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Orthographic and Phonological Coding during L2 Visual Word Recognition in L2 Learners: Lexical and Sublexical Mechanisms

Eva Commissaire

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Committee.

Pr. Séverine Casalis, Université Lille Nord de France	Supervisor (France)
Dr. Lynne G. Duncan, University of Dundee	Supervisor (UK)
Pr. Yann Coello, Université Lille Nord de France	Internal Examiner (France)
Pr. Trevor Harley, University of Dundee	Internal examiner (UK)
Dr. Jonathan Grainger, Université Aix en Provence	External Examiner (France)
Dr. Walter Van Heuven, University of Nottingham	External Examiner (UK)

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I think, at a child's birth, if a mother could ask a fairy godmother to endow it with the most useful gift, that gift should be curiosity.

Eleanor Roosevelt

Quien aprende una nueva lengua adquiere una nueva alma

Juan Ramon Jimenez, *Pensamientos*

Table of Contents

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DECLARATION

I declare that I am the author of this thesis, and unless otherwise stated, all references cited have been consulted by me. The work of which this thesis is a record has been carried out by myself and it has not previously been accepted for a higher degree.

Signed: ....

Éva Commissaire

I confirm, as thesis supervisor, that the conditions of the relevant Ordinance and Regulations for the Ph.D. degree have been fulfilled.

Signed: ....

Séverine Casalis

Signed: ....Lynne G. Duncan...

Lynne G. Duncan

Abstract.

While major breakthroughs were made in the last decades on lexical access in highly proficient bilinguals, little is known about the development of lexical *and* sublexical orthographic representations in second language (L2) learners whose vocabulary is rudimentary. The present thesis attempted to fill this gap by examining visual word recognition mechanisms in French learners of English (Secondary Grade 6 and Grade 8 children; adults). While Chapters 1 and 2 focused on *lexical* and *sublexical* orthographic representations respectively, Chapter 3 examined the orthography to phonology interface. Masked orthographic priming techniques revealed that lexical orthographic representations were finely-tuned after only two years of acquisition and that this coding was comparable for words of varying orthographic typicality (Study 1). Evidence in favour of language non-selectivity during lexical access was uncovered: a cognate inhibition effect emerged in Grade 8 for lexical decision (Study 2). In addition, tests of cross-language orthographic neighbourhood effects using masked priming, revealed cross-language lexical competition in the highest proficiency group only (Study 3). Intriguing evidence of facilitation effects in lexical decision for L2 words whose orthography was shared across languages compared to words whose orthography was L2 specific signalled the influence of orthographic typicality during L2 visual word recognition (Study 4). Grapheme coding was also shown to be functional after only a few months of L2 learning, although differences emerged across proficiency levels in relation to the orthographic typicality of graphemes (Study 5). Finally, evidence was found for the parallel activation of print-to-sound correspondences from both languages in young L2 learners (Study 6) and for the influence of first language correspondences

on L2 visual word recognition (Study 7). While these findings have important theoretical implications for models of bilingual visual word recognition, the data also point to the need to intensify research on L2 learners for whom word recognition mechanisms may differ subtly from those of highly proficient bilinguals.

Résumé

Depuis ces dernières décennies, un nombre croissant d'études sur la reconnaissance visuelle de mots chez l'adulte bilingue a émergé dans la littérature, abordant principalement la question de la sélectivité à la langue versus non sélectivité de l'accès au lexique. Les chercheurs ont notamment rapporté la co- activation des représentations orthographiques lexicales de chaque langue dans les étapes initiales de l'accès au lexique, ainsi que l'activation parallèle et automatique des correspondances grapho- phonologiques de chacune des langues. Cependant, force est de constater que peu de données existent sur l'acquisition d'une langue seconde (L2) chez des apprenants encore peu compétents dans la L2, un cadre d'apprentissage très répandu dans les pays industriels étant l'apprentissage en contexte scolaire. Certains défis que doivent relever ces apprenants pour atteindre une reconnaissance rapide, efficace et automatique des mots en L2 représentent pourtant des questions théoriques pertinentes, qui, par la même occasion, permettent de soulever certaines faiblesses dans les modèles existants de la reconnaissance visuelle de mots chez le bilingue. Parmi ces acquisitions particulières, citons le cas des représentations orthographiques sublexicales spécifiques à la langue seconde, pour lesquelles l'apprenant doit constituer de nouvelles correspondances grapho- phonologiques (par exemple, des graphèmes spécifiques et leur(s) représentation(s) phonémique(s) correspondante(s)) ou encore celui des représentations orthographiques sublexicales partagées entre les deux langues, dont les correspondants phonologiques peuvent cependant être incompatibles. Après examen de la littérature monolingue et bilingue sur la reconnaissance visuelle de mots, le présent écrit de thèse consigne les différentes contributions empiriques de mon travail de doctorat sous forme

de trois chapitres. La population d'intérêt était constituée d'enfants et d'adultes francophone apprenant (ou ayant appris) l'anglais comme langue seconde en milieu scolaire, à raison de trois ou quatre heures hebdomadaires, sans autre exposition à cette langue (ni environnement familial bilingue, ni expérience linguistique dans le pays). Notons qu'une étude de ce travail était par ailleurs conduite chez des anglophones apprenant le français langue seconde. Tandis que les Chapitres 1 et 2 abordent des thématiques relatives aux représentations orthographiques lexicales et sublexicales respectivement, le Chapitre 3 est centré sur l'interface orthographe- phonologie.

Deux questions étaient soulevées dans le Chapitre 1. Tout d'abord, le niveau de *précision* des représentations lexicales en L2 était évalué dans l'étude 1 afin de tester l'hypothèse de « lexical tuning » développée par Anne Castles et ses collègues chez des enfants monolingues. Cette hypothèse suggère qu'au fur et à mesure de l'acquisition de vocabulaire écrit au cours de l'apprentissage de la lecture, le codage de l'identité et de la position des lettres, nécessaire à la formation de représentations orthographiques, deviendrait de plus en plus précis. Afin d'évaluer le degré de précision des représentations orthographiques en L2, une tâche de décision lexicale en anglais (L2) associée au paradigme d'amorçage masqué était proposé à des élèves francophones en classe de 4ème, après deux années d'acquisition de l'anglais, et à des étudiants en 1er cycle d'université, hors études linguistiques, ayant appris l'anglais pendant sept années lors de leur parcours scolaire. Trois conditions d'amorçage était constituées : amorçage identité (*boat – BOAT*), amorçage formel (*doat – BOAT*) et amorçage non relié (*gick – DOAT*). Bien que les conditions d'amorçage identité et formel étaient supposées déclencher un effet facilitateur dans les temps de réponse sur la cible – par rapport à la condition d'amorçage non relié- l'idée sous- jacente était qu'une différence entre les conditions d'amorçage identité et formel refléterait l'existence d'un codage précis de l'identité des lettres. Afin d'évaluer l'influence de la typicalité orthographique sur le degré de précision des représentations, deux types de mots cibles étaient proposés : des cibles dites « spécifiques de l'anglais », dont l'orthographe est très typique de l'anglais du point de vue d'un francophone (par exemple, des mots tels que *think*), et des cibles dites « non spécifiques de l'anglais » dont la structure orthographique est au contraire légale en français (des mots tels que *fire*). Les résultats montrèrent un effet d'amorçage identité facilitateur, ainsi qu'une différence entre les conditions d'amorçage identité et formel, ceci de façon comparable chez les élèves de 4ème et les étudiants. Ce résultat, en faveur d'un codage précis de l'identité des lettres, était retrouvé indifféremment sur les mots cibles spécifiques et non spécifiques de l'anglais.

Les études 2 et 3 du Chapitre 1 visaient à évaluer dans quelle mesure un accès au lexique non sélectif à la langue pouvait être mis en évidence chez divers groupes d'apprenants L2, un phénomène jusqu'alors démontré chez des adultes bilingues très compétents uniquement. L'étude 2 visait plus particulièrement à examiner le traitement des mots « cognates », qui partagent la même orthographe et la même sémantique entre chaque langue (par exemple, *silence*), dans une tâche de décision lexicale en anglais, chez des élèves francophones en classe de 4ème. Un traitement différent des mots cognates par rapport à des mots contrôles était supposé refléter un accès non sélectif à la langue, cette différence de traitement indiquant la co- activation des deux langues lors de l'accès au lexique. Nos résultats étaient quelque peu dissonants avec la littérature puisqu'un effet *inhibiteur* des cognates était observé. La prise en compte de facteurs décisionnels tels que la confusion dans l'appartenance linguistique des mots cognates était discutée dans l'interprétation de ce résultat. Un second mode d'examen de cette question de la non- sélectivité à la langue était proposé dans l'étude 3, par l'investigation de l'effet de voisinage orthographique inter- langue, associé au paradigme d'amorçage masqué. Plusieurs expériences étaient proposées, évaluant l'amorçage orthographique de la L2 vers la langue première (L1) et de la L1 vers la L2. Dans chacune des expériences, l'amorce était un mot, voisin orthographique inter-langue de la cible tel que le mot amorce français *gare*, voisin orthographique du mot cible anglais *GAME*. Cet amorçage par voisin orthographique était contrasté avec une condition d'amorçage non relié. Ces différentes expériences mettaient en évidence un effet d'amorçage d'inhibition chez les adultes, en particulier de la L2 vers la L1, reflet de la compétition lexicale inter- langue en faveur d'un accès au lexique non sélectif. Bien que cet effet n'était pas observé chez les participants enfants (élèves de $6^{ème}$ et de $4^{ème}$), les résultats montraient une interaction entre la fréquence lexicale de l'amorce et l'effet d'amorçage obtenu, indiquant un certain degré de connectivité entre les deux lexiques.

Ces différentes études du chapitre 1 soulevaient ainsi des questions théoriques, déjà adressées chez l'adulte bilingue compétent, tandis que peu encore dans ce type de population. L'observation que peu de mots sont en réalité concernés par de fortes connexions inter- langues, du fait de la présence en anglais de structures orthographiques très spécifiques de cette langue, nous amena à considérer le codage des représentations orthographiques sublexicales.

Le chapitre 2 avait pour objectif de regrouper deux études ayant pour principal intérêt le codage orthographique sublexical. L'étude 5 consistait en une tâche de décision lexicale en anglais (L2), présentée à des enfants de classe de 6ème, 4ème et à des étudiants, dans laquelle les stimuli étaient manipulés selon leur typicalité orthographique (mots spécifiques de l'anglais vs. mots non spécifiques de l'anglais). Le but était de déterminer dans quelle mesure cette variable sublexicale pouvait affecter le traitement en langue seconde. Le résultat majeur de cette étude consistait en un effet facilitateur dans les temps de réaction pour les mots anglais non spécifiques (dont l'orthographe est partagée entre les deux langues) par rapport aux mots spécifiques (dont l'orthographe est très typique de l'anglais, du point de vue francophone), ceci dès les premiers mois d'acquisition de la L2. Afin de mieux appréhender d'éventuels facteurs ayant pu influencer ce pattern, l'étude 6 était axée sur le codage du graphème en L2, une unité ortho- phonographique dont le rôle a été mis en évidence dans la reconnaissance visuelle de mots. L'objectif était de déterminer si le graphème était une unité fonctionnelle de la reconnaissance de mots en L2 d'une part, et de comparer, le cas échéant, le codage de graphèmes appartenant aux deux langues (non spécifiques tels que « ai », « ou ») de ceux spécifiques de l'anglais (tels que « ea », « oa »). Pour ce faire, trois catégories de mots étaient proposées dans une tâche de détection de lettre : ceux contenant des graphèmes simples (d'une lettre, tel que *black*), des graphèmes complexes non spécifiques (*hair*) ou spécifiques (*beach*). Les données obtenues indiquaient l'existence d'un codage du graphème en L2, ceci dès la classe de 6ème. Tandis que les élèves de 6ème présentaient un coût de traitement pour les graphèmes spécifiques de l'anglais par rapport aux non spécifiques, un codage comparable pour ces deux types de graphèmes complexes était cependant observé chez les étudiants, le pattern obtenu dans le groupe intermédiaire, les élèves de 4ème, étant quelque peu confus. Ainsi, ces deux études du Chapitre 2 permettaient d'explorer l'influence de facteurs sublexicaux dans la reconnaissance visuelle de mots en L2, accentuant ainsi la particularité de la situation d'apprentissage d'une langue seconde par rapport au contexte monolingue et la nécessité d'examiner des groupes de compétences variables.

Le Chapitre 3, dont une des études composant ce chapitre était menée en Ecosse dans le cadre du Joint PhD, tentait d'intégrer à notre travail sur les représentations orthographiques une évaluation de l'interface entre orthographe et phonologie. Une particularité de l'acquisition d'une L2 dans ce cadre scolaire étant la faible exposition à la langue orale, et par conséquent, des capacités de décodage phonologique limitées, examiner l'activation phonologique en langue seconde et les interactions entre les correspondances grapho- phonologiques entre chacune des langues constituait un thème d'investigation incontournable. L'étude 6, réalisée en Ecosse, avait pour objectif de tester l'activation phonologique en français (L2) chez des élèves de $4^{ème}/3^{ème}$ anglophones, et, en particulier la co- activation des correspondances graphèmes-phonèmes de chaque langue. L'effet d'interférence par pseudohomophone était testé dans une tâche de décision lexicale en L2 : des pseudo-mots dont la phonologie correspondait à un mot réel, dit mot de base (par exemple, *veet*, pseudohomophone du mot français *vite*) étaient insérés parmi des pseudo-mots fillers, et comparés plus précisément à des pseudo-mots contrôles orthographiques (dans l'exemple précédent, *voet*), partageant la même proximité orthographique avec le mot de base. Deux expériences permettaient d'examiner l'effet de pseudohomophonie en intra- langue (en L2, en utilisant des pseudo-mots homophones grâce aux règles de correspondances françaises tel que *rouje*, pseudohomophone de *rouge*) et en inter- langue (en utilisant des pseudohomophones selon les règles de correspondances anglaises, tel que l'exemple de *veet*). Dans ces deux cas, un effet d'interférence des pseudohomophones était observé, pour les erreurs en condition intra- langue (plus de fausses alarmes pour les pseudohomophones par rapport aux pseudo- mots contrôles), pour les erreurs et temps de réaction en condition inter- langue (plus de fausses alarmes ainsi qu'un temps de rejet correct plus long par rapport aux pseudo- mots contrôles). Ces résultats indiquaient une activation phonologique lors de l'accès au lexique en L2, et l'activation multiple des correspondances graphèmes- phonèmes quelle que soit leur langue d'appartenance. Enfin, la question de la (in)compatibilité inter- langue des correspondances graphèmes-phonèmes était abordée dans l'étude 7. Dans une tâche de détection de lettre en anglais (L2), deux types de mots étaient présentés: des mots compatibles dont la lettre à détecter avait un correspondant phonémique identique dans les deux langues (la lettre A dans *have* se prononce /a:/ comme en français) et des mots incompatibles dont la lettre à détecter avait un correspondant phonémique en anglais différent de celui en français (la lettre A dans *take* se prononce différemment de la correspondance majeure française « a » → /a:/). Les résultats indiquaient un effet de compatibilité pour tous les participants réunis, bien que peu net chez les élèves de 6ème. Détecter la présence d'une lettre était en effet plus rapide lorsque la correspondance grapho- phonologique de cette lettre était compatible avec celle du français par rapport à la condition incompatible, reflétant l'influence des associations déjà créées en L1, et ainsi la nature non sélective à la langue de l'activation phonologique en reconnaissance visuelle de mots.

