POMAS codes

Next, we classified the errors on a more fine-grained level, following the POMAS codes (Bahr et al., 2012; Silliman et al., 2006), which are a detailed classification of errors according to specific linguistic features derived from general American English. For instance, if an error affected grapheme doubling (*rabit* for *rabbit*), it was classified into the code OGD (Orthographic grapheme doubling), because it was an omission of an obligatory doubling. If a cluster was misspelled and not all the elements were represented (like in *frien* for *friend*), it received a PCR code (Phonological cluster reduction). This level allows comparison with studies that used the same codes, revealing similarities and differences with native speakers and EFL learners from other linguistic backgrounds.

If a word contained multiple errors, the erors were labeled separately. Errors resulting from grammar rule confusion were excluded from the analysis (*he go* instead of *he goes*), as well as other errors that were not misspellings, but lack of vocabulary (e.g. use of false friends, code-switching, non-related word substitutions). By the same token, we also excluded verbs in those cases in which the spelling error was an omission (omitting *-s* for third person, or the whole suffix for past tenses *-ed*). This was done because it was not possible to distinguish between errors caused by misspelling and errors caused by lack of English grammar knowledge. However, errors affecting verbs that were clearly misspellings were included (*learnd* for *learned*). Finally, those errors that were independent of the language, like capital letters or word boundaries were also excluded. Although other studies have considered these errors (Bahr et al., 2015), we felt that they would not be representative of children's spelling skills in EFL, but more related to vocabulary and grammar rule knowledge. Since our participants were young EFL learners, a cautious approach was preferred.

We counted the total number of words as well as the number of errors of every participant. With this information, we calculated the percentage of total errors per participant by dividing the number of errors by the number of words. Percentage of errors per category and codes were calculated from the total number of errors. In our analysis we considered the mean number of words and percentage of total errors; percentage of errors per category; and percentage of errors per POMAS code.

Data analysis

From the data several comparisons were performed, using R-software (RStudio Team, 2020), to explore the impact of grade (fourth, fifth and sixth grade) on number of words and number of spelling errors. An ANOVA analysis was performed for the number of words. Regarding percentage of errors, the data were tested for normality and homogeneity of variance, and a Shapiro–Wilk test was performed, showing that the distribution departed significantly from normality ($W = 0.82$, $p < 0.001$). Based on this outcome, we performed non-parametric analyses. Kruskal–Wallis tests were used to determine the most frequent errors on both levels. Furthermore, differences across grades were also assessed.

Results

Number of words and percentage of errors

There was a statistically significant difference at the $p < 0.05$ level in the number of words for the three grade groups: $F\ (2, 133) = 36.81$, $p < 0.001$. On average, students wrote 75 words ($SD = 28$) in the fourth grade, 113 ($SD = 41$) in the fifth grade and 141 ($SD = 36$) in the sixth grade. Post hoc analyses (Bonferroni) showed significant differences between the three grade groups. The differences between fourth and fifth grades were significant ($Estimate = 38.2$, $p < 0.001$), as students in fifth grade wrote more words on average than fourth grade students. There were also significant differences between fifth and sixth grades ($Estimate = 27.6$, $p = 0.001$) and fourth and sixth grades ($Estimate = 65.7$, $p < 0.001$), as students in sixth grade wrote more words than students in fifth and in fourth grades.

Students had an average percentage of errors of 9.24% ($SD = 8.10$) in the fourth grade, 7.45% ($SD = 7.29$) in the fifth grade and 4.82% ($SD = 3.62$) in the sixth grade. A Kruskal–Wallis Test revealed a statistically significant difference in percentage

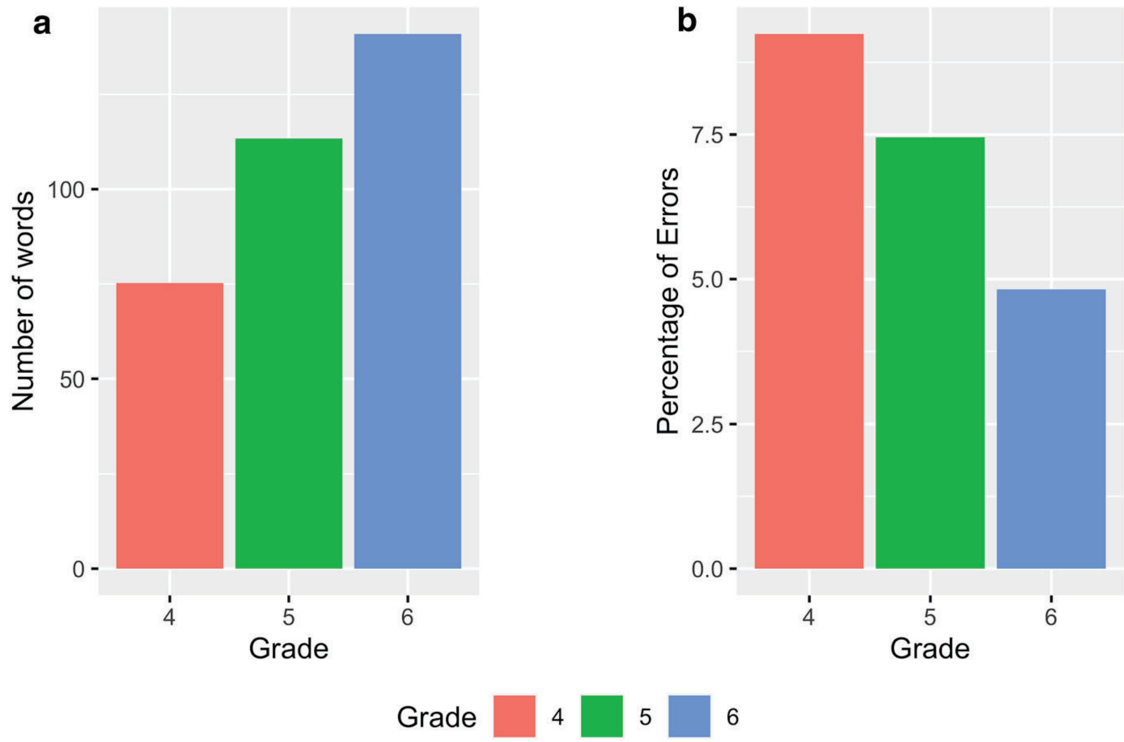

Fig. 1 Number of words **a** and Percentage of Errors **b** per Grade

of errors across the three grades (fourth, N = 44; fifth, N = 47; sixth, N = 45), χ^2(2, N = 136) = 7.132, *p* = 0.028. A pairwise post-hoc Dunn test with Bonferroni adjustments indicated that the percentages of errors made by fourth grade students were significantly greater (*z* = 2.67) than those made by sixth grade (*p* = 0.022) (see Fig. 1). No other differences were statistically significant. Furthermore, ten participants (3 in fourth, 3 in fifth and 4 in sixth grades) were excluded from the rest of the analysis. Although these ten participants had grammar and lexical errors in their samples and their writing was comparable to their peers, they did not have any errors affecting spelling. Therefore, their production was not analyzed in this study.

Level 1—categories

A total of 965 errors were found, representing 6% of the total number of words produced. Errors were found in all the categories, although the percentage of errors in each category differed. The category in which most errors were found was Orthography, as 60.30% (*SD* = 27.38) of the errors belonged to this category (e.g., *rabit* for *rabbit*). Phonological errors were less frequent, 25.58% (*SD* = 23.20) (e.g., *pay* for *play*). Morphological (e.g., *andemployed* for *unemployed*), Phonological-Orthographic (e.g., *whit* for *with*) and Morphological-Orthographic (e.g., *recepcionist* for *receptionist*) errors were least frequent, with 6.73% (*SD* = 13.77), 4.85% (*SD* = 10.02) and 2.52% (*SD* = 8.10), respectively.

The effect of grade was only significant in certain categories. Specifically, the results of the Kruskal–Wallis chi-squared tests were significant for Orthographic (χ^2(2) = 6.72, *p* = 0.034) and Morphological-Orthographic (χ^2(2) = 6.15, *p* = 0.046)

Table 2 Most Common POMAS Codes and Percentage of Errors (Mean and SD)

Category	Description	Code	Target	Error	Percentage of errors
Phonological	Addition of unnecessary letter	PEP	Beautiful	Beautirful	6.13% (12.91)
	Cluster reduction	PCR	Friend	Frien	5.36% (12.73)
	Plosive substituting fricative	PST	Bathroom	Badroom	3.93% (9.73)
	Consonant deletion	PCD	Always	Alway	2.80% (7.62)
Orthographic	Grapheme doubling (addition/omission)	OGD	Funny	Funyy	15.05% (23.31)
	Long vowel digraph misrepresented	OVDI	Cream	Creem	9.56% (17.08)
	Stressed short vowel substitution	OSE	Pretty	Pritty	6.38% (11.13)
	Unstressed vowel misrepresented	OUE	Physical	Physicol	5.70% (13.51)
	Short vowel digraph represented by one vowel	OSD	Football	Futball	4.93% (11.48)
	Silent letter omission	OSL	Know	Now	3.30% (7.63)
	Apostrophe addition	OAE	Likes	Like's	2.98% (12.10)
	Consonant digraph omission	ODI	Brother	Broter	2.52% (7.65)
Phonological-Orthographic	Phonological-Orthographic reversal	POR	T-shirt	Thisrt	3.86% (7.90)
Morphological	Homonyms	MHOM	One	Won	3.49% (11.97)

errors. A pairwise post-hoc Dunn test with Bonferroni adjustments indicated that the percentage of errors was different for the fourth graders compared to the sixth graders in the Orthographic category ($p = 0.036$) and in the Morphological-Orthographic category ($p = 0.039$). Specifically, students in the fourth grade had more orthographic errors than students in the sixth grade ($z = 2.51$), while they had less Morphological-Orthographic errors ($z = 2.47$). There were no differences in the rest of categories, as the results of the Kruskal–Wallis chi-squared test were not significant for Phonological, Morphological and Phonological-Orthographic errors.

Level 2—codes

Due to the high number of POMAS codes, we only included those codes that had a percentage of errors of 2% or above (see Table 2). A cut-off criterion was applied following the method by Bahr and colleagues (2015). Contrary to their study, where error samples were collected in Spanish and English, we collected our data in English only. Therefore, we calculated the percentage that allowed at least 20 error instances (instead of 40), which led to a percentage of errors of 2% or above.

The most frequent errors were grapheme doubling (OGD) representing 15.05% of the errors ($SD = 23.31$), followed by other orthographic errors like long vowel digraph misrepresentation (OVDI) with 9.56% ($SD = 17.08$), stressed short vowel substitution (OSE) with 6.38% ($SD = 11.13$), unstressed vowel misrepresentation (OUE) with 5.70% ($SD = 13.51$), and short vowel digraph misrepresentation (OSD) with 4.93% ($SD = 11.48$). Regarding errors of phonological origin, some of them occurred relatively frequently, like cluster reduction (PCR) with 5.36% ($SD = 12.73$) and addition of unnecessary letters (PEP) with 6.13% ($SD = 12.91$). Morphological and phonological-orthographic errors were less common, for example, homonyms (MHOM) with 3.49% ($SD = 11.97$) and phonological-orthographic reversal (POR) with 3.86% ($SD = 7.90$) which were the most frequent errors in each category, respectively. Examples of errors classified into every code are provided in Table 2.

With regards to the effect of grade, the results of the Kruskal–Wallis chi-squared test were significant for the orthographic error grapheme doubling ($\chi^2(2) = 7.98$, $p = 0.018$). A pairwise post-hoc Dunn test with Bonferroni adjustments indicated that, while the percentage of errors was similar for fourth and fifth graders, the difference was significant between fifth and sixth graders ($p = 0.018$). Specifically, fifth grade students had more errors than sixth grade students ($z = 2.73$). The effect of grade was also significant in the case of the phonological error consonant deletion ($\chi^2(2) = 7.89$, $p = 0.010$). The pairwise post-hoc Dunn test with Bonferroni adjustments also indicated significant differences between students in fourth and sixth grades ($p = 0.018$), since students in sixth grade had more errors involving a consonant deletion ($z = 2.73$).

Discussion

The aim of this study was to assess the variety of errors that Spanish-speaking children produce when writing in English. To do so, we analyzed and classified spelling errors obtained through a free writing narrative task. The categories that constituted the analysis were based on the POMAS system (Bahr et al., 2012). We hoped to highlight the different sources of knowledge (phonology, orthography, morphology) children rely on when spelling in a foreign language, specifically, a foreign language like English, which differs in terms of orthographic consistency from their native language (Spanish).

Predictably, the mean number of words produced was highest for sixth grade children, while the percentage of errors for this group was lowest. This could be explained by the increase of both writing practice and exposure time to English during their schooling experience, in line with other studies performed with foreign language learners (Chenoweth & Hayes, 2001; Palviainen et al., 2012). Overall performance across grades was good, as the percentage of errors did not exceed 10% in any grade. Nevertheless, the percentage was lower for older children. An improvement in spelling accuracy among older participants, with continuing presence of errors, has been found in Spanish EFL learners (Lindner et al., 2022) and EFL from other linguistic backgrounds (Hebrew: Russak & Kahn-Horwitz, 2015; Russak, 2022; or Arabic: Russak, 2022). The reason for these findings could be the complexity of the English orthography combined with a lack of explicit instruction about some specific English spelling rules such as, context-dependent spellings and rimes at school. Children's spellings may improve as they build orthographic representations for already known words, but since they keep learning new vocabulary, they may keep making errors.

The first questions considered if Spanish children relied on phonology, orthography, and/or morphology during spelling in English, and how their grade may influence the distribution of errors in each category. This was assessed using the first classification level, POMAS general categories. We found phonological, orthographic, and morphological errors, which confirms our first hypothesis concerning the presence of errors in all the categories. Nevertheless, morphological errors were the least common. This could be due to the choice of words by participants, who (as less competent EFL learners) might have preferred more simple words that did not involve morphological word formation processes like compounding, derivation, or inflection. Phonology was the category with the second lowest percentage of errors. Based on this finding, it appears that these children have partially internalized English phonological rules at this stage, with fewer errors related to phonology than orthography. Orthographic errors were the most frequent, in line with what Bahr and colleagues (2015) found in Spanish–English students. According to these authors, the origin of the spelling errors could be attributed to a reliance on phonology joined with an incomplete knowledge of English orthography.

Regarding differences across grades, we found an increased percentage of Morphological-Orthographic errors among older children. Their higher proficiency and more frequent use of morphologically complex words could be the reason for this finding, as suggested in previous studies (Bahr et al., 2012; Berninger et al., 2010). Moreover, the percentage of orthographic errors was higher for younger students, as previously found in native speakers (Bahr et al., 2012). We believe that limited experience could explain the high number of misspellings at the younger age. Improved scores among older children are likely to result from deeper knowledge of English orthographic rules (Lindner et al., 2022). Greater exposure to English words may have strengthened the older children's orthographic representations (Shahar-Yames & Share, 2008; Share, 1995). However, the percentage of phonological errors remained stable across grades. This result contradicts our hypothesis, as well as the results found by Bahr and colleagues (2012), where native speakers became less dependent on phonology while building their orthographic lexicon. In contrast, our participants showed continued dependence on phonology. This suggests that the developmental spelling pattern in EFL among Spanish speaking children differs from the pattern of native spellers. Among the phonological errors, most occurred with novel phonemes, which strongly supports the *Linguistic Affiliation* hypothesis (Russak & Saiegh-Haddad, 2011; Saiegh-Haddad et al., 2010) (like in *bro**d**er* for *brother*, ***c**ins* for *things*, or *t**o**lk* for *talk*). Less familiarity with the novel phonemes, and the absence of an identical phoneme in native language presents a challenge for EFL learners (Wade-Woolley & Geva, 2000), as evidenced among Hebrew (Russak, 2022; Russak & Saiegh-Haddad, 2011), Arabic (Russak, 2022), Chinese (Wang & Geva, 2003) and Spanish (Raynolds et al., 2013) speakers. Moreover, considering that readers of transparent orthographies (like Spanish) rely more on phonology, the continued use of phonological strategies shown by our participants could represent interference from their native language.

POMAS categories classification contributed to answering our first and second research questions about reliance on linguistic knowledge and changes across grades. The third question examined the type of linguistic features that were most apparent in the spelling errors. Code classifications provided a detailed analysis of our participants' spelling errors, as well as further evidence of native language interference. The most frequent errors were epenthesis (PEP) and cluster reductions (PCR) for Phonology; grapheme doubling (OGD) and errors affecting vowel representation (OVDI, OSE, OUE) for Orthography; phonological-orthographical reversal (POR) for Phonological-Orthographic; and homonyms (MHOM) for Morphology. All these errors were also found to be common in previous studies using POMAS classification (Bahr et al., 2012, 2015). In what follows we will discuss these errors.

Epenthesis errors (addition of unnecessary letters) was one of the most frequent phonological errors. These errors involved consonants, like *r* (*beuti**r**ful* for *beautiful*) or *d* (*bil**d**ich* for *village*), but also the vowel *e* (*mouth**e*** for *mouth, abaut**e*** for *about*). In the case of letter *e*, the origin could lie in a misapplication of final silent e. Children seem to be aware of the existence of this feature, but they do not discriminate in which cases it must be used. Regarding consonants, a specific pattern of misuse was observed for the letter *h*. Additions of this letter were either arbitrary and isolated (***h**avaut* instead of *about*), or to form a digraph (*t**h**enager* instead of *teenager*, *f**h**ather* for *father*). According to Bahr and colleagues (2015), both errors could be considered an influence of language transfer: use of native language linguistic features (the letter *h* is silent in Spanish) and overgeneralization of English spelling patterns (digraphs), which are novel for the EFL learners. As these authors suggest in their study, the origin of this last pattern could be an insufficient knowledge of English spelling conventions (children are not totally aware that digraphs represent specific phonemes). Errors affecting digraphs were also found by Palladino and colleagues (2016) among Italian EFL learners. As it also happens with Spanish, some Italian digraphs are formed with h (*ch* and *gh*), although English has specific digraphs that are novel for Italian speakers as well. Another frequent phonological error was cluster reduction. This error seems to be frequent in L1 spelling of younger children (Bahr et al., 2012, Treiman & Cassar, 1996), but there were no differences across grades in our sample. Furthermore, most of the reductions occurred in final clusters (*frien* instead of *friend*), which are very uncommon in Spanish. Our results are similar to previous findings among Spanish speakers (Fashola et al., 1996; Lindner et al., 2022), and point to L1 interference, supporting what Bahr and colleagues conjectured in their study (2015). But while clusters and initial *h* were found to be a challenge for Spanish speaking children, they were not problematic for speakers with other linguistic backgrounds like Hebrew (Kahn-Horwitz et al., 2011; Russak & Kahn-Horwitz, 2015). This suggests that EFL learners have specific difficulties with different English features, depending on their native language.

In line with earlier findings among non-native English spellers, many of the orthographic errors involved vowels (Bahr et al., 2015; Russak, 2022; Sun-Alperin & Wang, 2008). Particularly, errors affecting long vowel digraphs, stressed short vowels and unstressed vowels were the most frequent in our study. Regarding long vowels, they were sometimes spelled like diphthongs (*miusic* for *music*), reflecting the findings of Rolla San Francisco (2006) and Fashola and colleagues (1996). In some cases, the addition did not involve a vowel letter, but a consonant representing a vowel sound (*hello**w* for *hello*). Sometimes the error implied a total substitution of the grapheme (*ha**y* for *I*). There were no significant differences across grades in errors affecting vowels, contrasting what Bahr and colleagues found with native speakers (2012). The status of English in our study, as a foreign language (which implies less exposure to the language than native speakers) may explain the contradictory findings. Regarding homonyms, our results support previous findings with bilinguals (Bahr et al., 2015) and native children (Bahr et al., 2012) suggesting that the selection of an inappropriate word reflects choice of the most familiar form, instead of semantic processing of the linguistic context (*their* for *there*). This is a plausible explanation in our context as well, considering that our participants have had limited exposure to English. Orthographic forms may not be consolidated yet, and thus children transcribe the phonemes to the best of their limited ability.

One particularly interesting finding is the presence of differences across grades only for consonant deletion (PCD) and grapheme doubling (OGD). Grapheme doubling was one of the most frequent errors, especially among younger students. Errors were caused by omission (*ofice* for *office*) or addition (*preffer* for *prefer*). This confirms that it is a particularly challenging feature among Spanish speakers (Howard et al., 2006). Furthermore, no errors with grapheme doubling were found in other EFL learners, like Hebrew and Arabic (Russak, 2022). Doubling consonants that exist in Spanish do not have any relevance to previous vowel pronunciation (as they do in English). Thus, this specific rule may be difficult to assimilate by Spanish EFL learners if not explicitly taught. Less exposure to the English orthography may be another reason why our participants still have difficulties with this feature. As with other orthographic errors, improvement among sixth graders could be due to the growing understanding of specific English spelling rules, or the formation of orthographic representations as a result of increased exposure and practice with the written form of the language (Shahar-Yames & Share, 2008). Nevertheless, there seems to be an emerging awareness about doubled consonants and positional constraints among younger children. Similar to native speakers, who also struggle with consonant doubling at early stages (Bourassa & Treiman, 2003; Cassar & Treiman, 1997), errors were never located in starting positions. This spelling pattern, although yet not mastered, may be beginning to be assimilated by Spanish children spelling in EFL. A specific explanation could be plausible in those cases where doubling is applied to a wrong grapheme in the word (*soceer* for *soccer*, *funyy* for *funny*): EFL learners (who are not familiar with English phonology) could also be attempting spelling of difficult words through visually accurate matches. This strategy is similar in native spellers with less developed phonological skills, who are more likely to use visual memory strategies ((Lennox & Siegel, 1996). The way that native speakers integrate certain features of orthographic knowledge (Bahr et al., 2009; Wright & Ehri, 2007), could be the same in foreign language learners. Additionally, older children in our study had a higher percentage of errors related to consonant deletion (PCD) (*tenni* for *tennis*, *birthay* for *birthday*), although this code was not very frequent. This finding is in line with previous research with native and bilingual speakers (Bahr et al., 2012, 2015). Bahr and colleagues suggested that the origin of deletion errors could be an increased focus on what students wanted to say during writing, instead of paying attention to the form of individual words. Considering that our participants are writing in EFL, it is possible that certain consonant deletion errors may be influenced by working memory load. The demands of the task and the redistribution of cognitive resources could be also responsible for some of these and other errors, and not only the lack of knowledge of the spelling patterns themselves.

In sum, in this study we revealed more information about how Spanish children learning EFL begin to coordinate multiple sources of linguistic knowledge when writing, and how these patterns change across grades. With the help of an unconstrained approach to measure spelling accuracy, the POMAS system (Bahr et al., 2012), we can conclude that our participants rely on phonology, orthography and morphology during spelling. Distribution of errors varies across grades for morphology and orthography, while remaining constant for phonology. Our findings also suggest that spelling acquisition in EFL learners is not exactly equivalent to that of native speakers', being more affected by linguistic and educational variables, rather than developmental factors. Moreover, L1 Spanish interference can be confirmed by the presence of typical Spanish speakers' errors that were introduced in Table 1, supporting our third hypothesis as well. Novel phonemes and English orthographic conventions represent a challenge for all spellers learning EFL, although which patterns are unfamiliar for them will depend on their native language and its proximity to English. This is strongly evidenced by the similarities and differences found between the present findings and other studies carried out with speakers from different linguistic backgrounds (Bonifacci et al., 2017; Dixon et al., 2010; Palladino et al., 2016; Russak, 2022; Russak & Kahn-Horwitz, 2015).