Ces différentes études étaient interprétées dans le cadre théorique du « bilingual interactive activation model » de reconnaissance visuelle de mots mais des éléments explorés dans ce travail apportaient également de nouvelles pistes d'investigation chez le monolingue. Abordant diverses questions théoriques posées par l'apprentissage d'une langue seconde, ce travail met en évidence la nécessité d'approfondir dans le futur les recherches sur les apprenants L2, pour qui les mécanismes de reconnaissance de mots pourraient se distinguer légèrement de ceux abondamment décrits chez les bilingues très compétents.

Introduction

Learning a second language (L2) has become decisive for the population to adapt to the increasing globalized world. Learners of a L2 are faced with several challenges when beginning L2 acquisition. Firstly, new orthographic lexical representations must be learned and integrated to the lexicon. In adult learners, these representations may compete with first language (L1) lexical representations which are likely to be already highly specified during lexical access and efficiency therefore depends on some language control. The degree of precision of L1 lexical representations may not be as strong in child learners and the extent to which cross-language interactions may occur at the lexical level in this population could therefore be lower. Secondly, L2 learners must also build new sublexical orthographic representations such as graphemes that may be very specific to the L2 (e.g., “oa”, “ow” or “sh” for French learners of English). Even in the case of same- alphabet scripts such as French and English, the word recognition system must also compute more general orthographic sequences that may sometimes go against graphotactic rules from L1 (e.g., -ght) and the letters that compose them may be of low frequency in the L1 (e.g., w, y for French learners of English). Thirdly, these new language- specific graphemes must be connected to the corresponding phonemes. However, some difficulties may also be encountered for those graphemes that are legal in L1, given that the corresponding phonemes may be inconsistent with regard to the orthography- to- phonology correspondences from L1 (e.g., the grapheme “a” maps onto the phoneme /a/ in French but in multiple phonemic representations such as /a:/ but also /o/ or /eI/ in English). Though some of these issues such as lexical access in the bilingual lexicon or cross-language interactions of sublexical phonology have been examined in the literature on highly proficient bilinguals, there are as yet very few on- line word recognition studies on these topics in L2 learners. The terminology may appear somewhat unclear given that L2 learners -as they will be referred to in the present work- could also be termed “bi – linguals” (i.e., as referring to individuals who speak two languages). So, the term “bilinguals” will be reserved for characterizing those individuals who have usually lived in a bilingual environment from an early age, and who have a high degree of mastery of the L2, and the term “L2 school learners” will be used to refer to the population that has learned a L2 in a standard school context, with usually little exposure to the language -limited to the school context- and rudimentary vocabulary. Given the relative paucity of research on L2 school learners’ visual word recognition, the goal was to examine several theoretical issues corresponding to the above- mentioned challenges that L2 learners must face and to provide an overview of word recognition mechanisms in L2 learners of varying proficiency. In spite of the wide theoretical background implied by the position taken in the present work, it was felt that examining several related theoretical issues that pose a challenge for L2 word recognition was the most appealing approach for this project. It is hoped that this doctoral work will enable the opening of new perspectives on L2 word recognition and that future opportunities may arise to pursue this goal further in order to expand on each of these topics.

Part 1.

Theoretical background

The field of visual word recognition is a wide area of research, which has constantly been evolving over the last two decades. As a result of growing research using behavioural and electrophysiological data, we are progressively understanding more about how the cognitive system is able to successfully recognize thousands of words as rapidly as within a few milliseconds, by means of combinations of only a few letters (Diependaele, Ziegler & Grainger, 2010; Dufau, Grainger & Ziegler, 2012; Grainger, 2008; Grainger & Holcomb, 2009; Grainger & Jacobs, 1994, 1996; Jacobs, Rey, Ziegler & Grainger, 1998; McClelland & Rumelhart, 1981; see Dehaene, Cohen, Sigman & Vinckier, 2005 for a proposal on the neural correlates of word recognition). In the present work, we will consider visual word recognition as a hierarchical multi-stage process composed of various components, namely orthographic, phonological and semantic processes. We also focus our interest on *activation-based* and *localist* word recognition models which consider the existence of a lexicon (see Forster, Davis, Schoknecht & Carter, 1987 for an example of a *search-based* model of lexical access and Seidenberg & McClelland, 1989 for a *parallel distributed* model of word recognition). We present herein an overview of the theoretical approaches and empirical findings in monolingual and bilingual literature that are necessary to further understand the several studies that were conducted in the present work. Each of the essential theoretical elements will be further described in depth in each appropriate study introduction. This thesis examines the issue of language nonselectivity during lexical access in L2 school learners and explores the under- developed question of sublexical orthographic coding (see Figure 1 for an overview of experimental chapters). We further describe lexical access for both monolingual and bilingual individuals, that is, at the level of words themselves, and sublexical orthographic and phonological stages in the word recognition process. The first section will expose theories and data coming from monolingual literature whereas the second section focuses on bilingual word recognition literature.

Figure 1. Presentation of the experimental chapters.

Chapter 1.
Lexical representations

- Study 1. Within- language priming
- Study 2. Cognates
- Study 3. Cross- language priming
  - Experiment 1a and 1b. L2- to- L1 priming
  - Experiment 2. L1- to- L2 priming

Chapter 2.
Sublexical orthographic representations

- Study 4. Orthographic typicality
- Study 5. Grapheme processing

Chapter 3.
Sublexical orthography- to- phonology

- Study 6. Pseudohomophone interference effect
  - Experiment 1. Within- language homophony
  - Experiment 2. Cross- language homophony
- Study 7. Cross- language orthographic- to- phonology consistency

1. First section: On monolingual visual word recognition.

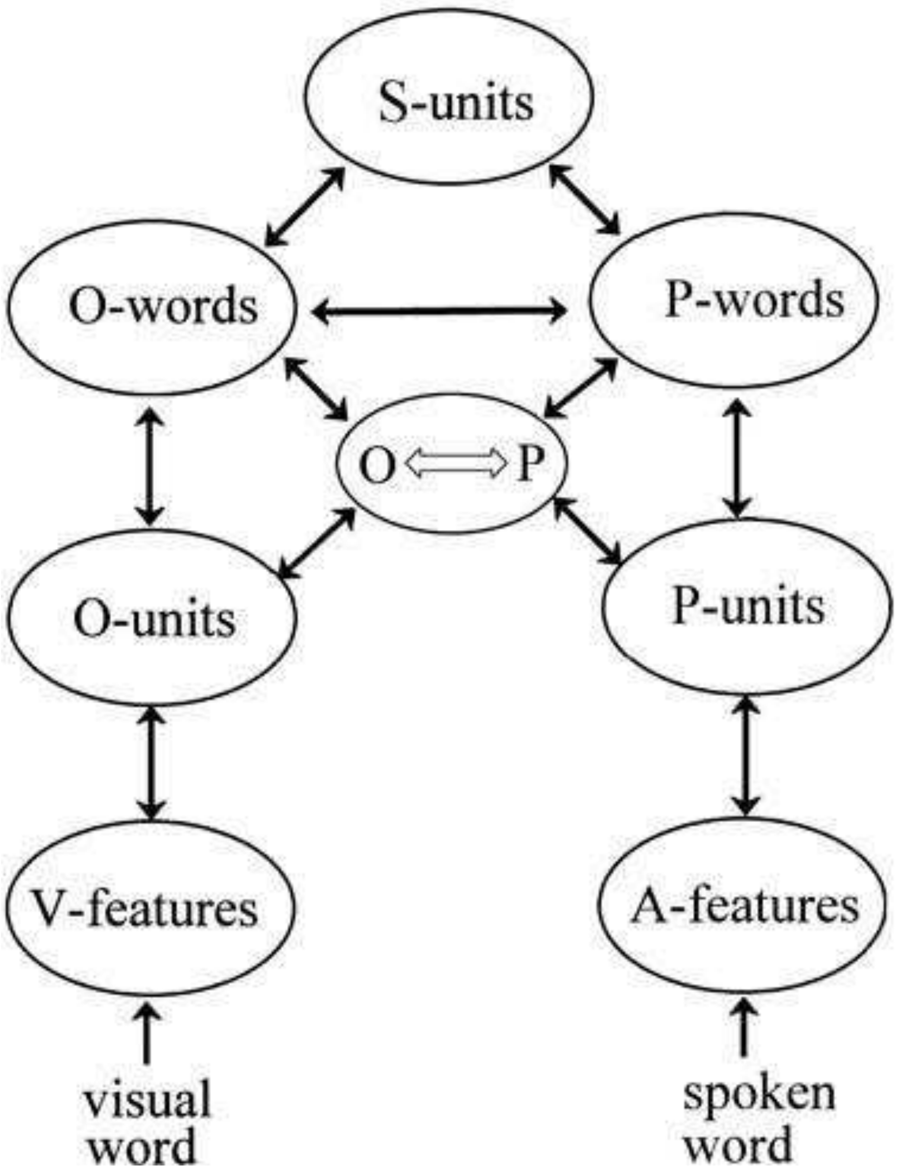
We do not pretend to give an exhaustive review of monolingual visual word recognition, but to provide the theoretical tools that are needed to further comprehend the bilingual literature as well as our current work. Below is presented one major theoretical approach on visual word recognition in monolinguals followed by several main empirical findings on lexical access and sublexical orthographic and phonological coding.

1. 1. On modelling visual word recognition in monolinguals.

One of the historical and most prominent activation- based models that assume the existence of a « mental lexicon » is the Interactive Activation model (McClelland & Rumelhart, 1981). This model is qualified as such due to the activation that spreads along bidirectionnal connections between different levels. Indeed, the IA model proposes 3 levels of orthographic activation during word recognition: the feature, letter and word levels. These levels are interconnected with excitatory and/or inhibitory connections and the model postulates parallel and interactive processes. Features send activation to the corresponding letters, which in turn send activation to the corresponding words. Words in turn send activation and inhibition back to the letters. At the word level, words are connected to each other according to orthographic similarity. The links at this intra-level are inhibitory and this last concept has been referred to as lexical competition. Therefore, activation spreads along these different levels: words receive excitatory and inhibitory activations until a word candidate is selected and the word is recognized.

Following the principle of nested incremental modelling, many extensions of the IA model have been proposed in order to incorporate a response/decision module and task- specific mechanisms (i.e., the Multiple Read- Out Model, Grainger & Jacobs, 1994, 1996; Jacobs & Grainger, 1992 Jacobs et al., 1998, and more recently, the Leaky Competing Acumulator Model, Dufau, Ziegler & Grainger, 2012) and a phonological pathway to the lexicon (Diependaele, Ziegler & Grainger, 2010), and therefore adjust for earlier omissions from the model. The Bi-modal Interactive- Activation Model (BIAM, Grainger & Ferrand, 1994; Diependaele et al, 2010) integrates to the orthographic pathway a phonological pathway. It also includes sublexical and lexical activations in explaining word recognition, as well as an orthographic- to- phonology interface, similar to the grapheme- to- phoneme conversion from other models of reading aloud (i.e., the Dual-Route Cascaded Model by Coltheart, Rastle, Perry, Langdon & Ziegler, 2001; the Connectionist Dual Process approach to reading by Zorzi, 2010). The BIAM dual route model that distinguishes between a lexical and a nonlexical route from print to sound also provides an amodal semantic level that enables to explain the reading process in a more integrative fashion. The model is presented in Figure 2. As in the IA model, visual input activates orthographic features (V-features) that activate orthographic sublexical units (O-units, i.e., letters). These sublexical orthographic units directly connect to the orthographic lexicon (O-words) but also via the phonological pathway. These orthographic sublexical units can therefore be converted into phonological sublexical units (P-units) via a sublexical interface, which connect to the phonological lexicon (P-words). These multiple interactions inherent to the model enable to account for several empirical findings such as fast phonological priming (see Rastle & Brysbaert, 2006 for a meta-analysis and review on fast phonological priming and Diependaele et al., 2010 for a simulation of this effect), and influences of orthography in spoken word recognition (Perre & Ziegler, 2008; Perre, Midgley & Ziegler, 2009).

Figure 2. Simplified overview of the architecture of the Bimodal Interactive Activation Model. From Grainger & Holcomb (2009).



Though not the focus of the present work, other theoretical endeavours have been provided to extend these models and more precisely explain sublexical orthographic processes in particular (i.e., letter identity and letter position coding), that slightly deviates from the original IA (Dandurand, Grainger, Duñabeitia & Granier, 2011; Grainger, 2008; Grainger & Jacobs, 1994; Grainger & Holcomb, 2009; Grainger & Ziegler, 2011). Again, although not debated here, note that other activation- based models that *exclude* the existence of a lexicon have also been proposed in word recognition literature, one of the major ones being the Parallel Distribution Processing model from Seidenberg and McClelland (1989).

1. 2. Lexical access in monolinguals: methodology and some empirical findings

Before we turn to empirical findings that have contributed to the modelling of visual word recognition, we present some methodological aspects of our work.

The lexical decision task and the masked priming paradigm

One of the most commonly used tasks in the word recognition literature is the lexical decision task first developed by Rubenstein, Garfield, and Millikan (1970). This task implies word/nonword discrimination and is supposed to tap into lexical access process and to measure the various stages of sublexical and lexical activation. This task has been associated with the priming paradigm, which was suggested to be used with a masked procedure by Forster and Davis (1984) in order to minimize the influence of episodic memory traces. It usually consists of presenting a prime word or nonword preceded by a forward mask (i.e., hashes for instance), and followed by a target word or nonword on which a response is generated such as a lexical decision or naming. In order to avoid any confounding perceptual variables, the prime is presented in lower-case while the target appears in upper-case. This enables the effects obtained to be more clearly interpreted as involving low-level perceptual processes as well as sublexical orthographic coding such as abstract letter identity coding. In the last decades, other procedures have been described such as the incremental priming technique which combines the classical comparison between priming conditions (i.e., related and unrelated) and reaction time progressions over time (i.e., by modulating prime duration presentation, De Moor, van der Herten & Verguts, 2007) or also the so-called “sandwich” priming (Lupker & Davis, 2009). The priming paradigm may be combined with a large range of tasks: lexical decision and naming tasks, but also semantic categorisation, cross-case same/different task to assess lower- level processes. The experimental technique has also been combined with neuroscience methodologies, such as EEG (Holcomb & Grainger, 2007) or MEG (Monahan, Fiorentino & Poeppel, 2008).

Note that some researchers consider the masked priming paradigm in terms of episodic memory accounts (Bodner & Masson, 1997, 2001; Masson & Isaak, 1999) and the lexical decision task as directly tapping into semantic processes (Plaut, 1999)[1].