One of the limitations of this study relates to the category of phonological errors. Since most of English teachers in Spain are not native speakers, it is impossible to assess if children have simply generated wrong phonological representations (Raynolds & Uhry, 2010; Read, 1971, 1986), or if they have learned the wrong phonological forms from their teachers, as mentioned in previous studies (Russak &

Kahn-Horwitz, 2015). In both cases, inaccurate phonological representation could be due to difficulties with discrimination between certain phonemes (novel and familiar), corroborating the *Linguistic Affiliation* hypothesis (Russak & Saiegh-Haddad, 2011; Saiegh-Haddad et al., 2010). Future studies should take this issue into consideration. Another limitation of this study has to do with one of the disadvantages of narrative tasks, which relates to word choice. Children may avoid certain words if they consider their spellings to be too challenging. This topic could be resolved by including dictation tasks with a closed list of words. Also, including younger and older students could elucidate a more complete developmental map of spelling errors among Spanish children learning EFL at school. This need is supported by the fact that spelling errors are also found in samples of older participants, like secondary school students (Kiernan & Bear, 2018; Lahuerta, 2019).

Despite these limitations, we believe that our findings have important theoretical and educational implications. Spelling error analysis broadens our knowledge about Triple Word Form theory (Bahr et al., 2009; Berninger et al., 2009; Garcia et al., 2010) in non-native speakers. Moreover, the POMAS system (Bahr et al., 2012; Silliman et al., 2006) has proved to be a useful tool in assessing which linguistic elements are more challenging for children learning EFL, and how these elements may vary depending on grade level. Our results also present a table of spelling error patterns that could be used in comparative studies. In this study the comparison was made with other studies analyzing spelling errors by native speakers, but it could also be made with speakers from other linguistic backgrounds. Regarding educational implications, information about spelling error patterns can help teachers detect which features or aspects should be targeted during instruction (Kiernan & Bear, 2018).

Finally, findings from this study confirm the existence of difficulties originating in differences between Spanish and English linguistic features. Similar percentages of phonological errors across grades also suggest a need for improving phonetic discrimination, as well as consolidation of English phonological knowledge. Given the challenge that novel phonemes present for Spanish speaking children (a fact explained by the *Linguistic Affiliation* hypothesis), students could benefit from increase of oral exposure (with input from native speakers, desirably). Furthermore, explicit training with typical English grain size units, like syllables or rimes, could facilitate the children's acquisition of the opaque English orthography. The more we know about how written languages are acquired, the more we can support children during the important achievement of learning a second language. As Frank Smith (2014) said "One language sets you in a corridor for life. Two languages open every door along the way".

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Declarations

Conflict of interest We have no known conflict of interest to disclose.

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Estudio V

Spanish children spelling in English as a Foreign Language: central and peripheral processes.

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Abstract:

Spelling acquisition requires the assimilation of the regularities of the writing system, but it could differ when it comes to a foreign language. The aim of this study was to know to what extent Spanish speaking children use sublexical and lexical information during EFL spelling, and whether this varies across grades. To achieve this, we designed a spelling-to-dictation task of monosyllabic words, where several variables were considered: P-O consistency, lexical frequency, and word length, in addition to the children's semantic knowledge of these words. Spelling accuracy, written latencies, and writing durations were collected. Results showed differences between grades, as word length only influenced younger children. Lexical frequency, consistency and semantic knowledge facilitated performance in older children. The cumulative exposure to English may lead to an improvement in spelling due to vocabulary growth and sensitivity to new spelling patterns and regularities. Such development occurs despite differences between the orthographies of the native and foreign language, and a lack of explicit instruction in EFL spelling.

Keywords: spelling, foreign language, central and peripheral processes, Spanish children.

What is already known about this topic

- Different linguistic variables impact on spelling development.
- English spelling acquisition is a challenge for Spanish-speaking children.
- Central and peripheral processes interact during handwriting.

What this paper adds

- Having semantic information about words facilitates spelling retrieval during writing in EFL.
- Spanish-speaking children develop sensitivity to English spelling patterns, and older children can take advantage of.

Introduction

Spelling is a crucial aspect of the written production (Chenoweth & Hayes, 2001; Van Galen, 1991). It is considered a *central process* (Purcell et al., 2011), referred to the retrieval and maintenance of the orthographic representation to be produced (Van Galen, 1991), while handwriting movements are considered *peripheral processes* (Purcell et al., 2011).

Spelling acquisition requires several years of instruction and practice, especially in deep orthographic systems. Many studies have tried to understand and describe how and when these writing mechanisms develop (Ehri, 1992, 2001; Frith, 1980; Share, 1995). However, spelling strategies and performance may diverge when dealing with a foreign language (FL), as it involves confronting new statistical regularities in the relationship between phonemes and graphemes. The present study addresses the English spelling performance of Spanish-speaking children. This study is of great interest from both practical and theoretical points of view, considering the importance of English language in today's society, and the marked differences between the English and Spanish orthographic systems (opaque *vs*. transparent). Most studies about this topic to date have been carried out in the United States, as there are a considerable number of Spanish speakers in the American education system (Hussar et al., 2020). By contrast, few studies have been performed in Spain, where children are only exposed to English in the school context (Hevia-Tuero et al., 2022; Lahuerta, 2015, 2018). Moreover, studies on FL spelling have generally focused on the number and type of errors, although several studies have shown that spelling processes modulate handwriting movements (Lambert et al., 2011; Sausset et al., 2012). Therefore, the current study provides data on English FL spelling, obtained in a dictation task, combining accuracy and kinematic measures in a population of Spanish children.

Spelling development and English orthography

In general, at the beginning of spelling acquisition, children learn the phonology-to-orthography (P-O) conversion rules of the language. This sub-lexical information is very useful as it allows for the spelling of unknown words; however, it does not guarantee the correct spelling of inconsistent words. It is only after years of exposure to spelling that learners can develop word-level orthographic representations for known words, providing a lexical strategy for spelling (Ehri, 1992; Frith, 1980; Rittle-Johnson & Siegler, 1999; Share, 1995). Thus, young children's spelling is mainly determined by word length (i.e., accuracy depends on the number of phoneme-to-grapheme conversions to be made), indicating a sublexical strategy (Goswami et al., 1998; Juul & Petersen, 2017; Sprenger-Charolles et al., 2003). As orthographic knowledge increases, and due to the formation of orthographic representations, the word length will cease to be a determining variable, and other variables, such as lexical frequency, will become more influential. High-frequency words are assumed to have strong orthographic representations, facilitating spelling accuracy (Bonin et al., 2016). The effect of lexical frequency has been observed in several languages and populations (French: Martinet et al., 2004; Spanish: Suárez-Coalla et al., 2016; and English: Caravolas et al., 2005). Nevertheless, spelling performance seems to be strongly determined by the characteristics of the writing system, where the orthographic consistency is one of the main characteristics that distinguish alphabetic writing systems from each other. There is considerable evidence that literacy acquisition is faster in transparent than in opaque orthographies (Bruck et al., 1996; Caravolas & Bruck, 1993; Caravolas, 2004; Goswami et al., 1998; Marinelli et al., 2015; Oney & Durgunoglu, 1997; Thorstad, 1991; Wimmer & Hummer, 1990; Wimmer & Landerl, 1997; Wimmer et al., 1991), and that it is more demanding to spell inconsistent than consistent words (Caravolas et al., 2005; Lété et al., 2008; Planton et al., 2019; Weekes et al., 2006).

The English orthography is characterized by its inconsistency, with a major impact on rate of acquisition and spelling strategies (Caravolas, 2004). Orthographic consistency is a complex concept. From a traditional point of view, consistency has been understood as the correspondence between spelling and sound, identified as *feedforward consistency*; thus, a word is consistent when its pronunciation matches that of words of similar spelling. For instance, "cake" is consistent because its pronunciation /eɪk/ matches that of "take", "make", "fake"; whereas "cough" is inconsistent because its pronunciation /kɒf/, conflicts with that of similarly spelled words, such as "dough" /dəʊ/, "tough" /tʌf/, "through" /θruː/ (Glushko, 1979). Besides, it has also been proposed as relevant the inverse relationship, between sound and spelling, known as *feedback consistency* (Chee et al., 2020, for an extended explication). For example, "roar" is feedback inconsistent because several other words that have the same pronunciation /ɔr/ (e.g., "core", "more", "bore") are spelled with '-ore', instead of "-oar". On the other hand, the degree of orthographic consistency can be considered a continuum, as it depends on the number of friends and enemies of words. A widely accepted way to calculate the degree of orthographic consistency of a word is to divide the number of friends by the total number of friends and enemies, the value being between 0 and 1 (Chee et al., 2020).

Furthermore, it is necessary to take into consideration the sub-syllabic elements, as consistency is computed at different sub-syllabic grain sizes, even when many studies have focused on rime level consistency. From a linguistic perspective, a syllable consists of several elements: the onset (any consonants that precede the vowel), the nucleus (the vowel), and the coda (the consonants that follow the vowel). Higher-order units such as the rime (the vowel and the coda forming a higher-order unit), and the oncleus (the onset and nucleus), can also be identified (Vennemann, 1988). For example, in the word “crab”, ‘cr-‘ is the onset, ‘-a-‘ is the nucleus, ‘-b’ is the coda, ‘cra-‘ in the oncleus, and ‘-ab’ is the rime. These sub-syllabic elements are particularly relevant for dealing with English orthography inconsistencies. According to the Psycholinguistic Grain Size Theory (Ziegler & Goswami, 2005), English spellers need to develop intermediate representations between grapheme and the whole word (i.e., syllables, rimes, morphemes) to reduce the level of inconsistency.

To this must be added the role of semantics in spelling development. Semantic representations, phonology and orthography constitute the three main components of word identity (Perfetti, 2007). A great deal of evidence has now been provided on the relationship between vocabulary and reading (NICHD Early Child Care Research Network, 2005; Nation & Cocksey, 2009; Ouellette & Beers, 2010), but some studies have also provided support for the role of semantics on the development of spelling abilities (Hilte & Reitsma, 2011; Ouellette, 2010; Tainturier & Rapp, 2001; Van Rijthoven et al., 2021). Indeed, Hilte & Reitsma (2011), in a study conducted with Dutch 2nd graders, showed that activation of semantic information of a word supports the acquisition of the phonology-orthography connection and leads to a well-specified lexical-orthographic representation that would facilitate retrieval. In the same vein, Ouellette (2010) suggests that semantics is an important factor in learning to spell, demonstrating benefits in spelling words presented with semantic support in 2nd graders.

Interaction between central and peripheral processes

While studies on the number and type of errors have offered important insights into writing processing, studies on kinematic measures (e.g., written latencies –WLs– or writing durations –WDs) have begun to provide data on the interaction between central (linguistic) and peripheral (motor) processes (Afonso, Álvarez, et al., 2015; Afonso, Suárez-Coalla, et al., 2015; Delattre et al., 2006; Kandel et al., 2006, 2014; Kandel & Perret, 2015; Kandel & Valdois, 2005; Lambert et al., 2011). In this line of research, the impact of several variables (e.g., lexical frequency, orthographic consistency, or word length) on handwriting movements has been studied. Results suggested that the central processing of some words does not end when motor execution begins, operating in a cascaded fashion (Bonin et al., 2012). However, the scope of the interaction seems to vary with age or level of spelling ability (Olive & Kellogg, 2002; Sausset et al., 2012).

As for orthographic consistency or regularity, it has been reported that orthographic inconsistencies systematically increase both WLs (Bonin et al., 2015; Delattre et al., 2006), and WDs (Afonso, Álvarez, et al., 2015; Afonso, Suárez-Coalla, et al., 2015; Lambert et al., 2011; Roux et al., 2013). Kandel and Perret (2015), in a study with French children (8-10 years old), found that WLs were influenced by orthographic regularity, but only in 8-9 years old children. However, orthographic regularity had an impact in handwriting movements at all ages. Moreover, in Spanish, orthographic inconsistency increased the duration of the first letter in a spelling-to-dictation task around the age of 8 years (Suárez-Coalla et al., 2018). Regarding lexical frequency, it has been found to have a clear impact on WLs (Afonso et al., 2018; Bonin & Fayol, 2002; Delattre et al., 2006); however, results about the impact on motor execution have not been as consistent (Afonso et al., 2018; González-Martín, et al., 2017; Kandel & Perret, 2015; Sovik et al.,1994). Kandel and Perret (2015) found a similar effect at all ages, meanwhile Afonso and colleagues (2018) concluded that the impact only appeared in young children, and Sovik and colleagues (1994) found that lexical frequency affected only long words.