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[1] Advocates of the episodic account of masked priming effects (Bodner & Masson, 1997, 2001) suggest that visual word recognition taps into similar processes to any other memory phenomena and that episodic processes are constructed for prime words, even when masked. They found three main effects that were claimed to be incompatible with the Search model of visual word recognition (Forster and colleagues, 1987, 1991): 1) the identity priming effect for pseudoword targets, 2) the validity priming effect (i.e.,

However, the perspective taken in the present work is that the masked prime pre-activates sublexical and lexical representations of words in the lexicon (orthographic and phonological priming; but see also semantic masked priming studies, Perea & Gotor, 1997) for which its nature and time course of activation may be investigated.

The monolingual literature on visual word recognition has aimed to understand how a lexical candidate may be selected when a visual input is presented to an individual given the huge amount of words an expert reader ultimately recognizes. As a consequence of this interest, major efforts have been made to understand the nature and time course of the different activations that arise in the word recognition system. We specifically focus on orthographic and phonological activations during lexical access, and exclude here any review of morphological or semantic variables. This brief review which is necessary before we turn to bilingual recognition issues will combine empirical findings on orthographic variables that affect visual word recognition (investigated within the masked priming paradigm) as well as on phonological representations that are simultaneously activated during lexical access.

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stronger identity priming effect when presenting a high proportion of identity primes as compared to when presenting a low proportion) and 3) the frequency attenuation effect (i.e., stronger identity priming effect for low frequency target words as compared to high frequency target words). In our view, these data are though likely to be interpretable within the Interactive Activation framework (McClelland & Rumelhart, 1981) and may not constitute evidence against lexical interpretations of visual word recognition. It is also felt that the finding of a "Visual Word Form Area" at the occipito- temporal junction –independent of any semantic variables- by neurophysiological research also supports lexical accounts of masked priming, rather than memory or semantic interpretations (Cohen et al., 2000; Dehaene et al., 2002).

Identity & form priming

Identity priming effects using a *masked* priming procedure were first investigated by Evett & Humphreys (1981) on target detection errors, and Forster & Davis (1984, experiment 1) on target reaction times. In all cases, facilitation priming effects have been found, that is faster reaction times on the target word when preceded by an identity priming condition (e.g., the same word, *boat – BOAT*) as compared to an unrelated condition (e.g., *dark – BOAT*) or a neutral condition (e.g., *xxxx – BOAT,* Segui & Grainger, 1990b, experiment 2). This facilitation priming effect has been shown not to interact with target frequency (Bodner & Masson, 1997; Forster & Davis, 1984, experiments 1, 5 and 6; Segui & Grainger, 1990a experiment 4, Segui & Grainger, 1990b) but to do so with target neighbourhood size (Perea & Rosa, 2000). Identity facilitation effects have also been demonstrated in English-speaking children, as early as Primary Grade 1 (Castles, Davis & Letcher, 1999; Pratarelli, Perry & Galloway, 1994).

Form priming refers to the presentation of a target word preceded by an orthographically similar word or pseudoword. Since lexicality of the prime has been shown to be a crucial factor in priming studies (see Mathey, 2001 for a review), only the case of *pseudoword* primes is considered here while the literature using words as primes is described further in the "orthographic neighbourhood using words as primes" section. Form priming effects (e.g., *doat* - *BOAT*) have commonly been shown to be facilitatory. However, several variables have been shown to affect the pattern of results, leading to either facilitatory or null effects. Effects have been shown to depend on 1) target length: facilitatory effects were reported for eight- letter words, while null effects for four- letter words (Forster, Davis, Schoknecht & Carter, 1987), 2) target neighbourhood size: the *density constraint hypothesis* suggests that facilitatory effects are expected only for target words whose neighbourhood size is low (Forster & al, 1987; Forster & Davis, 1991; Forster & Taft, 1984; Perea & Rosa, 2000), 3) prime-target shared neighbourhood: facilitatory effects are reported only when prime and target share no common neighbour word, while null effects are observed when one such neighbour can be identified, such as the case of *slort – SPORT* which also activates the neighbour word *short* (Hinton, Liversedge & Underwoord, 1998, experiment 2 with partial ambiguous vs. unambiguous primes, van Heuven, Dijkstra, Grainger & Schriefers, 2001 with nonword primes), and 4) prime duration of presentation or SOA: form priming effects seem to disappear as early as after 60 ms SOA in French (Ferrand & Grainger, 1992, 1993, 1994).

Orthographic neighbourhood using words as primes

As compared to identity and form priming effects which have been shown to be commonly facilitatory, manipulation of orthographic neighbourhood using words as primes has tended to show inhibitory priming effects. The *neighbourhood frequency effect* using a masked priming procedure was first reported by Segui & Grainger (1990a, experiments 2 and 3) who found that low frequency target words were responded to more slowly when preceded by an orthographically related higher frequency prime word (e.g., *boat – GOAT*) as compared to a control condition (e.g., *fire – GOAT*). This effect was further confirmed by many studies (Bijeljac- Babic, Biardeau & Grainger, 1997; Davis & Lupker, 2006; De Moor & Brysbaert, 2000; De Moor, van der Herten &

Verguts, 1997; Dijkstra, Hilberink- Schulpen & van Heuven, 2010; Nakayama, Sears & Lupker, 2008) though the strength of the inhibition effect appears to vary according to several factors: 1) prime neighbourhood size: inhibition priming effects were reported to occur whatever prime frequency when primes and targets had a large neighbourhood size but only for high frequency prime condition when prime and targets had few neighbors (Nakayama et al., 2008), 2) shared prime-target neighbourhood: inhibition effects tend to be stronger for no shared neighbour priming conditions as compared to one shared neighbour conditions (Davis & Lupker, 2006, experiment 2; but see Nakayama et al., 2008 for contradictory results) and 3) neighbourhood distribution: an inhibition priming effect emerges only when in a prime/target pair, the information shared by the neighbouring word is spread over different letter positions (e.g., *lo**ge*** in the pair ***r**obe* – ***L**OBE,* meaning respectively *lodge*, *dress* and *lobe*); null effects are however reported when the shared information occurs in the same letter positions (e.g., ***t**ard* in the pair ***l**ard* - ***F**ARD*, meaning respetively *late*, *bacon* and *blusher*, Mathey, Robert & Zagar, 2004). Recent studies from Andrews and colleagues have also revealed individual differences in that inhibition priming effects resulting from lexical competition only emerge in skilled readers (Andrews & Hersch, 2010; Andrews & Lo, 2012).

Note that neighbourhood effects have also received a large attention from studies using standard word recognition tasks, without any priming procedure (see Mathey, 2001 for a review). A facilitatory effect of neighbourhood size has been reported by Andrews (1989, 1992) in the lexical decision task. Regarding the neighbourhood frequency effect, the pattern of results seems to be dependent upon several variables, one of which is the task used. Neighbourhood frequency effects have been shown to be either inhibitory (Davis, Perea & Acha, 2009 using deletion and addition neighbours; Grainger, 1990, Grainger & Segui, 1990, Grainger, O'Regan, Jacobs & Segui, 1989, 1992) or null (Forster & Shen, 1996) in the lexical decision task; rather inhibitory in the perceptive identification task (Carreiras, Perea & Grainger, 1997; Grainger & Segui, 1990) though depending on visibility (Sears, Lupker & Hino, 1999, experiments 1 & 2), but rather facilitatory in the naming task (Grainger, 1990; Sears, Hino & Lupker, 1995). Other variables have been shown to influence these patterns such as strategies and decision processes (such as the type of pseudowords used in the lexical decision task, Grainger & Jacobs, 1996; Mathey & Zagar, 2000 or guessing strategies in the identification task, Forster & Shen, 1996; Paap & Johansen, 1994), the language used (Andrews, 1997) and those phonological processes inherent to the task (especially regarding the different patterns between the lexical decision and the naming tasks, Andrews, 1992).

Developmental perspective on visual word recognition

The issue of the developing lexicon and of associated coding mechanisms at different ages/grade levels has recently been attracting increasing interest[2]. The manner in which orthographic and phonological coding take place during visual word recognition in monolingual children and how these mechanisms become fast, highly specified and automatic constitutes a large field of investigation that

[2] We should note that though uncovering the on- line aspects of reading may constitute a new field in the literature, developmental theories of reading acquisition have been considerably discussed these last fifty years (see for instance proposals of Ehri, 2005 or Share, 1995). This literature will not be described in the context of this work.

ultimately will help to inform studies of L2 acquisition. Empirical findings using the masked priming paradigm such as identity and form facilitation priming effects commonly observed in monolingual adults have also been found in children (Booth, Perfetti & MacWhinney, 1999; Castles, Davis, Cavalot & Forster, 2007; Castles, Davis & Letcher, 1999; Pratarelli, Perry & Galloway, 1994; see also Janiot, 2011's doctoral dissertation for a thorough examination of masked orthographic priming in French children attending Primary Grades 3 and 5). Further, assessment of the influence of orthographic neighbourhood at different reading levels has also enabled developmental mechanisms that lead to expert reading to be uncovered. With regard to neighbourhood size effects, Castles et al. (1999) revealed that form facilitation priming effects occurred for both large and small neighbourhood size target words in children from Grades 2, 4 and 6 while only for small neighbourhood size targets in adults. Using the standard lexical decision task, results were found to be contradictory. While Duñabeitia & Vidal- Abarca (2008) reported faster reaction times for target words that had a large neighbourhood size as compared to small one in Spanish children attending Grades 1- to- 6 (see also facilitation effects in error data reported by Laxon and colleagues, 1988, 2002, no effects were reported by Dufau and colleagues (2010) in French children from Grades 1- to- 5 (see also null effects reported by Marinus & De Jong, 2010 using the naming task in children from Grades 2 and 4). With respect to neighbour frequency effects, Marinus & De Jong (2010) found that Grade 2 children and dyslexic children of comparable reading level, but not Grade 4 children, were slower when asked to name words that had a high frequency neighbour as compared to words that did not have it. Using the masked priming paradigm, Janiot (2011)'s doctoral work revealed that the neighbourhood frequency inhibition priming effect commonly reported in adults (Davis & Lupker, 2006; De Moor & Brysbaert, 2000; De Moor, Van der Herten & Verguts, 1997; Nakayama, Sears & Lupker, 2008; Segui & Grainger, 1990a) was observed in children in very limited circunstances. Not only were prime words more frequent than target words, but there also was a shared high frequency neighbour word between the prime and the target. Using this material, the inhibition priming effect, supposed to reflect lexical competition (McClelland & Rumelhart, 1981) was only observed in children attending Grade 5 and who had high orthographic processing skills. Null effects were reported for Grade 5 children with poor orthographic skills and all children from Grade 3, whatever their level of orthographic skill (see recent findings from Andrews and colleagues, 2010, 2012, emphasizing the influence of spelling skills in showing inhibition priming effects in adults). This experiment reveals that lexical competition is a late- developing mechanism within the word recognition system which develops after some number of years of reading exposure, and may not even emerge in all readers. This competition between orthographic lexical representations that emerges with reading acquisition could also be related to the progressive change in the tuning of these word representations, this latter phenomenon further referred to as the lexical tuning hypothesis (Castles et al., 1999, 2007) and fully described in Study 1. This hypothesis indeed postulates that orthographic representations become more and more fine- tuned as vocabulary grows (see also recent findings from Marinus & De Jong, 2010 using the naming task); this developmental mechanism could be theoretically related to the inhibitory links being formed in the lexicon (Castles et al., 2007). More recent contributions from Grainger & Ziegler (2011) on multiple routes in learning to read are considered in experimental chapters and general discussion of the current work.

1. 3. On Sublexical coding in visual word recognition

Word recognition cannot be restricted to lexical access and its investigation should involve the different stages that contribute to the integration of various sublexical units (such as letters, graphemes or bodies) into a word representation, and access to this word representation, or lexical access (Grainger & Dijkstra, 1996; see the interactive activation model, McClelland & Rumelhart, 1981). In models of monolingual word recognition, the orthographic sublexical unit that is most represented and investigated is the letter unit. However, other sublexical orthographic units have been investigated and proved to be functional during visual word recognition.

On letter coding

In the IA model, the orthographic sublexical level is referred to as a letter level. Both letter identity and letter position must be coded in order to accurately recognize the word. In this initial model, letter strings are assumed to be processed in parallel by a set of length- dependent, position-specific letter detectors. This *absolute* letter position coding has however been modified over new models inspired from IA into a *relative* position coding mechanism. Indeed, two lines of evidences have been provided: 1) transposed- letter priming effects found with transposed word primes (e.g., *trail* – *TRIAL*) or pseudoword primes (e.g., *snad* – *SAND*), and even with nonadjacent pseudoword primes (e.g., *cholocate – CHOCOLATE*; (TL priming; Perea & Lupker, 2003, 2004; Perea & Carreiras, 2006) and 2) relative-position priming (De Moor & Brysbaert, 2000; Perressotti & Grainger, 1999) assessed by presenting a prime word that contain the target word but differs in length (e.g., *spend – SEND*; see Grainger, 2008 for a review on both of these effects). This relative position coding scheme is more flexible and would better support the view that other sublexical units can be used during word recognition, one of interest in the present work being graphemes. Note that very recent theoretical premises from Grainger & Ziegler (2011) suggest the existence of a dual sublexical orthographic route to reading involving both a fine- grained route (that codes the orthographic input into chunks such as graphemes and is able to then convert these into phonemes) and a coarse- grained route (that codes the input into open- bigrams).

The "typicality" of letter sequences has received little attention in monolingual visual word recognition research. Orthographic typicality has been described as "the frequency of [their] component letter pairs (bigrams) and triplets (trigrams)" (Hauk, Patterson, Woollans, Watling, Pülvermüller & Rogers, 2006, p. 818) and is therefore a sublexical orthographic metric reflecting the frequency of its orthographic components. Orthographic typicality (i.e., comparing typical vs. atypical words or pseudowords) was reported by these authors to have an effect at around 100 ms using an EEG procedure, prior to any lexical effects (i.e., difference between words and pseudowords).

Another sublexical orthographic unit: graphemes

Graphemes can be considered as the written correspondent of oral phonemes (Berndt, Reggia & Mischurg, 1987) and can therefore be considered as functional phono- graphemic units. Graphemes can be constituted of only one letter also called “simple graphemes” such as in the case of the four graphemes M, A, S and K from the word *mask*, but also of two or more letters, called “complex graphemes”, such as the grapheme EA in the word *meat*.

Recent empirical findings using pseudoword naming (Rastle & Coltheart, 1998; Joubert & Lecours, 2000) or letter detection within words (Rey & Schiller, 2005; see also Rey, Jabobs, Schmidt- Weigand & Ziegler, 1998) have yielded evidence that graphemes have a role as perceptual units during visual word recognition. Interestingly, Rey, Ziegler & Jacobs (2000) showed in both French and English that detecting a letter embedded in a complex grapheme (e.g., detecting the letter “A” in the word *beach*) was slower than detecting this same letter when mapped onto a simple grapheme (e.g., such as the “A” in the word *black*). This grapheme complexity effect is supposed to occur because complex graphemes composed of multiple letters such as EA compete with its constituent single- letter graphemes E and A. This competition would therefore slow down word identification. Importantly, this graphemic complexity effect was reported to be independent of phonemic effects which show additive effects though (Rey et al., 2000, experiment 2; Rey & Schiller, 2005; see more explanations in Study 5).