In sum, existing evidence supports that spelling processes cascade onto handwriting movements. Thus, the effect of linguistic variables on WLs and WDs, in addition to spelling accuracy, may inform about spelling strategies.

Spelling in English as a foreign language

Spelling acquisition differs across orthographies. Moreover, spelling processing in a FL or second language (L2) is not comparable to that of the native language (L1) (Lemhöfer et al., 2008). In the framework of the *Linguistic interdependence Hypothesis* (Cummins, 1991), several studies using diverse methodologies addressed the possible L1 influence or transfer on English FL spelling. The influence will depend on the language's characteristics, and transfer can occur in different situations and lead to different effects. If the two languages share linguistic features, then transfer will be positive; while, if specific orthographic knowledge of English is required and has not yet been acquired, the use of L1 strategies may be counterproductive (Figueredo, 2006; Sammour-Shehadeh et al., 2022). In this context, differences in terms of orthographic depth between L1 and English seem to be critical for spelling (Geva et al.,1993; Katz & Frost, 1992; Sammour-Shehadeh et al., 2022). English learners whose L1 has a transparent orthography, such as Spanish, may struggle to learn the English phoneme-grapheme correspondences and to use different grain size units, which might push them to use the correspondences of their native language to spell in English (Dixon et al., 2010; Sammour-Shehadeh et al., 2022). On top of that, the English orthography includes several multi-letter correspondences, digraphs, and clusters (Schmalz et al., 2015) which learners may not be familiar with. But the reliance on L1 seems to disappear as learners improve their English language skills, with more reliance on English spelling rules and strategies, like orthographic context and bigger units (Wang & Geva, 2003). Many of the studies on spelling development in Spanish speakers have been conducted in the United States, where most children speak Spanish at home, but receive instruction in English or in both Spanish and English languages. So, explicit instruction in English would considerably reduce the number of transfer errors (Rolla San Francisco et al., 2006).

The situation is very different in Spain, where children do not receive explicit literacy instruction in English, and where exposure to the English language outside school is low. It may have important repercussions on spelling development (Sammour-Shehadeh et al., 2022). A recent study addressed the different sources of knowledge (phonology, orthography, morphology) used by Spanish children to spell in English, a less consistent orthographic system than that of their native language (Spanish), (Hevia-Tuero et al., 2022). They found that Spanish children (4^{th}-6^{th} grades) made more orthographic errors than phonological and morphological, as it had also been reported by Bahr and colleagues (2015). This is considered a consequence of a reliance on phonology in addition to an incomplete knowledge of English orthography, leading to a misapplication of phoneme-grapheme conversion rules. However, this kind of errors were grade-dependent, as they diminished in older students. Considering phonological errors, the results confirmed that Spanish children rely more on phonology, with a large number of phonological errors on novel phonemes, strongly supporting the *Linguistic*

Affiliation hypothesis (Russak & Saiegh-Haddad, 2011; Saiegh-Haddad et al., 2010). The presence of novel phonemes and the absence of familiarity with them constitutes a challenge for EFL learners (Dixon et al., 2010; Raynolds et al., 2013; Rolla San Francisco et al., 2006; Russak, 2022; Russak & Saiegh-Haddad, 2011; Wang & Geva, 2003). This leads to the application of native language phoneme-grapheme correspondences (Fashola et al., 1996; Howard et al., 2012; Lindner et al., 2022).

The mentioned studies highlight the importance of orthographic characteristics and differences between writing systems when it comes to learning to spell in a FL, even more when the foreign language's orthography is as complex as in English. Surprisingly, as far as we know, no study has collected kinematic measures to investigate the strategies used by children writing in EFL.

Our study

The aim of this study was to investigate the English spelling performance of Spanish children. To achieve this aim, we designed a spelling-to-dictation task of monosyllabic words, where several variables were considered: P-O consistency, lexical frequency, and word length, in addition to the children's semantic knowledge of these words. The objective was to know the extent of the use of sublexical and lexical information during EFL spelling, and whether this varies across grades. Word spelling accuracy, sublexical accuracy (i.e., accuracy for each of the syllable units: onset, nucleus, and coda), WLs, and WDs were collected. The analysis of WLs and WDs, in addition to the analysis of accuracy in the different sub-syllabic units, allows us to obtain a more detailed view of the spelling processes, as well as to detect subtle differences between participants in the different grades.

We expected significant differences between grades as well as higher accuracy and greater speed for consistent than for inconsistent words. It is hypothesized that word length will decrease its impact on the collected measures across grades, while lexical variables (i.e., word frequency) will gain importance. Consistency, as observed in previous studies conducted in the L1, will affect WD in English. We also expect that spelling and kinematic aspects of handwriting will be enhanced when the children have better semantic knowledge, and that this knowledge will increase with grade. Finally, we want to explore which parts of the syllable, if any, are particularly sensitive to the effects of the orthographic consistency during production, so we can establish the grain-size on which linguistic representations are processed during handwriting.

Method

Participants

In this study participated a total of 89 Spanish children in fourth (29 students; *Mage* = 9.43 years; *SD* = 6 months), fifth (28 students, *Mage* = 10.21 years; *SD* = 5 months), and sixth grade (32 students; *Mage* = 11.3 years; *SD* = 5 months).

All of them, native Spanish speakers, attended a primary school in the north of Spain. In this school, children are introduced to English in kindergarten, learning basic vocabulary on different topics (e.g., colors, numbers, animals). Fourth and fifth graders receive English classes for five hours a week, while sixth graders attend six hours of English classes per week. The English teaching in most Spanish schools includes relatively little explicit instruction in spelling. In the case of the participants in this study, although a phonic approach is increasingly being considered in this school, pupils were generally expected to learn the meaning, the pronunciation, and the spelling of words.

Teachers confirmed via personal communication that children showed a typical literacy development in their native language. Children with cognitive, motor, learning, or behavioral impairments were excluded from the study. Moreover, children speaking a second language at home were also excluded. The school was in an area of medium socio-economic status.

The procedure of the experiment was approved by the Ethics Committee of Research of the Principality of Asturias, Spain, and it has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. Parental written consent was collected for all participants, and children agreed to participate in the study.

Materials

A total of 58 English monosyllabic and morphologically simple nouns (M_{length} = 4.25; *SD* = 0.78) were selected for the children to complete two tasks: spelling-to-dictation and translation. The words were obtained from a database created in our laboratory. This database includes the words contained in the two most widely used English textbooks in Spanish primary education. The number of times that each word appears in these textbooks was considered as lexical frequency in the database. One of these two textbooks is used in the school attended by the participants in this study. The stimuli were selected so all of them had at least one consonant in both onset and coda (e.g., cat or desk). In addition, we considered the occurrence of the words in textbooks of grade 4 and below, to include words to which the children had already been exposed. For these words, we considered the following variables: word length (3 to 6 letters, M_{length} = 4.26; *SD* = 0.78); lexical frequency according to the English textbook used in the school (1 to 73 occurrences, *M*= 20.91, *SD*= 16.30); feedback consistency scores of the onset (0.061 to 1, *M*=0.94, *SD*= 0.15), the nucleus (0.003 to 0.995, *M*= 0.48, *SD*= 0.33), the coda (0.022 to 1, *M*= 0.63, *SD*= 0.33), and the rime (0.030 to 1, *M*= 0.63, *SD*= 0.29) according to Chee and colleagues' consistency norms for 37,677 English words

(2020). A list with all the words and their individual characteristics can be found in the Appendix.

The auditory stimuli, for the spelling-to-dictation task, were recorded by a bilingual (Spanish/English) speech therapist. She used an H4n voice recorder with a microphone Ht2-P Audix, and edited using Praat software (Boersma & Weenink, 2022).

Apparatus

Stimulus presentation and digital recording of the responses were controlled by Ductus software (Guinet & Kandel, 2010). The experiment was run on an HP Mini laptop. A WACOM Intuos 5 graphic tablet connected to the computer and an Intuos Inking Pen were used to register the participants' responses.

Procedure

Participants were tested individually at school, in a quiet space free of distracting elements. All children first completed the spelling-to-dictation task and then the translation task. Regarding the spelling-to-dictation, participants were asked to write the stimuli, as quickly as they could in lowercase letters, and trying to avoid errors. Each trial started with an auditory signal and a fixation point on the screen, with a duration of 500 ms. Subsequently, the stimulus appeared, and participants had to start writing with the inking pen on a lined paper -one line per word-, placed on the graphic tablet. When they finished the word, they should move to the next line without touching it, to get ready for the next word. Then, the experimenter would present a new stimulus using the mouse. Two different lists were created to randomize the order of presentation of the stimuli.

After the spelling-to-dictation task, children performed the translation task. For this purpose, a piece of paper including the 58 words was handed to the participants.

They were asked to write the Spanish translation for all the words they knew. The aim of this last task was to assess if children knew the meaning of the words of the experimental task. The score was considered an index of semantic knowledge. The total duration of the two tasks was approximately 15-20 min, although younger children were generally slower than their older counterparts.

Data analysis

In this study, we investigated central and peripheral processes during English spelling in Spanish children, 4^{th} to 6^{th} grade. We recorded a total of 5,162 data (4^{th}= 1,682; 5^{th}=1,624; 6^{th}= 1856). We measured spelling accuracy (scored as 0 when the word is misspelled and 1 when it is correctly spelled), sublexical units' accuracy (onset, nucleus, and coda accuracy, considering 0 when the sublexical unit was misspelled and 1 when it was correctly spelled), written latencies (WLs), and writing duration (WDs). WLs were measured as the time between the presentation of the stimulus and the onset of the response. WDs refer to the time between the first pen down produced in a word and the last pen lift in the same word. Statistical analyses were carried out using the R software version 4.1.3 (RDevelopment Core Team, 2022), and *lme4* (Bates et al., 2015), *lmerTest* (Kuznetsova et al., 2017), *broom.mixed* (Bolker & Robinson, 2022) packages.

Regarding the word spelling accuracy analysis, a Generalized Mixed Effects Modelling (GLMM), using the binomial family and the Laplace approximation for the likelihood, was performed. The aim was to estimate the odds ratios that a response would be accurate given a set of predictors. Random effects of both participants and items were considered, while grade, length, translation accuracy, English lexical frequency, onset consistency, nucleus consistency, coda consistency, and rime consistency were considered fixed effects. The absence of collinearity between the factors was tested, and an ICC of 0.403 was obtained. The significance level used was 0.05.

Moreover, different univariate linear mixed models were constructed to predict WLs and WDs. We considered the different predictor variables or factors as fixed effects (grade, semantic knowledge, length, lexical frequency, onset consistency, nucleus consistency, coda consistency, and rime consistency), and the interaction of each factor with grade. Participant and stimulus were included as random effects. The variables with a significance less than or equal to 0.20 were selected, and a multivariate model was built with them. The absence of collinearity was checked with the variance inflation factors and by calculating the intraclass correlation coefficient.

Word spelling accuracy

In the word spelling accuracy analysis, we included all responses: 2,227 (43.14 %) correct responses (587 -> 34.72 % in 4th grade; 703 ->43.28 % in 5th grade; and 937 -> 50.48 % in 6th grade); 2,935 (56.86%) incorrect responses (1095 in 4th grade, 921 in 5th grade, and 919 in 6th grade). Regarding the translation task, we found a total of 2,883 correct responses, indicating that participants know the meaning of an average of 55.85 % words (795 -> 47.50 % in 4th grade; 54.61 % in 5th grade; 64.71 % in 6th grade).

Starting from a maximal model that included all interactions with the grade, and given the existence of non-significant coefficients, we opted to apply a backward algorithm to simplify the model. The mixed effects logistic regression analysis showed a semantic knowledge effect, $\chi^2_{(1)}$=118.140, *p*<.001, where known words were more likely to be spell correctly than words that children don't know the meaning, *OR* = 6.03, *SE*= 0.242, *CI* = 0.011–2.67. A nucleus consistency effect was also significant, $\chi^2_{(1)}$=4.8382, *p*=.027, as words with more consistent nucleus were more likely to be spelled correctly than less consistent ones, *OR* = 4.93, *SE* = 3.58, *CI* = 1.19-20.5. In addition, we found an interaction between grade and semantic knowledge, $\chi^2_{(2)}$= 25.6464, p<.001, revealing that the effect of semantic knowledge is grade-dependent, as 6th graders benefit from word knowledge more than fourth and fifth graders, p < .001, *OR*= 0.368, *SE*= 0.07, *CI*= 0.246-0.551. The interaction between grade and length was also significant, $\chi^2_{(2)}$= 6.1273, p=.046, as the effect of length was higher in 4th grade than in 5th, p < .001, *OR*= 1.33, *SE*= 0.17, *CI*= 1.03-1.72, and 6th grades p < .001, *OR*= 1.32, *SE*= 1.65, *CI*= 1.03-1.69. There was a significant interaction between grade and lexical frequency, $\chi^2_{(2)}$= 11.3839, p=.003, with a higher probability of correctly spelling frequent words in 6th grade than in the 4th and 5th grades, p<.001, *OR*= 1.02, *SE*= 0.006, *CI*= 1.01-1.03.

Onset, nucleus, and coda accuracy

To find out which part of the syllable is the most challenging for Spanish children and whether it depends on the grade and the orthographic consistency, each part of the syllable (onset, nucleus, and coda) was coded as correct spelling (1), or incorrect spelling (0). After that, a Generalized Mixed Effects Modelling (GLMM), using the binomial family and the Laplace approximation for the likelihood, was performed for each part. Random effects of both participant and stimulus were included, while grade and consistency were considered fixed effects.

Children in the 4th grade committed a total of 1,812 errors: 271 (*M*= 9.34; *SE*= 15.17; 14.95 %) in the onset, 735 (*M*=25.34; *SE*= 16.10; 40.56 %) in the nucleus, and 806 (*M*=27.79; *SE*= 14.67; 44.48 %) in the coda; in the 5th grade made 1,470 errors: 201 (*M*= 7.17; *SE*= 14.55;13.67 %) in the onset, 600 (*M*= 24.42; *SE*= 15.89; 40.81%) in the nucleus, and 669 (*M*= 23.89; *SE*= 14.48; 45.51%) in the coda; and in the 6th grade committed a total of 1,389 errors: 171 (*M*= 5.34; *SE*= 12.56; 12.31%) in the onset, 562

(M= 17.56; SE= 14.72; 40.46%) in the nucleus, and 656 (M= 20.50; SE= 12.96; 47.22%) in the coda.

Onset accuracy

For the onset analysis, we built the model *onset-accuracy ~ onset consistency*grade+ (1 | participant) + (1 | stimulus)*, however, no factor was found to be significant.

Nucleus accuracy

For the nucleus analysis, the model was *nucleus-accuracy ~ nucleus consistency*grade + rime consistency*grade (1|participant) + (1|stimulus).* The intraclass correlation coefficient for this model was 0.349, and no collinearity was detected between the predictor variables, as verified through the variance inflation factors. The nucleus consistency effect was significant, $\chi^2(1)$= 13.9753, p=.000, as the higher the value of nucleus consistency, the lower the probability of error, p<.001, OR= 16.3, SE= 12.2, CI= 3.78-70.7; the rime consistency by grade interaction was also significant, $\chi^2(2)$= 8.8194, p=.012, as the effect of rime consistency on nucleus accuracy depended on the grade, with a tendency to benefit more from the rime consistency in 6th grade, p=.07, (OR= 2.44, SE= 1.23, CI=0.908-6.56).

Coda accuracy

For the coda analysis, *coda-accuracy ~ coda consistency * grade + rime consistency*grade (1 |participant) + (1 | stimulus)*. However, no factor was found to be significant.

Written latencies

For the analysis of WLs and WDs, we only studied the data of the words with a minimum of 50% spelling accuracy. That involved 2,136 responses (4th =696; 5th =672; 6th =768) for a total of 24 words. Of the 2,136 responses, a total of 1,436 were correct responses (67.22%), which were considered for the WLs and WDs analyses. Regarding the translation task, we obtained a total of 1,552 correct responses, which indicates that participants know the meaning of 72.65 % of words.

Following the procedure described above, the multivariate model was *WLs ~ semantic knowledge +grade+ nucleus consistency+ rime consistency + onset consistency*grade + length*grade+ (1 | participant) + (1 | stimulus)*. The intraclass correlation coefficient for this model was 0.218, and no collinearity is detected between the predictor variables, as verified through the variance inflation factors.

From the multivariate model, we found a semantic knowledge effect ($F(1, 1228.96)= 12.5539$, $p< .001$), as WLs was lower for words they do not know. The grade effect was also significant, $F(2, 1347.29)= 6.787$, $p= .001$), as 6th and 5th graders initiated the response significantly faster than 4th graders. The onset consistency effect ($F(1, 19.54)= 4.406$, $p= .049$) revealed that the higher the consistency of the onset, the lower the WLs. Finally, an onset consistency by grade interaction was found ($F(2, 1331.73)= 6.703$, $p= .001$), indicating that the onset consistency effect was higher in 6th and 5th than in 4th graders. See Table 1.

Table 1

	Estimate	*Standard Error*	*p- value*
Intercept	2497.481	270.340	<.001
Semantic knowledge	-120.824	34.101	<.001
Onset consistency	-515.764	147.685	.001
5th grade	-664.492	180.616	<.001
6th grade	-392.952	172.300	.022
Onset:5th grade	447.633	124.398	<.001
Onset:6th grade	316.095	120.123	.008

Writing duration

As with WLs, we built the following multivariate model *WDs ~ semantic knowledge + coda consistency + lexical frequency*grade + onset consistency*grade + nucleus consistency*grade + rime consistency*grade+ (1 | participant) + (1 | stimulus)*. The intraclass correlation coefficient for this model was 0.481, and no collinearity is detected between the predictor variables, as verified through the variance inflation factors.

We found a semantic knowledge effect ($F(1, 1380.79)= 7.280$, $p= .007$), as WDs were lower when translation accuracy was equal to 1. Grade also produced a significant effect ($F(2, 789.15)= 7.994$, $p< .001$), as the duration of the movement depended on the grade, with lower WDs in 6th grade than in 4th and 5th grades. Regarding the onset consistency effect ($F(1, 18.25)= 4.7005$, $p= .043$), the higher the consistency of the coda the lower the WDs. The nucleus consistency effect was also significant ($F(1, 18.30)= 17.1901$, $p< .001$), as the higher the consistency of the nucleus the lower the WDs. Similarly, we found a coda consistency effect ($F(1, 18.13)= 7.0987$, $p= .015$), as the higher the consistency of the coda the lower the WDs. The onset consistency by grade interaction ($F(2, 1326.04)= 3.4839$, $p= .030$), indicated that the impact of onset consistency on WDs depended on the grade, being higher in grade 6, although the differences between grades were not significant. See Table 2.

Table 2.

	Estimate	*Standard Error*	*p- value*
Intercept	3245.570	289.804	<.001
Semantic knowledge	-94.755	35.117	.007
6th grade	-563.414	169.657	<.001

Onset consistency	-552.067	245.383	.033
Nucleus consistency	-916.629	241.270	<.001
Coda consistency	-395.471	148.43	.015
Onset:6th grade	252.879	139.504	.070

Discussion

The aim of this study was to address the spelling performance of Spanish children (4th, 5th, and 6th) in EFL. Specifically, we were interested in the use of sublexical and lexical information during EFL spelling, and whether it may vary across grades. For this purpose, a spelling-dictation task of monosyllabic words was designed, in which several variables were considered: P-O consistency, lexical frequency and word length, as well as the children's semantic knowledge of these words. Different measures were collected: word spelling accuracy, sub-lexical accuracy (i.e., onset, nucleus, and coda), WLs, and WDs. From the analysis of WLs and WDs, in addition to the analysis of accuracy in the different sub-syllabic units, we tried to offer a more detailed picture of the spelling processes.

The results indicate that Spanish children make a high percentage of errors when spelling in English (56.86%), which is determined by factors such as word length, nucleus consistency, lexical frequency, and semantic knowledge. Specifically, all children wrote more accurately words with higher nucleus consistency. On the other hand, there were marked differences by grade, with 6th graders benefiting more from lexical frequency and semantic knowledge than 4th and 5th graders. By contrast, 4th graders are more affected by the word length, with more errors in long than in short words. If we look at the sub-lexical units, all the participants committed more errors in the coda, followed by the nucleus and the onset. This is probably due to the characteristics of the coda, which involves more multi-letter units. Regarding the variables determining accuracy in the sublexical units, we found that neither the onset nor the coda seem to be affected by grade or orthographic consistency. However, nucleus accuracy depends on the nucleus (vowel) consistency and the rime consistency, from which 6th graders seem to benefit more than 4th and 5th graders.

The spelling accuracy data inform us about the challenge of spelling in English, an opaque orthographic system, especially for Spanish children, whose native language has a transparent orthography (Figueredo, 2006; Sammour-Shehadeh et al., 2022). We did not study the characteristics of the errors, but linguistic distances between Spanish and English could motivate the huge number of errors. As reported in previous studies, L1 influences EFL spelling, evident when L1 information (e.g., P-O conversion rules, grain-size units) is used to English spelling. The magnitude of the influence depends on the linguistic distance between languages: writing systems, orthography, or phonology (Cummins, 1991; Figueredo, 2006; Sammour-Shehadeh, et al., 2022). In the case of English and Spanish, both are alphabetic languages, but English has some orthographic features that make it very different from Spanish and give rise to a significant number of errors (Bahr et al., 2015; Cronnell, 1985; Fashola et al., 1996; Hevia-Tuero et al., 2022; Howard et al., 2006, 2012; Lindner et al., 2022; Raynolds & Uhry, 2010; Rolla San Francisco et al., 2006; Sun-Alperin & Wang, 2008; Zutell & Allen, 1988). It has been described that the orthographic depth of English force to develop the ability to use grain size units other than phoneme-grapheme correspondences, that are not necessary in transparent orthographies (Ziegler & Goswami, 2005). Moreover, another important constraint relates to the phonemic inventory, as the absence of some English phonemes in L1 could hamper English spelling (Allaith & Joshi, 2011; Hevia-Tuero et al., 2022; Kahn-Horwitz et al., 2011; Russak & Kahn-Horwitz, 2015). In the current study, according to this, we found that the consistency of the vowel (nucleus) determines to a large extent the spelling accuracy. It should be noted that English vowels are very challenging for Spanish people (Fashola et al., 1996; Iverson & Evans, 2009; Sun-Alperin & Wang, 2008). However, older children seem to support on the rime consistency to spell the vowels, indicating the use of a grain-size unit larger than phoneme-grapheme. In addition, results showed that word length determines young children's spelling accuracy, while older children benefit from the lexical frequency and semantic knowledge. It suggests a change of spelling strategy, consequence of spelling exposure and English experience. High-frequency words have strong orthographic representation helping to achieve spelling accuracy, and it seems to be in 6th grade when children are taking advantage of lexical frequency to spell in English. However, the role of semantics should also be mentioned, as knowing the meaning of the word appears to be a determining factor in spelling (Hilte & Reitsma, 2011; Ouellette, 2010; van Rijthoven et al., 2021). These data confirm that knowing the word is fundamental for Spanish children to spell correctly in English, bearing in mind that children in Spain do not receive specific instruction in English spelling.

As for kinematic measures, we found that the semantic knowledge and grade makes the WLs decrease. On the other hand, WLs were also influenced by the onset consistency, but only in 5th and 6th graders. However, lexical frequency does not impact WLs, an unexpected finding, since this effect has been observed in several studies (Afonso, Álvarez, et al., 2015; Afonso, Suárez-Coalla, et al., 2015; Bonin et al., 2016; Lambert et al., 2011). Finally, WDs are determined by different variables. The known words were written faster, and 6th graders wrote faster than 4th and 5th graders. More interestingly, WDs were affected by the nucleus and coda consistency in all grades.