Models such as the Interactive Activation model of visual word recognition (McClelland & Rumelhart, 1981) or the Dual- Route Cascaded model of reading aloud (Coltheart et al., 2001) give little account of graphemes as an orthographic unit per se. Only letters were considered by the IA model and this may be explained by the fact this model only took into account the orthographic route to reading. In the DRC model, the graphemic effect found in the naming task (i.e., longer latencies for words composed of complex graphemes as compared to single graphemes, length controlled, Rastle &

Coltheart, 1998) is explained as the effect of a serial letter- by- letter print- to- sound processing. For complex graphemes, the system would first convert the first letter into a phoneme. Only when the second letter of the grapheme comes into the view would the system code the entire grapheme as a phoneme[3]. This delay, also called the "whammy effect" (Rastle & Coltheart, 1998) is thus assumed to occur at the sublexical orthographic- to- phonological conversion level, but no *orthographic graphemic level per se* – different from the letter level- is postulated. The most recent modifications made to these two models have, however, included a stage dedicated to grapheme parsing, prior to the grapheme- to- phoneme conversion mechanism, called the two-layer associative network (TLA, Houghton & Zorzi, 2003). Indeed, the Bimodal Interactive Activation Model or BIAM presented Figure 2 (Diependaele et al., 2010; Grainger & Holcomb, 2009) now integrates local representations for graphemes and gives some account for grapheme parsing, based on the connectionist dual- route model of spelling of Houghton & Zorzi (2003). Graphemes are therefore considered within this framework as functional units relevant to the orthographic- to- phonology conversion, but also as an independent sublexical orthographic mechanism (i.e., grapheme parsing) that would operate prior to the conversion to phonological units (Joubert & Lecours, 2000; see also CDP+ model by Perry, Ziegler & Zorzi, 2007). Recent theoretical proposal from Grainger & Ziegler (2011) for a "dual- route approach to orthographic

[3] Note that there are contradictory findings with regard to whether both letters of a complex grapheme are slowed down in the letter detection task (see Marinus & de Jong, 2011; Peereman, Brand & Rey, 2006) or whether only the second letter is concerned by this delay (see Brand, Giroux, Puijalon & Rey, 2007, although they use a slightly different letter detection procedure). While beyond the scope of the present work, this issue has important theoretical implications as to whether grapheme parsing and grapheme- to-phoneme conversion mechanisms may be considered as serial versus parallel processes.

processing" however seems to make a subtle difference as compared with these former models in that graphemes seem to operate at the lexical orthographic level –as well as at the sublexical orthographic- to- phonology conversion level- as an intermediate level between letters and the orthographic lexicon –along with a more coarse- grained code composed of contiguous and non-contiguous bigrams (see General Discussion for more details and Figure 6).

Note that other sublexical units have been investigated such as syllables (Ans, Carbonnel & Valdois, 1998; Carreiras & Perea, 2002) or onset- nucleus- coda units (Nuerk, Rey, Graft & Jacobs, 2000; Plaut, McClelland, Seidenberg & Patterson, 1996; see Carreiras & Grainger, 2004 for a review).

1.4 From orthography to phonology

Though word recognition could theoretically be performed directly from the visual input to the orthographic lexicon, a large consensus among modellers now supports the idea of automatic activation of phonological code during silent reading. Yet, while models such as the DRC (Coltheart et al., 2001) consider a rather slow phonological activation as compared to orthographic activation, others argue instead for a fast phonological activation (Diependaele et al., 2010; Perry, Ziegler & Zorzi, 2007). Evidence for the activation of phonological codes during visual word recognition comes from research on consistency effects, homophone and pseudohomophone effects, and phonological masked priming.

Consistency effects

Research on consistency effects have largely focused on spelling- to- sound word body consistency (e.g., "eard" in the word *beard*). The seminal study by Glusko (1979) showed that low frequency inconsistent words such as *pint* where the body "int" may be sounded out as /int/ or /aint/ were named more slowly than consistent words such as *deep* where "eep" is always pronounced /i:p/. This effect is seen to reflect "the parallel mapping of a single sublexical orthographic form (letter or letter cluster) onto several sublexical phonological forms (phonemes or phoneme clusters) that then compete following the principle of within-level lateral inhibition" (Grainger & Ziegler, 2008, p. 137). This effect has also been demonstrated in the lexical decision task (Gibbs & van Orden, 1998; Treiman, Mullenew, Bijeljac- Babic & Richmond- Welty, 1995) though the effect tends to be much smaller. This difficulty in observing this spelling- to- sound consistency effect in the lexical decision task was first thought to support the concept of a "delayed" phonological involvement in visual word recognition, an idea that is supported by the dual route model of word recognition and reading aloud by Coltheart et al. (2001). The underlying mechanism in this model is supposed to involve a slow nonlexical route to word recognition, also called assembled phonology, which has to compete with a faster direct lexical route, also called addressed pathway. The small or absent effect of spelling- to- sound consistency effect in the lexical decision task was therefore thought to reflect low phonological involvement in this task -note that phonology plays a much stronger role in the naming task given that phonemic buffer and articulatory processes are involved. Yet, spelling- to- sound consistency, also called feedforward consistency, is not the only consistency variable involved in word recognition. It has also been shown that sound- to- spelling consistency, or feedback consistency, may interfere with visual word recognition. As an example, a word such as *heap* contain a word body “eap” which is feedforward consistent in that it always lead to the rime /i:p/. Yet, this rime /i:p/ may correspond to two different spellings, either “eap” as in our example or “eep” such as in the word *deep*. This feedback inconsistency has been shown to slow down latencies in the lexical decision task (Stone, Vanhoy & Van Orden 1997; Ziegler, Montant & Jacobs, 2007; but see Ziegler, Petrova & Ferrand, 2008 for contradictory findings), in support of a fast -and not delayed- involvement of phonology in this task. Note that though consistency effects have been largely studied at the level of the word body in the English language, cross- language comparisons have revealed that this variable may operate at different grain sizes depending on the orthographic transparency of the language (Goswami, Ziegler & Richardson, 2005). Other research has used smaller graphemic units as the index of consistency of the word -termed in this research field either regular or irregular words- and reported similar effects (Coltheart et al., 2001; Rey & Schiller, 2005; Taraban & McClelland, 1987).

(Pseudo) homophone effects

Other types of studies that have demonstrated the involvement of phonology in visual word recognition have focused on homophone (e.g., *sail – SALE*) or pseudohomophone (e.g., *sail – SAYL*) effects. Rubenstein, Lewis & Rubenstein (1971) first studied the role of phonological activation in visual word recognition by manipulating the relative frequency of the two readings of homophonic pairs of words. They observed that response latencies in a lexical decision task were longer for the less frequent word of a homophonic pair of words (e.g., *sail* in the homophonic pair *sail* - *SALE*) compared to control nonhomophonic words. They interpreted this effect as reflecting the initial activation of the more frequent word of the homophonic pair and the confusion resulting from the presentation of the less frequent word entailed a spelling checking procedure that delayed word recognition. Using pseudohomophones in a lexical decision task, Coltheart, Davelaar, Jonasson & Besner (1977) first found that pseudohomophones took longer to be rejected than control graphemic pseudowords (see also Braun, Hutzler, Ziegler, Dambacher & Jacobs, 2009; Briesemeister, Hofmann, Tamm, Kuchinke, Braun & Jacobs, 2009 and Seidenberg, Petersen, MacDonald & Plaut, 1996 using the same task). This effect was also found in the semantic categorization task (Van Orden, 1987; Van Orden, Johnston & Hale, 1988), in the naming task (Grainger, Spinelli & Ferrand, 2003; McCann & Besner, 1987). This effect was also reproduced by recording eye movements (Inhoff & Topolski, 1994; Sparrow & Miellet, 2002), pupillary responses (Briesemeister et al., 2009) and ERPs (Braun et al., 2009; Briesemeister et al., 2009) in both isolated words and sentences. In both lexical and semantic decision tasks, pseudohomophone items were shown to slow down responses in comparison with orthographic controls (e.g., *brane* and *prain* for respectively pseudohomophone and orthographic control of the baseword *brain*). Note that orthographic similarity between pseudohomophones and orthographic controls has been shown to be a crucial factor to take into account when manipulating pseudohomophones: a pseudohomophone and its orthographic control should both be orthographic neighbours' of the same baseword (Marmurek & Kwantes, 1994), or at least share the same amount of orthographic overlap with the baseword. This is important in order to interpret the pseudohomophone effect as reflecting *phonological* activation. Indeed, if any difference arises between the two types of items, it should not be explained by the pseudohomophones being more "word- like" than the orthographic control. In the lexical decision task, the interference effect was interpreted as arising from a conflict between phonological and orthographic representations[4]. Contrary to orthographic control pseudowords (e.g., *prain*), pseudohomophones (e.g., *brane*) are able to activate lexical phonological representations (e.g., /brein/) and this activation indicates to the system the presence of words. Given that these pseudohomophones do not strongly activate lexical orthographic representations, a conflict arises which takes time to be solved. Another interpretation arising from the Multiple Readout Model of Orthographic and Phonological processes (MROM-p) of Jacobs et al. (1998) suggests that the interference effect could be explained by an increased global lexical activity in the system. While both pseudohomophones and orthographic control pseudowords activate the orthographic lexicon, pseudohomophones also activate the phonological lexicon and this top- down feedback to the orthographic lexicon increases the global lexical activity[5]. This enhanced global lexical activity following the presentation of a pseudohomophone leads to the readjustment of the temporal threshold that is used to respond "no" to the task: either this temporal deadline is delayed leading to longer response times for pseudohomophones as compared to orthographic controls, or the activation of the lexicon is driven above the temporal deadline and an error is therefore

[4] Note that pseudohomophones were reported to be be facilitated as compared with control pseudowords in the naming task (princeps study by McCann & Besner, 1987) and this was interpreted as an advantage at the level of articulatory trajectories (Seidenberg et al., 1996 using both immediate and delayed naming tasks).

[5] Similar interpretations in terms of increased global lexical activity were made by Jacobs et al. (1998) to explain neighbourhood size effects shown in pseudoword responses.

made. Pseudohomophone effects were found to be modulated according to several factors, namely stimulis list composition (McQuade, 1981), baseword frequency (see Grainger et al., 2000 and Seidenberg, et al., 1996 in the naming task). and individual characteristics such as participants' speed (i.e., the faster, the less amount of interference effect, Seidenberg et al., 1996) and auditory category perception skills (the effect size is related to the higher auditory skills, Luque, Luque & López- Zamora, 2011; but see evidence for a pseudohomophone interference effect in a lexical decision task in deaf children, Transler & Reitsma, 2005).

Masked phonological priming

The masked phonological priming paradigm was first initiated by Humphreys, Evett & Taylor (1982) with words as primes, and further extended by Perfetti & Bell (1991) with pseudowords as as primes (see also Grainger, Diependaele, Spinelli, Ferrand & Farioli, 2003; Lukatela & Turvey, 1994, and Rastle & Brysbaert, 2006 for a meta analysis). They showed that a tachistoscopically presented English target was better recognized when preceded by a masked English homophonic prime (a word or a pseudoword) than when preceded by a graphemic control prime that shares the same number of letters with the target word but not the same number of sounds (*male* - *MAIL* vs. *mall* - *MAIL*). Ferrand & Grainger (1992, 1993) further investigated this phonological priming effect in French speakers by comparing it to orthographic priming and examined the temporal pathway of such effects. Target words were preceded by pseudoword primes that were (1) orthographically and phonologically related to the target (O+P+ *lont* - *LONG*) (2) orthographically related but phonologically dissimilar to the target (O+P- *lonc* - *LONG*) or (3) unrelated to the target (*tabe* - *LONG*). Globally, they found that orthographic facilitation priming effects emerged at around SOA of 17 ms and declined around 50 ms, whereas phonological facilitation rose from SOA of 50 ms to decline around 100 ms. This time course of orthographic and phonological priming effects were further confirmed with different control conditions (Ferrand & Grainger, 1994): pure orthographic effects were then examined by comparing O+P+ items to O-P+ items –not only compared to unrelated prime words. This change was motivated by the fact that when comparing O+P- to unrelated primes, not only was there more orthographic overlap between both conditions but also more phonological overlap. An example of such a new manipulation would be: O+P+ prime (e.g., *mert* – *MERE*), O-P+ prime (e.g., *mair* - *MERE*), O+P- (e.g., *merq* – *MERE*) and unrelated prime. Moreover, cross-task comparisons have shown that these pure orthographic and phonological effects appear consistently in the lexical decision and the perceptual identification tasks but not in the naming task (Grainger & Ferrand, 1996).

The three research fields yield evidence that phonological representations are also rapidly and automatically activated during tasks such as the lexical decision or naming. Among word recognition models, not all are able to simulate these findings. According to Rastle & Brysbaert (2006), the Dual-Route Cascaded Model from Coltheart and colleagues (2001) does not permit simulation of *fast* phonological priming. In order to simulate this effect, the nonlexical route has to be speeded up, which in turn triggers regularization errors on irregular word reading. The BIAM model (Grainger & Ferrand, 1994; Diependaele et al., 2010) whose architecture is based on the IA model (McClelland & Rumelhart, 1981) and which includes both lexical and sublexical phonological levels which are directly related to orthographic counterparts, seems to better support these empirical findings. When a visual input activates letters, these in turn activate the orthographic lexicon on the one hand, and each corresponding phoneme on the other hand. This latter connection is conducted via an intermediate layer that includes a graphemic buffer and a grapheme-to- phoneme conversion. As for the orthographic pathway, phonemes then activate the phonological lexicon, which directly interacts with the orthographic lexicon. We should note in this brief review on phonological activation that the precise type of orthographic- phonological coding unit relevant for word recognition has received interest from researchers. Not only have phonemes been investigated but also syllables, rimes (the phonological correspondent of word bodies) and structures such as onset- nucleus- coda (Gross, Treiman & Inman, 2000; Nuerk, Rey, Graf & Jacobs, 2000; Rey & Schiller, 2005).

We should note that phonological coding in visual word recognition has also received some attention in children. Phonological priming effects have led to conflicting results in children and are still a matter of debate. While Booth et al. (1999) reported a masked phonological priming effect in a naming task among children from Grades 1- to- 6 -using a priming paradigm where both primes and targets had a very short exposure of 30 ms followed by a mask-, Davis, Castles & Iakovidis (1998) found no evidence for any phonological effect in a masked lexical decision task –using a SOA of 57 ms. Phonological involvement during visual word recognition has however received stronger support from studies assessing the pseudohomophone interference effect in the lexical decision task (Goswami, Ziegler, Dalton & Schneider, 2001; Sprenger- Charolles et al., 2003).