The reduction of the WLs across grades may indicate that older children are faster accessing and retrieving the spelling orthography of words. They are faster than younger children to completing the central processes, and this could be a consequence of spelling experience. The impact of spelling experience has been demonstrated in many studies (Kandel & Valdois, 2005; Rosenmblum, et al., 2003). Contrary to ours results, literature has showed lexical frequency effects in WLs (Afonso, Álvarez, et al., 2015; Afonso, Suárez-Coalla, et al., 2015; Bonin et al., 2016; Lambert et al., 2011). In our case, the effect of frequency has been probably replaced by the effect of semantic knowledge, as children were faster to retrieve the spelling of words they know. This highlights, once again, the importance of the semantic representation in spelling (Hilte & Reitsma, 2011; Ouellette, 2010; van Rijthoven et al., 2021). The relevance of semantic knowledge is perhaps most meaningful in the context of Spanish children learning to spell English as FL. The children in the present study are non-native speakers of English, living in a non-English-speaking country, and receiving limited attention to English spelling rules at school.

It must be added that both grade and semantic knowledge variables impact in WDs, indicating that older children (6th grade) showed a faster graphomotor execution of words than younger children (4th and 5th graders), and the known words were written more quickly than unknown words. This might indicate that a different strategy is used for the latter. Regarding P-O consistency, WDs were affected by nucleus and coda consistency indicating that the orthographic retrieval does not end before the graphomotor execution starts, according to the cascade effect reported in several studies (Bonin et al., 2012). In addition, it suggests that Spanish children have developed a certain sensitivity to English spelling consistency, which allows them to write consistent words more quickly.

In sum, this study informs about the English spelling performance of Spanish children. It is the first study addressing this topic that includes kinematic measures. We observed differences between grades. The cumulative exposure to English may lead to an improvement in spelling for many reasons. One of them is the vocabulary growth, as having semantic knowledge about words facilitates their spelling. Another one is the increasing sensitivity to new spelling patterns and regularities, which older children are able to take advantage of. Such development occurs despite differences between the orthographies of the native and foreign language. Furthermore, the shift from relying on purely letter-by-letter processing to using more complex strategies, adapted to the characteristics of English.

Limitations

Despite the interesting contributions of this study, one of the limitations is the type of task used. Since Spanish children are not as exposed to oral English as their counterparts in United States, the dictation task may be biased by their weak phonological knowledge. It is possible that certain words were not recognized by hearing, or they were recognized after a while, affecting both accuracy and kinematic measures. In this sense, lexical retrieval could differ depending on input modality for these children. This issue should be clarified in future studies.

In addition, it should be interesting to collect data in older children (Secondary education) to know how Spanish children develop spelling strategies and sensitivity to English P-O correspondences. Moreover, more evidence about the effect that syllabic complexity may have on the task may be necessary.

Implications

This study broadens our knowledge about spelling in a FL and has the potential to contributes to improve EFL instruction in Spain. One of our main findings is the awareness of English regularities by 6th graders. This suggests that children become sensitive to this type of information, and, moreover, that they rely on it to spell. Explicit instruction could strengthen their knowledge of the English orthographic conventions, providing them with strategies to spell (and read) words. The facilitation effect of semantic knowledge highlights the relevance of a strong vocabulary to spell in EFL. Considering this, instructors should guarantee that children know the meaning of the words they are using in the class.

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Appendix

Word	Lexical frequ	Lenght	Onset consist	Nucl consist	Coda consist	Rime consist
beach	43	5	0.9993464	0.2490512	0.4214876	0.6315789
beak	9	4	0.9993464	0.2490512	0.1171171	0.4324324
beard	1	5	0.9993464	0.0174037	0.4923077	0.1
bed	33	3	0.9993464	0.7940877	0.7620482	0.3983051
bird	48	4	0.9993464	0.052368	0.4923077	0.3684211
bone	13	4	0.9993464	0.8649425	0.0223089	0.7142857
bread	8	5	1	0.0657492	0.7620482	0.5677966
bridge	30	6	1	0.8236548	0.5849057	1
cat	21	3	0.9195313	0.9951112	0.7043478	0.9423077
cheese	33	6	0.9847095	0.2025617	0.1917808	0.0882353
clock	49	5	0.96875	0.6589123	0.3153153	0.6506024
coat	9	4	0.9195313	0.0948276	0.7043478	0.625
crab	5	4	0.8941799	0.9951112	0.9576271	0.9811321
dad	41	3	0.9990557	0.9951112	0.7620482	0.9418605
desk	4	4	0.9990557	0.7940877	0.826087	1
dog	27	3	0.9990557	0.5382831	0.9356061	0.8
doll	5	4	0.9990557	0.6589123	0.1709402	0.1071429
door	17	4	0.9990557	0.0110209	0.8813861	0.0305344
foot	2	4	0.8971722	0.4132029	0.7043478	0.8571429
frog	13	4	0.9770115	0.6589123	0.9356061	0.9615385
gate	6	4	0.9772727	0.724749	0.1217391	0.6949153
girl	47	4	0.9772727	0.052368	1	0.5714286
glove	9	5	1	0.1655961	0.9279279	0.875
grape	6	5	1	0.724749	0.1339286	0.9
hat	26	3	0.981904	0.9951112	0.7043478	0.9423077
heart	12	5	0,981904	0.0069161	0.9782609	0.3076923
horse	30	5	0.981904	0.5382831	0.7674419	0.56
job	53	3	0.6794055	0.6589123	0.9576271	0.9615385
king	32	4	0.0617188	0.8236548	0.3346693	0.3671498
leaf	19	4	0.998227	0.2490512	0.5078534	0.2173913
leg	17	3	0.998227	0.7940877	0.9356061	0.7619048
life	40	4	0.998227	0.7666864	0.1465969	1
luck	2	4	0.998227	0.3360915	0.3153153	0.2972973
man	28	3	1	0.9951112	0.962963	0.9934641
meal	9	4	1	0.2490512	0.7264957	0.225
month	16	5	1	0.1655961	1	1
moon	17	4	1	0.2312824	0.962963	0.65625
mouse	6	5	1	0.6772247	0.091224	0.96875
mouth	8	5	1	0.6772247	0.9591837	0.9166667
night	32	5	0.9058488	0.7666864	0.1304348	0.7093023
noise	8	5	0.9058488	0.6823529	0.1917808	0.5
nose	14	4	0.9058488	0.8649425	0.1917808	0.4324324
noun	8	4	0.9058488	0.6772247	0.962963	0.761194

path	10	4	1	0.9951112	0.9591837	1
pen	16	3	1	0.7940877	0.962963	0.9930716
queen	20	5	0.9627329	0.0033207	0.962963	0.0487805
rice	10	4	0.9564835	0.7666864	0.091224	0.9333333
road	15	4	0.9564835	0.0948276	0.7620482	0.4117647
room	73	4	0.9564835	0.2312824	0.8884263	0.5
shark	6	5	0.895122	0.2980195	0.9090909	0.7777778
shirt	20	5	0.895122	0.052368	0.9782609	0.4
skin	11	4	0.3232323	0.8236548	0.962963	0.9198556
spoon	26	5	1	0.2312824	0.962963	0.65625
stair	4	5	1	0.0262487	0.8813861	0.4301676
street	30	6	1	0.2025617	0.7043478	0.4347826
wall	20	4	0.988111	0.225058	0.1709402	0.288
week	64	4	0.988111	0.2025617	0.1171171	0.4324324
wood	32	4	0.988111	0.4132029	0.7620482	0.9666667

Discusión general

Las características de las ortografías del español y del inglés hacen que los procesos de lectura y escritura no sean iguales en ambas lenguas. Esto supone que durante el aprendizaje bilingüe los niños deben adaptarse y aprender a utilizar las estrategias más adecuadas para procesar cada sistema ortográfico. Existen evidencias sobre el aprendizaje de la lectoescritura en inglés por parte de hablantes de otras lenguas y habitantes de otros países. Aunque estos estudios sirven de referencia, la importancia de los factores lingüísticos y educativos hace que los hallazgos no puedan transferirse totalmente al caso de los niños españoles. Este trabajo tenía como objetivo principal conocer cómo es el aprendizaje de la lectura y la escritura en inglés de los niños españoles de Educación Primaria. Mediante diversos estudios se pretendía investigar los conocimientos que los niños españoles tienen sobre la ortografía y la fonología del inglés, las fuentes de información y las estrategias en las que se apoyan durante el procesamiento, y la gestión que realizan de las posibles influencias cros-lingüísticas del español.

Estudio 1

Para estudiar el aprendizaje de la lectura y la escritura en inglés como LE, fue necesario comenzar investigando dos aspectos fundamentales: la gestión de las incongruencias y la adaptación a distintos tamaños de grano. En los sistemas ortográficos del inglés y del español existen grafemas compartidos que no tienen las mismas correspondencias en una lengua y otra. Estas incongruencias generan un conflicto que puede dificultar el procesamiento. Por otro lado, en la ortografía del inglés también existen elementos novedosos, como los grafemas complejos, que no existen en español. Para procesarlos, serán necesarias estrategias específicas para un tamaño de grano superior al que los españoles están habituados. Con el fin de comprobar cómo los niños españoles de diferentes cursos de Educación Primaria gestionan el conflicto entre correspondencias y se adaptan a nuevos tamaños de grano, en el primer estudio se investigaron los efectos de la congruencia y de la complejidad grafémica. Se diseñaron dos tareas de detección de letras basadas en la metodología descrita en estudios previos (Rey et al., 2000; Commissaire et al., 2014), pero con la novedad de la incorporación del paradigma de seguimiento del ratón. En el primer experimento se manipuló la congruencia de las correspondencias grafema-fonema, comparando grafemas congruentes (detectar la *a* en *park*) e incongruentes (detectar la *a* en *name*) con el español. En el segundo experimento se manipuló la complejidad del grafema, comparando grafemas simples (detectar la *a* en *park*) y complejos, siendo estos específicos del inglés (detectar la *a* en *beach*). Los resultados indican que el efecto de la congruencia sólo afectó a los estudiantes más jóvenes, con diferencias que únicamente emergieron en las trayectorias del ratón. En cambio, la complejidad afectó a todos los participantes, pues detectaron con mayor facilidad las letras en los grafemas simples.

Los hallazgos del primer experimento (congruencia) sugieren que los niños españoles aprenden progresivamente a inhibir las correspondencias de su propia lengua, adaptándose a la inconsistencia del inglés sin dejar que el español influya en el procesamiento. La fonología de ambas lenguas se activa de manera no selectiva durante las etapas iniciales del aprendizaje, posiblemente por la limitada experiencia de los niños españoles. Esto concuerda con otros estudios, en los que se señala el inicio del aprendizaje de la ortografía de L2/LE como una etapa sensible a las influencias cros-lingüísticas (Bialystok et al., 2005; Jared et al., 2012; Sun-Alperin & M. Wang, 2008). La gestión de las influencias cros-lingüísticas mejora con el incremento de la competencia y del nivel de exposición al inglés. Estos resultados no coinciden con los encontrados en otras poblaciones aprendiendo inglés, como los adolescentes franceses (Commissaire et al., 2014). Es posible que las influencias entre lenguas sean más pronunciadas cuando ambas ortografías son profundas. Asimismo, es probable que la edad de inicio del aprendizaje del inglés, que en Francia es más tardía que en España, también influya en los resultados. Más años de experiencia lectora exclusivamente en la lengua nativa podrían implicar un menor desarrollo de las habilidades para inhibir la lengua no-objetivo.

Los resultados de complejidad indican que los niños españoles son capaces de interiorizar los grafemas específicos del inglés. El efecto de complejidad está originado por un conflicto de coactivación de unidades (letra y grafema). Las letras se detectan peor en los grafemas complejos, pues estos se procesan como una unidad en sí mismos. Los niños españoles se comportarían de manera similar a nativos (Rey et al., 2000; Marinus & de Jong, 2011) y a otros bilingües (Commissaire et al., 2014). El efecto de complejidad fue mayor en los niños de cursos inferiores, algo que podría deberse al uso de estrategias de procesamiento serial. Aunque Marinus y de Jong descartaron esta explicación en un estudio similar con nativos holandeses (2011), la edad de los participantes de nuestro estudio y las características de la ortografía española nos impiden rechazar esta posibilidad. Los niños de cursos superiores, en cambio, estarían recurriendo a un procesamiento léxico global.