2. Second section. Lexical access in bilinguals

2. 1. The debate on language- selectivity versus nonselectivity in lexical access

Since the early 80's, one debate on bilingual lexical access has emerged in the psycholinguistics literature, known as the language- selectivity versus nonselectivity debate. The issue raised is whether bilinguals co- activate both languages when dealing with one language or whether only the target language under use is activated. This lexical *access* issue is strongly related to the lexical *organisation* issue, which questions whether there are separate lexicons for each language or one integrated lexicon. Theoretically, these two issues could be disentangled leading to four approaches: 1) separate lexicons, selective access 2) separate lexicons, nonselective access 3) integrated lexicon, selective access and 4) integrated lexicon, nonselective access. However, the literature has often combined lexicon access and organisation issues and proposed two hypotheses, either integrated lexicon associated with a language- nonselective lexical access or separate lexicons associated with a language- selective access.

Initial studies tended toward a selective access hypothesis due to the observation of interference effects in language switching experiments: code- mixed sentences were observed to be processed more slowly than code- unique sentences and this interference was thought to reflect the time cost to switch lexicon (Macnamara & Kushnir, 1971; Soares & Grosjean, 1984). This was interpreted within an "input switch" mechanism, which was supposed to guide the incoming visual information to the right lexicon before its recognition. However, more recent data using isolated word recognition paradigms support the language- nonselective hypothesis, that is, lexical candidates from both target and nontarget languages are supposed to be co- activated during word recognition and language membership information would therefore be activated once the word is accessed, post- lexically.

Two lines of evidence have been reported in support of the language-nonselectivity hypothesis: 1) findings regarding cognate words and interlingual homographs on the one hand and 2) consideration of cross-language orthographic – and phonological - neighbourhood effects on the other hand.

2.2. On cognates and interlingual homographs

Cognate words refer to those words that share form and meaning across two (or more) languages, where form overlap is commonly considered as orthographic overlap. As a consequence of historical relationships between France and the United Kingdom, the French and English languages share many words such as *silence* - orthographic and semantic overlap - or *piano* - orthographic, phonological and semantic overlap. Oppositely, words that differ in meaning but share either orthographic overlap or phonological overlap are called interlingual homographs (e.g., the French word *four*, meaning *oven* is an example of such words) and interlingual homophones respectively (e.g., *buy* and *baille*, meaning *yawn*). Though we acknowledge the theoretical contribution of interlingual homograph studies, for sake of concision and clarity, a focus is made on cognates which will constitute a core aspect of our experimental work.

Cognate words have been shown to be facilitated as compared to control matched words in a variety of word recognition paradigms and tasks: the lexical decision task (Dijkstra, Grainger, & van Heuven, 1999; Dijkstra, van Jaarsveld, & ten Brinke, 1998; Gollan, Forster & Frost, 1997; Lemhöfer & Dijkstra, 2004; Lemhöfer, Dijkstra & Michel, 2004; van Hell & Dijkstra, 2002); the progressive demasking task (Dijkstra et al., 1999; Dijkstra, Miwa, Brummelhuis & Baayen, 2011); the naming task (Kim & Davis, 2003; Jared & Szucs, 2002; Schwartz, Kroll & Diaz, 2007); and word production (Costa, Caramazza & Sebastián-Gallés, 2000). Note the use of the masked priming paradigm by some authors (De Groot & Nas, 1991; Gollan, Forster & Frost, 1997; Kim & Davis, 2003).

The fact that responses to these items are faster than those to monolingual matched words suggests that access to the target language of the task is affected by the individual's other language, an argument for language- nonselective lexical access. An additional cognate facilitation effect has even been reported when cognates occur in three languages as compared to cognates that occur in two languages (Lemhöfer, Dijkstra & Michel, 2004), revealing that language- nonselectivity applies for multiple languages in polyglots and that a L2 can also influence a L3.

However, this facilitation effect has been shown to depend on several variables. First, cognate words have been either defined as *identical* words such as our example *silence* in French and English, or as *similar* words or so-called *neighbour cognates* such as *oncle – uncle*. Though some studies have somewhat mixed these two categories of items (De Groot & Nas, 1991), the degree of orthographic overlap has however proved a relevant variable in examining cognate effects. Cognate facilitation has also been reported for these neighbour cognates in L2 tasks (De Groot & Nas, 1991; Dijkstra, Miwa et al., 2011; Font, 2001) but the amplitude of the effect seems smaller than the one for identical cognates (see Dijkstra, Miwa et al., 2011 for precise examination of the influence of orthographic similarity). Confusion in the field also comes from the somewhat unclear assessment of both orthographic *and* phonological overlap of the cognate words across languages. Though cognates are commonly defined as sharing form and meaning across languages, the presence or absence of phonological similarity seems to make a difference in the patterns observed (Dijkstra, Grainger & van Heuven, 1999; Lemhöfer, Dijkstra & Michel, 2004; Schwartz, Kroll & Diaz, 2007). Dijkstra, Grainger and van Heuven (1999) first tried to disentangle the effects from the different codes involved by examining different degrees of overlap: items sharing semantics, orthographic and phonological codes (SOP, *piano* in French- English), items sharing semantics and orthography (SO, *silence*) and items sharing semantics and phonology (SP, *règne* - *reign*[6]). Note that this same distinction was made for interlingual homographs -or homophones (OP, O, P). Whereas Dijkstra and colleagues found the common facilitation cognate effects for the SOP (e.g., *piano*) and SO (e.g., *silence*) categories, cognates that only shared semantics and phonology, that is SP (e.g., *règne*), produced null effects as compared to matched control words. These null effects however strongly contrast with masked priming studies that used cross- script cognates (necessarily from the SP condition given that they do not share a script) and found cognate facilitation effects as compared to non- cognate words (Gollan, Forster & Frost, 1997; Kim & Davis, 2003). Second, the language of the task (dominant versus nondominant) has been shown to be relevant in observing this effect.

[6] Note that this SP condition is especially hard to localize in the French- English language pairing and that the chosen words in this example are not phonological identical, but rather very similar. The authors of the cited study tested Dutch/ English bilinguals, a language pairing that yielded more items for this condition.

Though cognate facilitation has been widely found in word recognition tasks in L2, the findings are sparser and less clear in L1. Several studies have indeed failed to find such an effect from the nondominant to the dominant language (Caramazza & Brones, 1979; Gollan, Forster & Frost, 1997 with cross- script cognate priming, and more recently Brenders, van Hell & Dijkstra, 2011 in child L2 learners). However, van Hell and Dijkstra (2002) reported a cognate facilitation effect in a L1 lexical decision task when cognate words existed in participants' L2 and even L3 when these languages were highly proficient. Using electrophysiological recordings, Midgley, Holcomb and Grainger (2011) confirmed this cognate facilitation in a L1 semantic categorization task in late L2 learners by means of ERP data. Third, individuals' proficiency is of particular interest in investigating cognate processing and related strategies. Both van Hell and Dijksta (2002) and Lemhöfer, Dijkstra and Michel (2004) reported proficiency effects in trilinguals where only the higher proficiency bilinguals showed a L3- to- L1 cognate facilitation effect. Though most studies assessed highly proficient bilinguals, one recent study by Brenders and colleagues (2011) investigated cognate processing in Dutch children of Secondary Grade 5, 7 and 9 learning English at school as a L2. They reported cognate facilitation effect in a lexical decision in L2 (experiment 1) but not in L1 (experiment 2). However, this L2 facilitation effect disappeared when adding interlingual homographs to the list (experiment 3), a finding that contrasts with adult high proficiency bilinguals for whom a cognate facilitation effect is still observed under these conditions. This may be explained by the ambiguity children may feel about cognate words regarding language membership, ambiguity that is exacerbated by the presence of other ambiguous words such as interlingual homographs. This latter example reflects the importance of one other variable when considering cognate processing: task effects. Cognate effects have been shown to be facilitatory in both standard lexical decision task (i.e., decide whether the item is a word in a particular language or not) and generalized lexical decision task (i.e., decide whether the item is a word or not, whatever the language it belongs to, Dijkstra, Grainger & van Heuven, 1999; Lemhöfer & Dijkstra, 2004); though, it has been less clear in the progressive demasking task, with either facilitation effects (Dijkstra, Grainger & van Heuven, 1999) or an interaction with cognate frequency, the facilitation arising for low frequency cognates only (Dijkstra, Miwa et al., 2011). Cognate effects tend to be inhibitory when using a language- decision task where participants have to decide on the language membership of the item.

The representation of cognate words in the bilingual lexicon has also raised different interpretations and the question remains open. Some researchers suggest that cognates consist of one unique orthographic representation across languages and that a facilitation effect may be seen as a cumulative frequency effect. This representational hypothesis, however, cannot explain the observation of *neighbour* cognate facilitation effects (e.g., *tomato* – *tomate*) for which several orthographic representations must be assumed. Globally, a semantic- to- orthography feedback effect may account for the cognate facilitation effect. Cognate words would receive more semantic feedback from L1 and L2 nodes as compared to control words for which only L2 node feedback may be sent back to the lexical representation.

2. 3. On orthographic neighbourhood effects

Findings relative to cross- language orthographic neighbourhood effects can be considered as the strongest evidence in favour of language- nonselective lexical access in bilinguals since the materials presented only belong to one language, and there is no presentation – al least consciously perceived- of the nontarget language. As in the monolingual literature, both effects of the *number* of cross- language neighbours and of the *frequency* of these neighbours have been observed.

In English- French bilinguals, Grainger and Dijkstra (1992) found that lexical decisions were faster for English words that had many more neighbours in English than in French or so-called "patriots" than for "neutral" words that had equal number of neighbours in both languages, which in turn were recognized faster than "traitors" that had more neighbours in French than in English. With the same population, Van Heuven, Dijkstra and Grainger (1998) manipulated orthogonally Dutch and English neighbourhood size in both lexical decision and progressive demasking tasks in the two languages. The items either had a small neighbourhood in English and Dutch (Small E/ Small D), small in English but large in Dutch (Small E/ Large D), large in English but small in Dutch (Large E/ Small D) or large in both languages (Large E/ Large D). They observed within- and cross- language inhibition effects of the Dutch (L1) neighbourhood, that is, reaction times increased when either Dutch or English target words had a large Dutch neighbourhood size. However, large English neighbourhood size tended to facilitate processing, as has been sometimes found in the monolingual literature too (Andrews, 1992). These effects of cross- language neighbourhood size were also observed in an ERP study from Midgley, Holcomb, van Heuven & Grainger (2008), who found a more negative-going waveform in the N400 window for those words with several cross- language neighbours as compared to those without.

A frequency neighbourhood effect has also been reported across languages

(Bijeljac- Babic, Biardeau & Grainger, 1997; Dijkstra, Hilberink – Schulpen & van Heuven, 2010; Font & Lavaur, 2004). Bijeljac- Babic and colleagues (1997) first showed an inhibition priming effect in French- English bilinguals when target words from one language were preceded by orthographically related high frequency prime words from the other language (e.g., *gare – CARE* for a French- English bilingual). These effects were demonstrated bidirectionally from L1- to- L2, and from L2- to- L1. This latter effect was significant in higher proficiency bilinguals only, and null effects were reported in lower proficient bilinguals and monolinguals. Dijkstra et al (2010) also tested frequency neighbourhood effects in a priming paradigm in Dutch- English late bilinguals but added a pseudoword priming condition. They found inhibition priming effects with words as primes but facilitation priming effects with pseudowords as primes, a pattern which was significant at the first presentation of the targets only. These findings would support the idea that the null effect found by Bijeljac- Babic et al. (1997) in lower proficiency bilinguals and the so-called adult monolinguals –who had in fact studied English at Secondary school as our own population of adult L2 learners - may have reflected a mix of lexical inhibition and sublexical facilitation from letter overlap processes, since facilitation priming effects would have been expected if primes had been totally unknown, as is the case for pseudowords (Forster & Veres, 1998). The neighbourhood frequency effect has also been shown in French – Spanish bilinguals in a standard lexical decision task. Font and Lavaur (2004, experiment 1) found in both L1 and L2 that response latencies to words that have cross-language neighbours of higher frequency were longer than for words that do not have any neighbours, confirming evidence of neighbourhood frequency effects from the monolingual literature using this same task (Grainger, 1990; Grainger & Segui, 1990).

2. 4. On phonological interactions

Phonological activation across languages during word recognition has been less studied than orthographic activation. As evidence, the first version of the Bilingual Interactive Activation model (Dijkstra, van Heuven & Grainger, 1998) did not include any phonological representations in their model, contrary to its revised version, BIA + (Dijkstra & Van Heuven, 2002) which does include a phonological lexical and sublexical level.

Nas (1983, experiment 2) examined the pseudohomophone interference effect in Dutch- English bilingual participants in an English lexical decision task. Pseudowords that sounded like Dutch words when pronounced using the English spelling- to- sound rules were included in the stimulus list (e.g., the pseudoword *snay* which, according to the English conversion rules, sounds like the Dutch word *snee*). He found that these Dutch pseudohomophones took longer to be rejected than control pseudowords, a finding that supported the idea of parallel co-activation of the grapheme- to- phoneme correspondences whatever the language. Similarly, Haigh & Jared (2007) found a homophone advantage in an English lexical decision task. French- English bilinguals were faster in accessing English words that were homophonic to French words (e.g., *sank* homophone of *cinq*, *five*) as compared to control English words (for a contradictory pattern, see Jared & Szucs (2002) who found an interference homophone effect in a naming task). As is the case in monolingual research on homophony effects (McQuade, 1981), this facilitation effect was modulated according to stimulus list composition (i.e., adding pseudohomophones, cognates or interlingual homographs to the materials).

In the fields of cognate and translation equivalence research, several studies have also found support for a co- activation of cross-language phonological representations. However, there are contradictory findings about the direction of such phonological effects depending on the methodology used. Cross- script studies using the priming paradigm have reported facilitation priming effects for phonologically overlapping primes and targets. Gollan, Forster and Frost (1997) had Hebrew-English and English-Hebrew bilinguals perform an English lexical decision task associated with the priming paradigm. L2 targets were preceded by L1 translation equivalents that were either cognates (i.e., they shared semantics and phonology) or noncognates (i.e., they shared semantics without any phonological form overlap). They found a translation priming effect from L1- to- L2 only, which was larger for cognates than noncognates. Since Hebrew and English do not share the same script, cognate words shared semantics and phonology, but not orthography and the authors attributed this increased effect for cognate words to the phonological overlap between the prime and the target. Using a standard English (L2) lexical decision task, Dijkstra, Van Heuven and Grainger (1999, experiment 2) observed that translation equivalents that only shared semantics and phonology (SP condition) were processed similarly to control words; further, cross-language non-cognate homophones (i.e., P condition, *cow* in English; *kou* in Dutch, meaning *cold*) that did not share much orthographic similarity, were responded to more slowly than control words by Dutch- English bilinguals. In contrast, in a naming task performed by Spanish – English bilinguals, Schwartz, Kroll and Diaz (2007) found that cognate words that were orthographically similar (S+O+ items), were responded to slower in a naming task when phonologically dissimilar (S+O+P- items, such as the cognate word *base* in English- Spanish) compared to when phonologically similar across languages (S+O+P+ items, such as *piano*). Thus, it seems from these three studies, that phonological similarity is likely to facilitate responses when the words also share semantics (Gollan & al 1997 in a translation priming experiment; Schwartz & al, 2007 in a naming task; but see Dijkstra et al., 1999 when orthographically dissimilar), but will slow down responses when words do not share any semantic relationship (Dijkstra et al. (1999) with cross- language homophones in a lexical decision task).