En conjunto, los resultados de ambos experimentos indican una adaptación al procesamiento de una ortografía con mayor profundidad e inconsistencia que la de la lengua nativa. Esta adaptación se ha reportado en diversos conjuntos de ortografías, como francés-alemán (de León Rodríguez et al., 2016), inglés-galés (Egan et al., 2019), francés-español (Lallier et al., 2014), y francés-vasco (Lallier et al., 2016). Nuestro estudio confirma que esto también ocurre en español-inglés.

Estudio 2

La habilidad para gestionar elementos incongruentes y la adaptación a las nuevas estrategias de procesamiento son necesarias para leer y escribir en inglés, pero la adquisición de la lectoescritura no es posible sin el aprendizaje del código alfabético. Un conocimiento de las correspondencias entre grafemas y fonemas permitirá la decodificación, que posteriormente facilitará la construcción de representaciones ortográficas (Share, 1995). Los niños españoles tendrán que aprender las correspondencias del inglés como LE e integrar la ortografía y la fonología de esta lengua. En el segundo estudio se quería conocer de qué manera influyen la edad y la exposición en el aprendizaje de las reglas de correspondencia grafema-fonema. Esto se comprobó mediante el estudio de la activación de la fonología durante el reconocimiento visual de palabras y pseudohomófonos.

Coincidiendo con hallazgos de otros autores (Commissaire et al., 2019; Nas, 1983), los resultados de este estudio confirman que los niños españoles son sensibles al efecto de los pseudohomófonos, y por tanto activan la fonología durante el procesamiento ortográfico. Además, las diferencias entre cursos y entre colegios sugieren que una mayor exposición contribuye a mejorar el desarrollo ortográfico, facilitando la formación de representaciones ortográficas y la consolidación de las correspondencias grafema-fonema. Por otra parte, los niños más mayores y los niños del colegio bilingüe rechazaron de manera más eficiente las correspondencias del español. Esto sugiere que un aumento de la competencia en la L2/LE ayuda a desarrollar una mejor inhibición de la lengua nativa, coincidiendo con lo encontrado en la literatura (Jarvis & Pavlenko, 2008). Esta eficiencia para rechazar las correspondencias del español indica que los niños se vuelven sensibles a los marcadores ortográficos (Casaponsa et al., 2014; van Kesteren et al., 2012), y demuestra que son capaces de discriminar entre la ortografía del inglés y la del español al poco de comenzar su aprendizaje. Un hallazgo inesperado fueron las diferencias de procesamiento de las correspondencias del inglés en los niños más mayores, observables a través del patrón de respuesta. Las trayectorias del ratón demostraron que los pseudohomófonos ingleses provocaban una mayor activación de la fonología en los niños del colegio bilingüe. Un mayor conocimiento e interiorización de las reglas de correspondencia del inglés podría explicar esta activación.

Los resultados obtenidos en el segundo estudio indican que los niños españoles activan automáticamente las reglas específicas del inglés durante la lectura. También sugieren que el método de enseñanza puede influir en la lectura en inglés como L2/LE, pues la manera en la que los niños están expuestos a inglés determina cómo integran la ortografía y la fonología.

Estudio 3

Pero además del método de enseñanza, existen otros factores que determinan la adquisición de la lectoescritura. Las oportunidades de exposición y de uso de la lengua también influyen en el desarrollo fonológico y ortográfico, los cuales tendrán repercusión en el aprendizaje de la lectura y la escritura. Además, en ambientes bilingües los niños tendrán que lidiar con interferencias tanto de su propia lengua (intra-lingüísticas) como de la lengua no-objetivo (inter-lingüísticas). Esto motivó el tercer estudio, en el que se comparó el procesamiento de dos grupos de participantes: niños de un centro bilingüe de España y niños de un centro bilingüe de Estados Unidos. El objetivo de este estudio era comprobar el efecto que ejercía la lengua dominante del país de origen y la lengua con la que se construían los estímulos en el procesamiento visual de palabras en inglés. Esto se llevó a cabo mediante una tarea de decisión léxica visual con pseudohomófonos.

Los resultados indicaron que los participantes de ambos países descartaban con mayor facilidad las correspondencias del español, demostrando que la interferencia ortográfica intra-lingüística es más potente que la inter-lingüística. La interferencia puede estar producida por la presencia de marcadores ortográficos (Casaponsa et al., 2014; van Kesteren et al., 2012), que hacen que su rechazo sea más difícil que el de patrones similares al español. Esto sugeriría que todos los niños tienen un conocimiento de los patrones específicos de la ortografía del inglés, y que se apoyan en los marcadores ortográficos a la hora de reconocer una palabra o descartarla. De hecho, estudios sobre identificación de la membresía de la lengua sostienen que este proceso puede tener lugar antes del procesamiento léxico (Hoversten et al., 2017) y semántico (Hoversten et al., 2015). Teniendo en cuenta estos hallazgos, es posible que en nuestro estudio el rechazo de las correspondencias del español se haya producido antes de que concluyera la decodificación. En concordancia con los resultados de Oganian y colaboradores (2015), ciertos elementos subléxicos informarían sobre la identidad de la lengua y permitirían una toma de decisión basada en ésta, sin necesidad de acceder a las representaciones ortográficas del inglés. En cuanto al resto de estímulos, los bilingües de Estados Unidos mostraban un mejor rendimiento que los bilingües de España. A pesar de la exposición bilingüe que ambos grupos de participantes reciben, otros factores ajenos al entorno escolar moldean el procesamiento de la lectura. Tanto la cantidad y el tipo de exposición a la lengua, como el contexto de aprendizaje influyen en la adquisición de la lectoescritura (Gilquin, 2016; Sammour-Shehadeh et al., 2022).

Por otra parte, gracias al paradigma de seguimiento del ratón se observaron diferencias en el patrón de respuesta a los pseudohomófonos formados con las correspondencias del inglés. Estudios previos realizados con MouseTracker han mostrado patrones compensatorios similares en bilingües realizando otras tareas (Incera &

McLennan, 2016). Nuestros resultados confirman que los bilingües de Estados Unidos no sólo son más eficientes, sino que su procesamiento también es distinto. Los niños de Estados Unidos mostraron una desviación inicial más fuerte hacia la respuesta incorrecta (esto es, reconocer el pseudohomófono como una palabra real), seguida de un movimiento correctivo más eficiente hacia la respuesta correcta (rechazar el pseudohomófono). Esto podría explicarlo una fuerte activación de la fonología de las palabras reales, seguida de una respuesta compensatoria muy efectiva. La activación fonológica de los niños de Estados Unidos podría deberse a su mayor exposición al inglés, mientras que la respuesta compensatoria se podría producir por un mayor apoyo en estrategias léxicas. Como respuesta a la inconsistencia de la ortografía del inglés, se desarrollara un mecanismo de verificación ortográfica, cuya existencia sugirieron Ziegler, Jacobs y Klüppel (2001). Aunque sería necesario investigar esto en mayor profundidad, nuestros resultados con las trayectorias del ratón parecen no solo confirmar la existencia de este mecanismo, sino también mostrar el momento exacto de su intervención.

Estudio 4

Gracias a estos estudios se pudo comprobar qué estrategias aplican los niños españoles durante el procesamiento visual del inglés. Los resultados también demostraron la interiorización de la fonología y las convenciones ortográficas. Sin embargo, no aportaron información sobre qué conocimiento fonológico, ortográfico y morfológico del inglés tienen los niños, y el uso que hacen de cada uno de ellos. Ambos aspectos se ven reflejados de manera muy clara en los errores de escritura. Por eso, en el cuarto estudio se recopilaron narraciones escritas en inglés por niños de diferentes cursos de Primaria. De estas narraciones se obtuvieron errores de escritura, que fueron analizados en base a la teoría de la triple forma de la palabra y clasificados según el sistema POMAS. Los resultados indicaron que cuando escriben en inglés los niños españoles se apoyan en las tres fuentes de conocimiento (fonología, ortografía y morfología). Sin embargo, el patrón de desarrollo no sigue el de los niños nativos (Bahr et al., 2012), pues en el caso de nuestros participantes los errores fonológicos fueron similares en todos los cursos. Esto sugiere un desarrollo mediado por factores educativos y lingüísticos, en lugar de por factores evolutivos. Los errores más frecuentes fueron los ortográficos, en consonancia con otros estudios realizados en bilingües (Bahr et al., 2015). Por otra parte, si bien los niños más mayores tuvieron un porcentaje menor de errores, estos persisten. Este hallazgo coincide con otros estudios de errores de escritura en inglés como L2/LE, realizados tanto en hablantes de español (Lindner et al., 2022) como de otras lenguas (Russak & Kahn-Horwitz, 2015; Russak, 2022). El origen podría ser la combinación de la complejidad de la ortografía del inglés con la ausencia de una enseñanza explícita de los patrones ortográficos. Así, aunque suplan sus carencias gracias a la formación de representaciones ortográficas (Shahar-Yames & Share, 2008; Share, 1995), los niños seguirán construyendo un vocabulario y encontrando nuevas palabras con las que corren el riesgo de seguir cometiendo errores.

Los errores analizados también sirvieron para identificar los elementos del inglés con los que los niños españoles parecían tener más dificultades. Dentro de los errores fonológicos, la mayoría de los fonemas implicados eran novedosos para los hablantes de español, lo cual apoya la hipótesis de restricción de la afiliación lingüística (Russak & Saiegh-Haddad, 2011; Saiegh-Haddad et al., 2011). Una menor familiaridad con los fonemas específicos ingleses y la ausencia de un equivalente en la lengua nativa implicará una mayor dificultad, tal y como se ha demostrado en estudios realizados con hablantes de hebreo (Russak, 2022; Russak & Saiegh-Haddad, 2011; Wade-Woolley & Geva, 2000), árabe (Russak, 2022), chino (M. Wang & Geva, 2003) y español (Raynolds et al., 2013).

En cuanto a los errores ortográficos, los elementos que representaron una mayor dificultad coincidían con aquellos señalados en otros estudios realizados en población hispanohablante (Bahr et al., 2015; Cronnell, 1985; Fashola et al., 1996; Howard et al., 2006, 2012; Lindner et al., 2022; Raynolds & Uhry, 2010; Rolla San Francisco et al., 2006; Sun-Alperin & M. Wang, 2008; Zutell & Allen, 1988). Los elementos novedosos del inglés fueron los afectados principalmente, como las vocales largas, las letras silentes, los dígrafos, o los grafemas dobles, entre otros. No obstante, también se detectaron dificultades para representar grafemas y fonemas cuya correspondencia es incongruente con la del español. Aunque algunos de los errores también han sido reportados en hablantes de otras lenguas, como italiano (Palladino et al., 2016) o hebreo (Russak & Kahn-Horwitz, 2015), otros sólo estaban presentes en población hispanohablante (Howard et al., 2006). Esto apunta a que la dificultad que representan algunos elementos del inglés podría depender de la lengua nativa.

El análisis de estos errores sugiere que son originados por un conocimiento ortográfico del inglés insuficiente. No obstante, la diversidad observada en las producciones parece responder a las distintas estrategias que los niños utilizan para compensar sus limitaciones. Así, algunos errores son el resultado de un apoyo en las reglas del español. Estos errores serán más evidentes durante las primeras etapas del aprendizaje (Zdorenko & Paradis, 2008). Otros se deben a una excesiva generalización de los patrones de escritura del inglés (Bahr et al., 2015), los cuales son comunes en etapas más avanzadas, cuando los niños son más competentes y tienen mejor conocimiento de las reglas del inglés. Por otro lado, se detectó el uso de patrones que, pese a estar mal aplicados, demostraban una conciencia emergente de rasgos y elementos específicos de la ortografía inglesa. Esto incluyó a los dígrafos como *th* o *sh*, o a los grafemas dobles, un patrón cuyo aprendizaje también resulta difícil para los nativos (Bourassa & Treiman, 2003; Cassar & Treiman, 1997). En algunos casos, estas convenciones se aplicaron a grafemas incorrectos (*funyy* en lugar de *funny*, *shcool* en lugar de *school*). Este fenómeno sugiere que, ante la certeza de la presencia de un elemento dado (pero el desconocimiento de su posición dentro de la palabra), los niños recurren a una estrategia de recuperación ortográfica basada en la memoria visual. Esta estrategia ha sido descrita con anterioridad en nativos con habilidades fonológicas limitadas (Lennox & Siegel, 1996). En el caso de nuestros participantes, podría explicarse por un escaso conocimiento ortográfico y fonológico, así como por la borrosidad y baja precisión de las representaciones léxicas en la L2/LE (Bordag et al., 2022; Gor et al., 2021).