More recently, a few studies have emerged on cross- language phonological activation using the masked priming paradigm. Brysbaert, Van Dyck and Van de Poel (1999) first used the masked phonological priming procedure in bilinguals. They aimed to investigate phonological activation within a L2 and across languages from the L1 to the L2. Dutch- French bilinguals had to perform a L2 lexical decision task. Two conditions were studied: within- L2 phonological activation - that is French prime/French target - and cross-language - Dutch prime/French target. In the cross-language condition, French target words were preceded by a prime word (experiment 1, *dier – DIRE*, meaning *say*) or a prime pseudoword (experiment 2, *foer – FOUR* meaning *oven*) that according to the Dutch L1 spelling- to- sound conversion rules was homophonic to the French target word (/dir/ and /fur/ respectively). For the French/French condition, the stimuli used were taken from Grainger & Ferrand (1996). The French target word *FAIM* could be preceded by a pseudohomophone O+P+ *fain*, by the graphemic control O+P- *faic* and by a P+O- condition, such as *fint*. The phonological effect was the difference between the conditions 1 and 2 (O+P+ and O+P-) and the pure orthographic effect was the difference between the conditions 1 and 3 (O+P+ and O-P+; to see the arguments for the use of this third condition instead of the usual unrelated condition, see Grainger & Ferrand, 1996). For the Dutch/ French condition, the French target *OUI* could be preceded by its Dutch homophone prime word *wie*, a graphemic control *jij* and an unrelated word *dag* (experiment 1). Note than item constraints prevented Brysbaert and his colleagues from using the P+O- condition. For experiment 2, the same priming conditions were used but with pseudowords as primes which were homophonic to the French target words according to Dutch spelling-to- sound rules only. In both experiments, the results showed within and cross-language orthographic and phonological priming effects. Target words were responded to faster when preceded by a (pseudo)homophone prime than when preceded by a graphemic control prime. This first study reveals that: (1) even though a second language is usually acquired on the basis of visual/orthographic learning simultaneously or even before oral proficiency develops, when processing in a L2, phonology is automatically activated; and (2) when processing a L2, the L1 phonological code is automatically and sublexically activated. Thus, it would seem that phonological coding happens independently of language and simultaneously for all the conversion rules mastered by a bilingual. Kim & Davis (2003) failed to find a phonological priming effect for Korean-English bilinguals in the lexical decision task, although they did find it in the naming task and for prime/target conditions where both phonology *and* semantics were shared, results that were explained in terms of task effects modulating the degree of phonological involvement when making a response. Nevertheless, phonological priming was recently reported in Chinese- English bilinguals for whom the two languages differ in family membership (logographic vs. alphabetic). Zhou, Chen, Yang & Dunlap (2011) reported a facilitation effect when a target word from one language was preceded by a homophonic prime word from the other language (that shared neither orthography nor semantics). This effect was equivalent from L1- to- L2 and from L2- to- L1, and independent of participants' proficiency in the L2. This is strong evidence for language nonselective phonological coding in bilinguals, whatever the nature of the languages.

The use of pseudowords in Nas (1983) and Brysbaert et al (1999, experiment 2) gives some evidence for a *sublexical* locus of the cross-language phonological interaction. Not only could the lexical phonological codes across languages be linked, but also the spelling- to- sound correspondence sets in each language (see Jared & Kroll, 2011 for further evidence of co- activation of correspondence rules in a naming task and examination of several factors such as participants' expectancy, bilinguals' proficiency, language of the task, and recent reading experience). Language-nonselective phonological activation seems to be supported now by most studies, both at the lexical and sublexical phonological levels; yet, the influence of participants' proficiency remains unclear. While some report a proficiency effect in the co- activation of sublexical phonology (Jared & Kroll (2001) by manipulating body neighbourhood size across languages in a naming task), others using the masked priming paradigm provide evidence of similar phonological priming effects whatever the language of the task (Duyck et al., 2004; Zhou et al., 2011; however, see Brysbaert & al, 1999 for a trend for smaller L1- to- L2 phonological priming among balanced compared to less proficient bilinguals).

2. 5. The Bilingual Interactive Activation model

The bilingual interactive activation (BIA, Dijkstra, van Heuven & Grainger, 1998) and its extension BIA + (Dijkstra & van Heuven, 2002, see below Figure 3) are both derived from the previously described monolingual IA model (McClelland &

Rumelhart, 1981). These models share the same principles of interactivity across three levels: features, letters and words. A language level (i.e., including language nodes for L1 and L2) has also been added to the BIA models to represent the language membership of words.

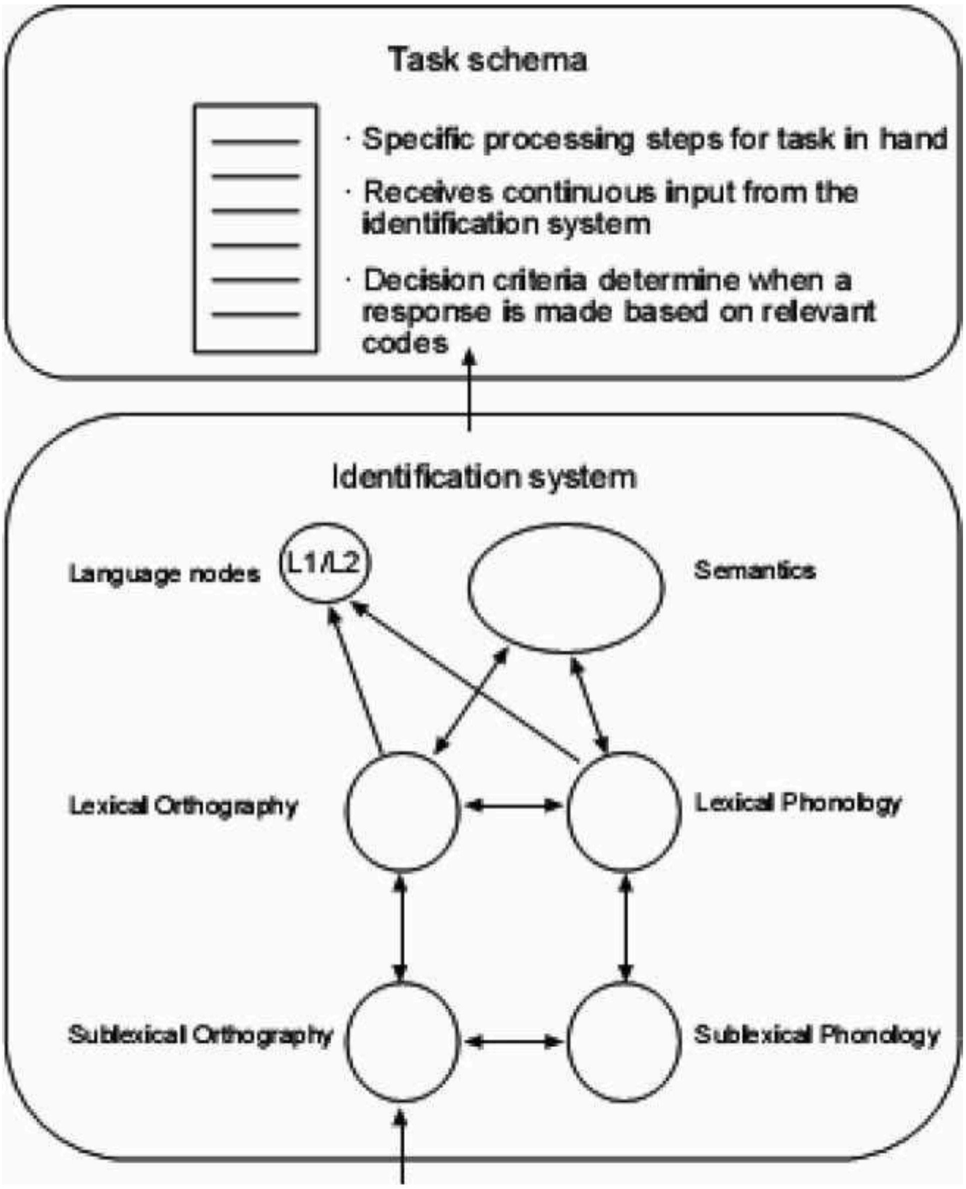
The BIA model was presented in 1998 by bringing together all existing empirical evidence found on the orthographic side of lexical access. As demonstrated by cognate/homograph studies on the one hand and cross- language orthographic neighbourhood studies on the other hand, lexical access was postulated to be language nonselective in the initial phases, that is, words from both languages were supposed to be co- activated whatever the language input. The existence of “language nodes” is another major characteristic of the model. These language nodes were conceived so that they could receive bottom- up activation from the corresponding words (word X activates language node X/ word Y activates language node Y) and send top-down inhibition to the words from the other language (language node X inhibits word Y/ language node Y inhibits word X). In this initial model, language nodes were thought to assume four functions in the word recognition system. Firstly, these can be seen as language tags which enable the representation of language membership information for words. Secondly, these nodes also collect global lexical activation information in a given language, a function that was useful in explaining language switch costs. Thirdly, language nodes also behaved as language filters whose aim was to modulate the relative activation of each language. For instance, this function was thought to explain differential orthographic neighbourhood effects found by van Heuven et al (1998) depending on whether items were presented in a blocked list (i.e., one language per list) or in a mixed list (i.e., the two languages presented in the same list).. Finally, the language nodes in the BIA model were thought to collect non-linguistic contextual activation (e.g., pre activating one language node and its connected word representations according to expectancy or instructions). This model played a major role not only in detailing for the first time the mechanisms in play during bilingual visual word recognition but also by simulating a large set of empirical findings (e.g. cross- language neighbourhood size and frequency effects (Bijeljac- Babic et al., 1997; Van heuven et al., 1998), variations of these effects according to experimental conditions (see Van Heuven et al., 1998, comparing in a Dutch lexical decision task English neighbourhood size effects according to whether recently exposed to English or not), and according to proficiency (Bijeljac- Babic et al., 1997), homographs effects (Dijkstra, Timmermans & Schriefers, 2000) and language switch effects (Von Studnitz & Gree, 1997)). In spite of this important advance in the field, some limitations or gaps in the model led to the development of the BIA+ model a few years later.

In the BIA+ model, phonological levels (lexical and sublexical) as well as a semantic level were added in order to incorporate the most recent data. Note that although not implemented in the model, the authors postulate intermediate sublexical orthographic and phonological levels, namely Onset- Nucles- Coda units, between letters/phonemes and words. As for orthographic representations, language nonselectivity was claimed to be the processing principle for both of these representations. Specifically, the authors also proposed that, due to lower subjective frequency, L2 phonological and semantic codes are delayed in activation relative to L1 codes, an idea referred to as the “temporal delay assumption”. According to the authors, one consequence is that cross- linguistics effects should be larger from L1- to- L2 as compared to from L2- to- L1. Nevertheless, contradictory evidence has emerged from the literature. For instance, Jared and Kroll (2001) reported that French- English bilinguals, but not English- French bilinguals were affected by the number of French body neighbours in an English naming task. Indeed, only participants for whom French was the L1 were affected by this variable in that they named English words with French enemies more slowly than English words with no French enemies. This result therefore points to an effect of participants' language dominance in modulating the influence of cross- language phonological information –at the body/rime level. In contrast, a study from Van Wijnendaele and Brysbaert (2002) revealed no effect of language dominance when using the masked phonological priming paradigm. They showed in Dutch- English bilinguals (non balanced late L2 learners) that cross- language phonological priming effects were of comparable magnitude from L2- to- L1 and L1- to- L2 (see also Lee, Nam & Katz, 2005 for similar priming manipulation with Korean- English bilinguals, though at a longer SOA of 140 ms). As argued by Brysbaert, Van Wijnendaele and Duyck (2002, p. 199) in their comments on the model, " if the activation of phonology in L2 were rather slow (and/or weak), then one would expect less impact of phonology in second language processing than in first language processing". More studies are therefore needed in order to assess this particular point of debate of the BIA+ model. Note that a cross- linguistic perspective examining the influence of the specific language of the task on the weigh of phonological activation (Frost, Katz & Bentin, 1987; Goswami & Ziegler, 2006; see Goswami et al., 2001 in German and English children), and on the role of the different grain size in phonological coding (Goswami et al., 2001, 2003) could also shed some light on the mechanisms that may be "transferred" across languages versus those that may be specifically developed in the L2 (see Green, 2002's commentary on this point and doctoral dissertation on the topic by Sumutka, 2003). A major change also came from the distinction the authors made between the "identification system" and the "task schema" where task and decision parameters are set up, which can be considered as independent though interconnected systems. Task schema refer to those mental operations that are carried out when responding to a specific task, operations which are set up during the practice trials or retrieved from memory. A decision mechanism, which belongs to the task system, continuously checks the relative activations from all codes within the lexical system and formulates an appropriate output response which may optimize performance in terms of speed and accuracy. While the identification system may be influenced by linguistic variables such as syntactic and/or semantic influences at the word/sentence levels, only the task schema can be influenced by non-linguistic variables such as participants' expectancy, instructions, and recent exposure[7]. Note that this perspective contradicts Grosjean (1997, 2001)'s *language mode hypothesis* which postulates that linguistic and non-linguistic variables may affect the relative activation of each language (see Chapter 1, Study 3 for further details). Changes in the conception of language nodes were also made so that these now only function as language tags and global lexical activity indicators. This language membership information was also modelled so that it had a late influence in the identification system. Modulation of relative language activation and non-linguistic contextual preactivations were supposed to be assumed by the task/decision system and therefore not to affect visual word identification *per se*. More details about cognate and homograph representation also

[7] Note that this particular point is relatively novel in this model given the former version postulated that language nodes -which belong to the identification system- could be influenced by non-linguistic variables.

constitute relevant contributions from this extension.

Figure 3. The BIA + model. From Dijkstra & Van Heuven, 2002.



So, cognate facilitation effects may be conceived in the BIA+ model as benefiting from a strong feedback from semantics to the orthography but the specific representation of identical cognates is still under debate (Dijkstra & van Heuven, 2002;

van Hell, 2002). Orthographic neighbourhood effects may be explained by the same formulation in monolingual and bilingual word recognition. Orthographic neighbourhood size effects (Grainger & Dijkstra, 1992; van Heuven et al., 1998; Midgley et al., 2008), that is longer recognition latencies when the target word has a large number of cross- language neighbours as compared to when it has a few, can be explained by the mutual inhibition these neighbour words exert on the target word, that do not affect target words without neighbours[8]. With regard to the orthographic neighbourhood frequency effect in highly proficient bilinguals, high frequency words are activated more strongly and send more inhibition to their neighbours as compared to low frequency words, within and across languages. High frequency prime words therefore send strong inhibition to the orthographically related low frequency target word as compared to an unrelated control condition. Note that the lower the proficiency in L2, the more asymmetrical cross- linguistic effects may be expected (i.e., stronger from L1- to –L2 than in the opposite direction). Language- selectivity occurs in the later phases of word recognition when language nodes start to inhibit the nontarget language.