En resumen, el cuarto estudio aportó información sobre como los niños españoles aprendiendo inglés como L2/LE comienzan a coordinar múltiples fuentes de conocimiento para escribir. También sirvió para observar cómo es el patrón de desarrollo, el cual parece estar más influido por factores lingüísticos y educativos que por factores evolutivos. Asimismo, confirmó los elementos de la ortografía inglesa que suponen una mayor dificultad para los niños españoles.

Estudio 5

Si bien la tarea de escritura espontánea aportó mucha información sobre los conocimientos del sistema ortográfico del inglés, no deja de estar limitada al vocabulario que los niños pudieran conocer y decidieran utilizar. Por ello, en el quinto y último estudio se diseñó una tarea de escritura al dictado que fue completada por niños españoles de diferentes cursos de educación Primaria. En este estudio, el primero en investigar la escritura en inglés como L2/LE mediante medidas kinemáticas, se comprobó la posible influencia de la frecuencia léxica, la longitud, la consistencia fonema-grafema en segmentos subsilábicos y el conocimiento semántico. Los resultados se caracterizan por el alto número de errores, posiblemente debidos a la distancia entre las ortografías del inglés y el español. Esto destaca la dificultad de aprender a escribir en una ortografía más profunda que la de la lengua nativa (Figueredo, 2006; Sammour-Shehadeh et al., 2022). Debido al grado en el que la fonología estaba involucrada en la tarea, no podemos descartar por completo que las limitaciones fonológicas de los niños españoles hayan perjudicado la ejecución de la tarea, pues es posible que ciertas palabras no fueran reconocidas de forma oral, o fueran reconocidas de manera posterior.

El análisis de exactitud indicó que los niños más jóvenes parecen tener más dificultades para escribir correctamente las palabras de mayor longitud, las cuales podrían estar originadas por el apoyo en una estrategia de procesamiento serial. Por el contrario, la frecuencia léxica y el conocimiento semántico ejercieron un efecto facilitador en los alumnos más mayores, pues cometieron menos errores con las palabras frecuentes y con aquellas cuyo significado conocían. El efecto de la frecuencia léxica podría explicarse por la creación de representaciones ortográficas tras años de enseñanza. Esto indicaría un cambio en las estrategias de procesamiento, como consecuencia de la experiencia y el incremento de la exposición a la ortografía del inglés. En cuanto a la semántica, conocer el significado de la palabra fue un factor determinante, en la línea de otras investigaciones (Hilte & Reitsma, 2011; Ouellette, 2010; van Rijthoven et al., 2021). En cuanto a los segmentos subsilábicos, la mayor parte de los errores se localizaron en la coda, algo que podría explicarse por la presencia habitual de grupos consonánticos al final de las palabras. El núcleo fue el único segmento de cuya consistencia dependió la exactitud, pues al escribir vocales muy consistentes se cometían menos errores. En la exactitud para escribir el núcleo también influyó la consistencia de la rima (formada por núcleo + coda), siendo los alumnos más mayores los que se beneficiaron en mayor medida. Cabe destacar que las vocales son uno de los elementos más difíciles de representar para los hablantes de español (Fashola et al., 1996; Iverson & Evans, 2009; Sun-Alperin & M. Wang, 2008). Si son consistentes, serán más fáciles de escribir correctamente, sobre todo para los niños más mayores. Estos también se apoyan en la consistencia de la rima, indicando que procesan unidades lingüísticas con un tamaño de grano mayor que el fonema-grafema.

Los resultados para las medidas kinemáticas indicaron que las latencias y las duraciones de escritura fueron menores para las palabras cuyo significado era conocido. La frecuencia léxica no influyó en ningún caso, algo inesperado considerando la literatura previa (Afonso, Álvarez, & Kandel 2015; Afonso, Suárez-Coalla, & Cuetos, 2015; Bonin, Fayol & Chalard, 2001; Bonin & Fayol, 2002; Lambert et al., 2011). Es posible que en nuestros participantes el efecto de conocimiento semántico haya desplazado al efecto de frecuencia. Estos hallazgos, por otra parte, apuntan a la utilización de una estrategia diferente para escribir aquellas en las que la representación semántica no está disponible. Por otro lado, los niños más mayores demostraron una ejecución grafomotora de las palabras más rápida, comenzando a escribir antes que sus compañeros de menor edad, y tardando menos en terminar. Esto sugiere que son más rápidos accediendo y recuperando la ortografía de las palabras y completando los procesos centrales, lo que podría explicarse por una mayor experiencia con la escritura (Kandel & Valdois, 2006). La consistencia de los segmentos subsilábicos también les influyó en su ejecución: la consistencia del onset disminuyó las latencias, iniciándose antes la escritura de palabras cuando el inicio era más consistente; de igual forma, los núcleos y las codas más consistentes acortaban la duración de la escritura, aunque este efecto se produjo en todos los participantes y no sólo en los más mayores. Este último hallazgo indica, por una parte, que la recuperación ortográfica no termina antes de que empiece la ejecución grafomotora, de acuerdo con el efecto cascada (Bonin et al., 2012). Por otra, sugiere que los niños españoles desarrollan cierta sensibilidad a la consistencia ortográfica del inglés que les permite escribir las palabras consistentes más rápidamente.

Los hallazgos de ambos análisis (exactitud y medidas kinemáticas) parecen indicar que la exposición acumulada al inglés conduce a una mejora en la escritura por diferentes razones. El aumento de vocabulario podría ser uno de ellos, teniendo en cuenta la relevancia del conocimiento semántico de las palabras. Otra podría ser la creciente sensibilidad a los patrones de escritura y las regularidades del inglés, en los que los niños más mayores parecen apoyarse. Así, los resultados apuntan a un cambio de estrategia, por el que los niños dejan de apoyarse en un procesamiento puramente serial (letra a letra) y pasan a utilizar estrategias más complejas adaptadas a las características ortográficas del inglés. Esto ocurre pese a las diferencias en profundidad ortográfica entre el inglés y el español y lo que es más importante, pese a la falta de una enseñanza explícita. En este sentido, es posible que una enseñanza específica de las convenciones ortográficas del inglés potenciara el conocimiento que ya adquieren de manera implícita los niños, equipándoles con más estrategias para leer y escribir en inglés.

En conjunto, los cinco estudios realizados aportan información sobre el aprendizaje de la lectura y escritura en inglés de los niños españoles. El proceso se ve dificultado por la complejidad y profundidad de la ortografía del inglés y sus diferencias con la del español, así como por la falta de enseñanza explícita y las limitaciones en el aprendizaje de la fonología. A pesar de esto, los resultados indican que, tras años de exposición a la lengua, los niños tienen un mejor conocimiento del código ortográfico del inglés y han desarrollado ciertas adaptaciones para su procesamiento.

Estudios como los incluidos en este trabajo tienen el potencial de contribuir a la mejora de la enseñanza del inglés como lengua extranjera en España. La investigación es imprescindible para diseñar programas de educación bilingües específicos y acordes a las necesidades de la población en la que van a ser aplicados, en este caso niños españoles de Educación Primaria. Las condiciones educativas y culturales de nuestro país no favorecen la exposición oral y el aprendizaje del inglés de manera ecológica y natural. Y, por ahora, las políticas de educación actuales tampoco contemplan una enseñanza explícita del código ortográfico del inglés. Tal y como Miller (2019) sugiere, es importante que los profesores no subestimen las dificultades que supone aprender una ortografía tan profunda como la del inglés, y que además difiere tanto de la española. Leer y escribir en otra lengua no solo es cuestión de aprender un nuevo conjunto de símbolos, sino que también implica la adaptación a nuevas formas de procesamiento y nuevas correspondencias. Conocer aún más en detalle estos aspectos permitiría desarrollar estrategias *ad hoc* para la enseñanza. De lograr su aplicación en el aula, sería posible facilitar el desarrollo de la lectura y la escritura en inglés como lengua extranjera de los niños españoles de Educación Primaria.

Conclusiones/conclusions

Conclusiones

1. Los niños españoles interiorizan la ortografía del inglés desde edades tempranas, y son capaces de reconocerla y distinguirla del español. También aprenden a procesar unidades con tamaños de grano distintos a los de su lengua nativa al poco tiempo de comenzar su instrucción.

2. El nivel y la calidad de la exposición al inglés, la lengua dominante del entorno y el método de enseñanza influyen en el aprendizaje de la lectura. Concretamente, tienen efectos sobre los patrones de procesamiento y sobre el nivel de activación de la fonología durante el reconocimiento visual de palabras en inglés.

3. El desarrollo de la escritura en inglés como LE sigue un patrón diferente al de los nativos, al estar condicionado por factores lingüísticos y educativos. Además, está definido por la existencia de elementos característicos del inglés que no existen en español. Algunos de ellos suponen una dificultad específica para los nativos españoles.

4. La influencia de la lengua nativa depende de la competencia de los niños y de la distancia lingüística entre el inglés y del español. Los niños se apoyan en el español cuando su conocimiento es insuficiente para las demandas de la tarea, aplicando las correspondencias del español o utilizando estrategias de procesamiento propias de ortografías transparentes.

5. La ganancia de experiencia y la exposición acumulada contribuyen a un cambio evolutivo al final de la etapa de Educación Primaria. Los niños pasan por un proceso de adaptación, por el cual abandonan el procesamiento serial y comienzan a apoyarse en estrategias de procesamiento más apropiadas para la ortografía inglesa.

6. A pesar de la limitada exposición al inglés y de la ausencia de una enseñanza explícita de las convenciones ortográficas, los niños españoles desarrollan una sensibilidad a las regularidades y reconocen los patrones ortográficos del inglés. Además, se apoyan en esta información para poder leer y escribir correctamente.

7. Los niños se apoyan en diversas fuentes de conocimiento durante la lectura y la escritura, como la fonología, la ortografía y la morfología. También se apoyan en el conocimiento semántico, en los marcadores ortográficos y en la consistencia de las vocales y de las rimas.

Conclusions

1. Spanish children interiorize English orthography from an early age. They are able to recognise it and they distinguish it apart from Spanish orthography. They also learn to process different grain size units soon after beginning their instruction.

2. The quality and level of exposure to English, the dominant language in the environment, and the instructional methods have influence on learning to read. In particular, they shape processing patterns and affect the level of phonological activation during visual word recognition.

3. Spelling development patterns are different for a native speaker and for an English as a foreign language learner, as the latter is constrained by linguistic and educational factors. Moreover, there are unique elements of English orthography that pose specific challenges for Spanish speakers.

4. The influence of native language depends on the children's proficiency and the linguistic proximity between Spanish and English. Children rely on their native language when their English knowledge is insufficient for the demands of the task. This reliance translates into the appliance of Spanish correspondences, or the use of processing strategies that are more suitable for transparent orthographic systems.

5. Increasing experience and cumulative exposure contribute to a developmental shift at the end of the Primary Education stage. Children adapt to the requirements of English orthography, and they reduce their reliance on serial processing strategies.

6. Despite their limited exposure to English, and the lack of explicit instruction in orthographic conventions, Spanish children develop a sensitivity to statistical regularities, and they recognise English orthographic patterns. They also take advantage of this information during reading and spelling.

7. Children rely on different sources of knowledge during reading and spelling, such as phonology, orthography and morphology. Furthermore, they benefit from semantic knowledge, orthographic markers and vowel and rime consistencies.

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