While this model enabled the summarization and simulation of many empirical findings, and provided a valuable theoretical tool when examining bilingual processing, some issues could not be entirely addressed. In particular, the static nature of the model seems to prevent from providing developmental assumptions on bilingual word recognition (Green, 2002; Jacquet & French, 2002; Li, 2002; Thomas, 2002; Van Hell, 2002). Some mechanisms were suggested by the authors to account for proficiency effects such as modulating the resting level activations according to factors such as

[8] Note that monolingual research has sometimes found facilitation effects when targets have a large neighbourhood size as compared to small size (Andrews, 1989, 1992)

words' subjective frequency or slightly varying the decision parameters and these mechanisms proved fruitful in the BIA model for simulating the proficiency effects found by Bijeljac- Babic and colleagues (1997). Yet, the possibility that the *nature* of representations, as referring to sublexical orthographic and phonological representations for instance, may evolve as individuals learn a foreign language was not addressed. Other limitations were pointed out in the peer commentary section of the paper, such as the lack of precision about how to include the semantic module (Jacquet & French, 2002; van Hell, 2002), the exact processing role of the language nodes (Green, 2002; Jacquet & French, 2002; Thomas, 2002) and as already pointed out, the temporal delay hypothesis (Brysbaert, van Wijnendaele & Duyck, 2002).

Recently, Grainger, Midgley & Holcomb (2010) developed a theoretical approach and extended the BIA model by incorporating the developmental dynamics on late L2 vocabulary acquisition – in a school contex- from Kroll & Stewart (1994)'s Revised Hierarchical Model (RHM). As in RHM, they suggested that during an initial phase of supervised L2 learning, L2 word forms were first strongly connected to their L1 translation equivalents (from which semantics was retrieved). During a following unsupervised learning phase, L2 word forms progressively made direct contact with their semantic representations (excitatory connections between L2 words and semantics increase), while connections between L2 words and their translation equivalents decreased. In order to develop efficient language control as vocabulary grows, connections between L2 word forms and the L2 language node increase as well as inhibition from the L2 language node to L1 word forms. Though this theoretical proposal addressed one of the major criticism of the BIA and BIA+ models, namely the lack of a dynamic learning principle, we should note that the focus of this contribution was rather on the relationship between orthographic and semantic representations –an issue that is obviously crucial when considering vocabulary acquisition- but little on the lower levels of lexical and sublexical orthographic and phonological representations.

So, several theoretical issues remain to be explored in our view, related to the role of proficiency in observing language nonselectivity in lexical access. More precisely, the extent to which this nonselectivity processing principle in visual word recognition could be found in L2 school learners of varying proficiency was of major interest in the present work (see Chapter 1). Elements of the models such as language nodes and the role of non-linguistic variables on the identification system were also assessed in this population in some of our studies. Yet, another major interest developed in this work aimed to contribute to the model by exploring sublexical orthographic variables, such as the role of orthographic markers during lexical access and the building of new L2- specific orthographic representations, i.e., language- specific complex graphemes (see Chapter 2). This issue seemed of particular relevance given the observation that many L2 words contain orthographic components that make them very language- specific (Lemhöfer et al., 2008; Vitevitch, 2012). The final issue of interest, namely phonological interactions across languages, could also shed some light on the BIA+ model which integrated lexical and sublexical phonological modules, and especially on the language nonselectivity of print- to- sound correspondences activation and of the effect of cross- language differences in the existence of multiple or inconsistent print- to- sound associations (Chapter 3).

The next section further describes the overall goals of the present work, directly resulting from the major challenges L2 learners are faced with during L2 acquisition, as well as the population and context of acquisition. As already pointed out, each experimental chapter and study then begins with a corresponding introduction where all theoretical elements that are necessary to the comprehension of the studies are presented, including both monolingual and bilingual theories and previous empirical findings, and where more specific hypotheses can be made.

3. The present endeavour

Learning a second language has become fundamental over the last decades to the adaptation to globalization and it has progressively received greater attention from educational policies over the world. In many industrial countries, second language (L2) teaching starts from Grade 6 at Secondary school and represents a substantial part of children school curriculum throughout their education (between 3 to 4 hours per week).

What we know about L2 acquisition mostly comes from studies that investigate bilingual or highly proficient L2 learning children who learn a L2 very early in age and who come from linguistic minority backgrounds and/or attend immersion classes. Globally, these studies have dealt with three main issues related to L2 *literacy* acquisition: 1) cross-language interactions between reading- related skills, namely, cross- language *transfer*, 2) the effect of the orthographic distance between the two languages mastered by the learner, and 3) the advantages in reading or metalinguistic abilities of being bilingual over monolingual. Though the relationship between these issues and the examination of *on-line* mechanisms of word recognition in L2 learners is difficult to establish –as in the monolingual reading literature-, we cannot dismiss them without giving a brief review on this research.

3.1 A brief review on L2 reading acquisition

The investigation of cross- language transfer of reading and reading- related skills has emerged from the “linguistic interdependence hypothesis” developed by Cummins (1979) that postulates that cognitive and linguistic abilities in the L1 are also available in a L2 given that they reflect language- general processes. The concept of transfer refers to the influence of previous knowledge or abilities on newly acquired knowledge or abilities. Similarly, difficulties in the L1 are supposed to be observed in the L2 since they reflect a general cognitivo- linguistic deficit. Word and pseudoword reading skills have been shown to correlate across alphabetic languages, and L1 skills to predict L2 skills (DaFontoura & Siegel, 1995 in Portuguese children learning English as a L2, D'angiulli, Siegel & Serra, 2001 in Italian children who are English learners); this effect has also been reported among alphabetic languages whose scripts differ (Geva, Wade-Woolley & Shany, 1997; Geva & Siegel, 2000 in English children attending respectively Grade 1-2 and Grade 1 to 5 learning Hebrew as a L2, Wang, Park & Lee, 2006 in Korean children from Grades 1 and 3 learning English as a L2), as well as in English learning children whose L1 has a logographic script such as Chinese (Gottardo, Yan, Siegel & Wade-Woolley, 2001 in a longitudinal study from Grade 1 to Grade 8 and Wang, Perfetti & Liu, 2005 in 8 years old children). More, predictors of successful reading, namely phonological and orthographic processing skills (Cunningham, Perry & Stanovich, 2001), have been reported to correlate between L1 and L2, and to predict reading outcomes across languages (Cisero & Royer, 1995; Comeau, Cormier, Grandmaison & Lacroix, 1999; Deacon, Chen, Luo, & Ramirez, 2011; Deacon, Commissaire, Chen & Pasquarella, in press; Deacon, Wade-Woolley & Kirby, 2009;

Durgunoğlu, Nagy & Hancin-Bhatt, 1993; Geva & Siegel, 2000; Gottardo et al., 2001). Our recent study, Commissaire, Duncan and Casalis (2011) added evidence for cross-language transfer of orthographic processing skills in French adolescents who start English (L2) learning at Secondary school from Grade 6. One major difference between this study and the majority of published data is that cross- language transfer was considered for one particular skill, not from one skill to reading outcome. In Commissaire et al., (2011), French (L1) orthographic skills explained unique variance in English (L2) orthographic skills after controlling for L1 reading skills and L2 vocabulary. This result was found after 2 years of L2 exposure (significant for Grade 8 children; not for Grade 6 children) and for a *lexical* measure of orthographic processing that taps word- specific orthographic knowledge (i.e., for instance, choose the correct spelling between *boat* and *bowt*). What was termed *sublexical* orthographic processing or also called sensitivity to orthographic regularities (i.e., for instance, decide which pseudoword is more word-like, *buff* or *buph*?) was, however, not found to transfer across languages at either grade.

Although transfer of reading skills have been observed in many studies, there has been evidence too that these links depend on the "orthographic distance" between the two languages as well (Koda, 1996) and that specific features of the L1 or L2 may influence processing during L2 learning. Learning graphemes in a L2 whose corresponding phonemes do not exist in L1 has been shown to be a challenge for L2 learners and to depend on oral language skills such as auditory discrimination (Wang & Geva, 2003). Research comparing English (L2) learners from varying linguistic backgrounds has also shed some light on the specificities of L2 learning depending on L1 characteristics (Koda, 1999; Muljani, Koda & Moates, 1998, Richard Liow & Lau, 2006; Wang, Koda & Perfetti, 2003). Wang, Koda and Perfetti (2003) compared English learners from an alphabetic L1 background (Korean) or a logographic background (Chinese) in a L2 semantic categorisation task. Participants had to decide whether an English (L2) word belonged or not to a prespecified semantic category. Two foil conditions were added in order to assess the influence of L1 background: homophonic foils (e.g., *feat* as homophone of *feet* for the category "body part") and visual foils (e.g., *fees* as orthographically similar to *feet*). The authors revealed different L2 processing patterns according to participants' L1. First, the Korean participants scored higher at the task as compared to the Chinese participants and this was interpreted as an overall advantage of decoding for the Korean participants given the alphabetic nature of their L1 (note that Korean and Chinese languages share similar visual properties and therefore make a good comparison pair). Second, the Koreans made more errors on homophones such as *feat* (i.e., that were supposed to be rejected in the task) while the Chinese participants made more false alarms on orthographically similar words such as *fees*. This was interpreted by the authors as reflecting the transfer of "preferred" procedures developed in their L1 to the processing of a newly acquired L2. Thus, orthographic distance between the two languages may influence L2 learning both quantitatively in terms of the degree of abilities developed, and qualitatively in terms of the procedures used. Comparisons of linguistic background on L2 learning have also been conducted when both L1s are alphabetic languages but differ in terms of the processing skills used in literacy. Besse, Demont and Gombert (2007) compared French L2 learners aged 14 years from either Arabic or Portuguese L1 background on various tasks assessing L2 phonological (rime and phoneme) and morphological (derivational and inflexional) processing. Their results revealed lower phonological awareness in

Arabic as compared to Portuguese (L1) participants but higher morphological awareness. The correlational pattern between reading skills and these metalinguistic tasks, however, reveal an interesting pattern: L2 reading in Portuguese speakers was correlated with morphological awareness while it correlated with phonological awareness in Arabic speakers. This was interpreted as reflecting the need to develop strategies adapted to the L2 and the relation between this ability and acquiring literacy in a L2: Arabic speakers for whom phonological skills may be less relevant in their L1 would benefit in L2 reading success from developing this skill while Portuguese speakers may have to develop morphological skills, given they already master L2 phonology due to the proximity between French and Portuguese. In all, these two research fields reveal the need for jointly considering the transfer of abilities across languages and specificities in the process depending on the languages' characteristics when examining L2 learning (Gholamain & Geva, 1999).

The third aspect of L2 learning that is currently under consideration in the literature concerns the comparison of monolinguals with bilinguals or L2 learning children. In literacy, several studies have reported an advantage of early bilinguals over monolinguals on phonological awareness (Bialystok, Majumder & Martin, 2003 for a comparison of Spanish- English and Chinese- English bilinguals; Campbell & Sais, 1995; Kovelman, Baker & Petitto, 2008) or morphological awareness (Kuo & Anderson, 2006), although these results are dependent on variables such as proficiency, age of acquisition or language characteristics. We should also note that a bilingual over monolingual advantage is evident not only in linguistic tasks but also in more general cognitive domains (Bialystok, 2009, although see Ivanova & Costa, 2008 for a disadvantage in naming speed for bilinguals, even in their L1, in comparison with monolinguals).

3.2. Context of the present work

Surprisingly, there is a huge gap on the issue of word recognition in L2 acquisition, among populations who have not yet mastered the L2, have a rudimentary lexicon and little exposure to the language. As can be seen from the preceding review, both the theoretical background (i.e., transfer of reading and reading- related skills) and the methodology (i.e., off- line measures of literacy and their predictors) used in investigating L2 learning strongly differ from those in the adult bilingual literature. Globally, the present work is concerned with L2 word recognition as referring to the process by which a word is computed as “a form representation of the physical signal that is then matched to abstract representations stored in memory” (Grainger & Dijkstra, 1996, p. 139). More precisely, word recognition can be seen to involve both integration of various sublexical units (i.e., such as letters, graphemes or bodies) into a word representation, and access to this word representation, also called *lexical access* (see the interactive activation model, McClelland & Rumelhart, 1981). It seems crucial from a developmental perspective to examine the extent of L1/L2 lexical integration and the nature of lexical access in L2 school learners, whose characteristics are minimal L2 exposure and practice, and a limited lexicon.

To our knowledge, only a few studies have been published on L2 word recognition in L2 school learners, most of them dealing with University students. Globally, the issue of interest in these studies was about language- nonselectivity in lexical access. Using cross- language orthographic neighbourhood effects as an index of lexical organisation, two studies failed to find any evidence for cross- language interactions in low- proficiency adult L2 speakers who have learned English in a standard school context (Bijeljac- Babic et al., 1997; van Heuven et al., 1998). However, the study by Midgley, Holcomb & Grainger (2011) using ERP recordings did show signs of cognate facilitation effects. To our knowledge, only one study investigated lexical access in Secondary school children: Brenders et al. (2011) found a cognate facilitation effect in a L2 lexical decision task in Dutch children from Grades 5, 7 and 9 who have been studying English as a L2 for five months, three and five years respectively. However, no study appears to have been published that has used the masked priming paradigm in L2 school learners of this age or degree of exposure to the L2. In addition, we found no evidence for other issues being addressed in these populations on either orthographic sublexical mechanisms or orthographic- to- phonology correspondences[9].

It is important to reiterate that one difficulty in assessing L2 *child* learners is that not much is known about the developing lexicon in L1, making it unclear whether the visual word recognition mechanisms described in adult individuals may also be observed in children. Before describing the present endeavour and its theoretical components, the population of L2 learners who participated in these experiments will be described together with the languages' characteristics. We refer here to L2 school learners as those individuals who have learned a L2 in a school context, usually from Secondary school. Among this group, three levels were regularly tested during the

[9] We deliberately choose here not to report the literature on vocabulary acquisition in late L2 learners and on links between orthography and semantics (see RHM by Kroll & Stewart, 1994 and BIA- D by Grainger, Midgley & Holcomb, 2010).

doctorate[10]: children attending Secondary Grade 6 and Grade 8 and University students. They were all native French speakers who had learned English as a L2. They all have in common several characteristics: they learn or have learned English systematically during Secondary school; none of their parent is an English native speaker; they have no experience of living in an English-speaking country and none of them considered themselves as bilinguals or to have a good mastery of the language. More particularly, children attending Grade 6 Secondary school have only a few months of written English teaching. Most of them had some exposure to *oral* English during Elementary school though there is a great diversity regarding the starting age and the knowledge of English on entry to Secondary school. Secondary Grade 8 children have been learning English for two years and a few months –varying according to time of testing. All these children have between three to four hours per week of English classes throughout Secondary school and some exposure to the oral language by entertainment (music, internet or video games). The adult groups who participated in these experiments had no English teaching at the time of testing. They were studying as Undergraduate students at the University in any department but Modern Languages. They had learned English as a L2 from Secondary Grade 6 (but some had started earlier, mostly in Grade 5). As for the children, none had ever lived in an English speaking country nor had any family bilingual environment involving the English language. Most had some exposure to the language via media but none of them considered themselves as highly proficient.

Given this choice of participants, we encountered a large restriction in terms of

[10] Study 6 from Chapter 3 comprises two experiments that were conducted in Dundee, UK, with English speakers who learned French as a L2. Description of these participants is available in this specific chapter.

vocabulary in creating materials for the present study. The English language is known to be one of the hardest language to learn to read for native speakers (Seymour, Aro & Erskine, 2003) and it is even considered by some as an outlier orthography (Share, 2008). Regarding orthography, English and French share the same Roman alphabet. English has however many more graphemes than French. Among these graphemes, some are very specific to the English language while others are shared between the two languages. For example, both languages share complex graphemes such as “ch” or “ou”. Each of these languages has however language-specific graphemes: “sh” or “ea” in English; “oin” or “an” in French. More globally, some English words may be considered as more or less English language- specific depending on whether their orthography is legal in both languages (i.e., further termed as English non- specific) or whether at least one letter sequence is specific to the language (i.e., further termed as English specific). Note that these terms referring to language orthographic typicality will be used throughout the present work. Regarding orthography- to- phonology relationships, one particular feature of the English language is the lack of consistency between spelling and sound, especially at the phoneme level. This inconsistency appears from orthography- to- phonology (feedforward consistency) but also from phonology- to- orthography (feedbackward consistency, see Ziegler, Stone & Jacobs, 1997 for statistics on English monosyllabic words). As an example, the grapheme “a” may be pronounced as /a/ as in *cat*, /ə/ as in *america*, /a:/ as in *car*, /o:/ as in *ball* or /eI/ as in *hate*. Similarly, the phoneme /o:/ may be transcribed as an “a” but also as “au” as in *fraud*, “oa” as in *broad* or even “aw” as in *crawl*. This inconsistency at the grapheme- to- phoneme level is reduced when context is considered, especially at the rime level (Treiman et al., 1995). In comparison, French is mostly inconsistent in the spelling direction (phoneme- to- grapheme correspondences) while quite consistent in the reading direction. That is, though phonemes such as /o/ may be spelled in various forms: "o", "au", "eau", "ot", "op", these latter graphemes are always sounded out as /o/ (see Ziegler, Jacobs & Stone, 1996 for statistics on French monosyllabic words and Peereman, Lété & Sprenger- Charolles, 2007 for those based on a children's lexicon). Though not examined here, it is important to keep in mind that differences in orthographic transparency affect both the rate of reading acquisition (Defior, Martos & Cary, 2002; Seymour et al., 2003) and those specific mechanisms involved in reading and their contribution weight, in both novice and expert readers (Frith, Wimmer & Landerl, 1998; Frost, Katz & Bentin, 1987; Goswami, Ziegler, Dalton & Schneider, 2001, 2003; Ziegler & Goswami, 2005).

3.3. Main issues investigated in the present work

Learning a L2 implies having to access words that are progressively integrated to a lexicon. In our work, participants already have a long exposure to the orthography of their L1 (i.e., at least five years of literacy in the youngest group that was studied in the thesis) but a much more recent exposure onset in L2, and importantly, little vocabulary in this language. As mentioned above, the extent to which Secondary school children can be considered as expert readers in their L1 also constitutes a research issue on its own (see Janiot, 2011).

As a starting point, Chapter 1 investigated lexical orthographic representations in L2. Specifically, Study 1 examines whether orthographic representations in L2 can be activated in a masked priming paradigm by assessing identity and form priming effects in two groups of participants: Grade 8 children and University students. To our knowledge, this methodology has never been used in a developmental study of L2 word recognition (see Bijeljac-Babic et al., 1997 for the use of this paradigm in an adult group of L2 learners of comparable characteristics) and only rarely with monolingual children (Castles et al., 1999, 2007; Janiot, 2011; Quemart, Casalis & Colé, 2011). In line with the monolingual developmental issues explored by Castles and colleagues (1999, 2007), we also test for the precision or *tuning* of L2 orthographic representations, and its modulation according to sublexical orthographic features of L2 words, namely orthographic typicality. If the tuning of L2 orthographic representations depends on vocabulary size, we could hypothesize that a difference in the level of precision should emerge among Grade 8 children and adults. Alternatively, these representations may already be fine- tuned given the long experience with L1 reading that these children have. This level of tuning could however be modulated by orthographic typicality given some English words contain orthographic sequences that may be more slowly acquired by L2 learners.

The second main "lexical" topic of the thesis was about the issue of language-nonselectivity in lexical access. In highly proficient bilinguals, both languages have been shown to be co- activated during the initial steps of lexical access and this hypothesis has recently been supported in young L2 learners in a cognate experiment (Brenders et al., 2011). Theoretically, nonselectivity in lexical access as soon as a word is learned and integrated to the lexicon seems the most sensible assumption. The alternative hypothesis that would suppose that lexical access is first selective to the language and increasingly becomes nonselective would raise several limitations regarding the role of language nodes or "language membership", which information would have to be considered as pre-lexically driven for beginning L2 learners but post-lexically for highly proficient bilinguals. Considering that lexical access is first language- selective and progressively becomes nonselective also appears against adaptive behaviour: this would imply that L1/L2 lexica would become integrated when the lexicon gets larger and proficiency increases, that is when language discrimination is more needed, which is quite inefficient. Our goal was to further test the language-nonselective lexical access hypothesis in L2 school learners. As for the highly proficient adults, two types of study were conducted to assess cognate word processing on the one hand and cross- language orthographic neighbourhood effects on the other. The processing of cognate words in Grade 8 children was assessed using a lexical decision task in Study 2. We compared cognate words to two types of English control words, either English specific (i.e., very English- like) or non- specific (i.e., orthographically legal and occurring in both English and French). This manipulation aimed to dissociate lexical influences of cognate words as has been demonstrated by the literature, from a potential sublexical effect arising from the orthographic structure of these cognate words, which strongly resemble L1 words in terms of orthographic legality.

Study 3 aimed at examining cross- language orthographic neighbourhood effects. Based on Bijeljac- Babic et al. (1997) and more recently on Dijkstra et al. (2010), cross- language inhibition priming effects were investigated as these would be considered to reflect lexical competition across languages, and therefore support the concept of language nonselective lexical access. The first experiment used a lexical decision task together with masked priming to test L2- to- L1 cross-language neighbourhood frequency effects in Grade 6 and Grade 8 children as well as University students. This was followed both by follow-up analyses examining the role of prime frequency and an adult control experiment varying the instructions provided. The second experiment tested for L1- to- L2 orthographic priming effects in Grade 8 children and adults and directly manipulated prime frequency in order to maximize the possibility of observing an inhibition priming effect.

The following issues described in Chapters 2 and 3 focused in more detail on sublexical orthographic coding and the orthographic- to- phonology pathway to word recognition. Not much has been published on these issues except for the literature on masked phonological priming effects in highly proficient adult bilinguals (Brysbaert et al., 1999). As diverse as these issues seem, they may be considered as very relevant in the case of L2 learning. English learners as our participants may be confronted with two major challenges in reading words: 1) accessing words whose orthography is very specific to the L2 and which may comprise graphemes that do not occur in French; and 2) acquiring the grapheme- to- phoneme correspondences of the language, which are usually different from those existing in L1.

We focused in Chapter 2 on sublexical orthographic coding. In particular, Study 4 tested orthographic typicality effects in Grade 6 and Grade 8 children as well as University students in an English lexical decision task. As this issue has already been explored in other monolingual studies, the present experiment tried to add evidence for the role of this sublexical variable in L2 word recognition and to apprehend the underlying mechanisms. Orthographic typicality may be considered a broad concept, and so an attempt was made to deepen this exploration by testing the processing of complex graphemes themselves in L2. Study 5 therefore used the letter detection task (i.e., participants had to say whether a target letter was present or not in a following word) in Grade 6 and Grade 8 children as well as adults in order to investigate whether complex graphemes were a relevant unit in L2 lexical access. Following Rey et al (2000), it was assumed that if graphemes were functional units, detecting a letter when embedded in a complex grapheme should take longer than when mapping onto a simple grapheme. In addition, to investigate how English specific complex graphemes might be acquired in the course of L2 acquisition, items containing English specific complex graphemes (e.g., “oa” in *boat*) were contrasted with those containing English non-specific ones (e.g., “ou” in *hour*).

Finally, Chapter 3 aimed to investigate the phonological pathway to L2 word recognition. Study 6 was conducted in Scotland with English speakers who learn French as a L2. This study was composed of two experiments investigating the pseudohomophone interference effect. Experiment 1 tested in a French (L2) lexical decision task whether pseudohomophones that sounded like real French words using *French* print- to- sound rules were processed differently from orthographic controls. Similarly, Experiment 2 investigated this same effect by using pseudohomophones that were homophonic to real French words when using *English* rules. This study therefore enabled assessment of the extent to which phonological information was automatically activated in a L2 in young L2 school learners and whether sublexical correspondences were co- activated whatever the language. The last study, namely Study 7, explored the role of cross- language orthographic- to- phonology consistency effects in three groups of French speakers who learn English as a L2 (adults, Grade 8 and Grade 6 children) in a letter detection task. Letter detection latencies were compared when the target letter had a consistent French/ English orthography- to- phonology mapping (i.e., detect letter “A” in *have* where “a” → /a:/ as in French) or an inconsistent one (i.e., detect letter “A” in *take* where “a” → /eI, a correspondence that only occurs in English). This comparison was intended to shed light on the cross- language influences on the sublexical orthographic- to- phonology conversion system.

So, several theoretical issues were investigated in this work, which was divided into three main experimental chapters. For each study, an introduction was provided that specifically presented the relevant theoretical background. Most studies assessed three groups of participants of varying exposure to the L2. However, in some cases, the number of groups was reduced. This can be explained by theoretical reasons – for instance, if the type of task could not be performed by a group- or due to more pragmatic reasons – results from another group suggested that assessing one other group would add little information. The three groups of participants differed in terms of number of years of exposure to the L2, and also in proficiency. Proficiency was assessed in most studies by using a productive vocabulary test constructed by us, for which participants were asked to translate from L1 to L2 (from French to English for French speakers from studies 1 to 5 and study 7 and from English to French for English speakers from study 6). This test can be found in Appendix p 323. Though our cross-sectional approach impeded us from making clear developmental hypotheses, some modulation of each mechanism under interest was predicted among the three groups of participants given their different exposure/proficiency levels. In terms of statistical analyses, all groups of participants were entered in combined analyses unless variance between the groups was found to be inhomogenous. Given that these groups differed on several factors – L2 exposure but also L1 reading experience-, it was felt that if this criterion was not respected, separate analyses had to be conducted to better examine the effects under study. An intermediate conclusion is provided for the reader after each chapter.

Part 2.

Empirical Contributions

Chapter 1.

Lexical orthographic representations

Study 1. Within-language (L2) priming.

The present study aimed to examine how precise orthographic representations in L2 are and whether the priming paradigm may be a good tool for investigating word recognition in young L2 learners. Though orthographic representations are supposed to be highly specific in balanced bilinguals whose proficiency is high, it may not be the case for L2 school learners who have little exposure and proficiency to the L2.

Our approach in the present study takes a leaf out of developmental monolingual word recognition research. The idea of a progression from coarse to fine- tuned orthographic representations comes from studies on monolingual novice readers (Castles, Davis, Cavalot & Forster, 2007; Castles, Davis & Letcher, 1999) which have been inspired by the Search model of word recognition of Forster and colleagues (1987, 1984). What has been referred to as the *tuning* of the automatic word recognition system, that is the precision of the letter identity and letter position coding in orthographic representations may be modulated according to the size of vocabulary[11]. Indeed, the *lexical tuning hypothesis* (Castles et al., 1999, 2007) postulates that the word recognition system progressively adapts during development of language acquisition to the growth of lexicon by becoming more and more fine- tuned. The need for discriminating more and more words would constrain word recognition mechanisms to

[11] As for the language selective vs. nonselective debate in bilinguals which cannot be disentangled from the separate vs. integrated lexicon debate, we could not make the distinction between processing and representational aspects of the lexical tuning hypothesis. Both of the terms "fine- tuned *coding*" and fine- tuned *representations*" are therefore used interchangeably.

become more precise. Castles et al. (1999) first demonstrated letter *identity* coding changes between developing reading children and adult expert readers by examining neighbourhood size effects in form priming. In adult participants, the form facilitation priming effect is classically found for target words of low neighbourhood size only (Andrews, 1992). Null effects are observed when target words have a large neighbourhood and this would be due, according to the authors, to the fine- tuned coding mechanism that has developed for these words in order to discriminate them from their neighbours and adapt to the growth of vocabulary. Castles and colleagues reported in developing readers a facilitation effect whatever the target neighbourhood size and this was explained by the presence of a coarse- grained tuning at this reading level due to little vocabulary and little need for word discrimination. Letter *position* coding was also shown to be modulated according to reading proficiency. Castles et al. (2007) evidenced in a longitudinal design that though both form (*rlay – PLAY*) and transposed- letter (*lpay – PLAY*) priming effects were found in Grade 3 children, the former disappeared two years later, when the same children attended Secondary Grade 5, while the latter remained. For adult expert readers, neither form nor transposed- letter priming effects were observed.

Though this general approach falls into a Search model theory of lexical access, which is not the theoretical framework of this thesis, it seems to us that the concept of representation *tuning* is clearly relevant from a developmental point of view and may be integrated into interactive activation models of word recognition, both monolingual IA (McClelland & Rumelhart, 1981) or BIAM (Diependaele et al., 2010) and bilingual BIA (Dijkstra & Van Heuven, 2002). For instance, the developmental reduction of facilitation orthographic priming effect that is observed for high neighbourhood target words could be related to the increasing inhibitory links between lexical orthographic representations (Castles et al., 2007). Developing a wider orthographic lexicon would tend to increase the number of lexical competitors (i.e., orthographic neighbours) by means of increased inhibitory links at the word level, a mechanism which would minimize facilitation priming effects. While this particular effect may well be interpreted by interactive activation models, it is not clear though how the precision of the lexical representations *per se* could change over reading development within this theoretical framework (see Grainger & Ziegler, 2011 for recent proposals on a dual-route orthographic coding, and General Discussion of the thesis).

As observed for monolinguals, L2 orthographic coding and/or representations may evolve as L2 proficiency and exposure increase. Following Castles et al. (1999, 2007), one could hypothesize that the coding system becomes more and more fine-tuned as one learns new L2 vocabulary. In this case, differences in L2 word recognition tuning may arise between groups of varying L2 exposure. Our aim was to investigate letter identity coding in L2 school learners of varying years of exposure, after either two years as it is the case of Grade 8 school children, or after seven years as for University students. Note that on the basis of Castles and colleagues' studies, L1 representations should be expected to be finely- tuned in our children sample.

Although Castles and colleagues (1999) used a neighbourhood size metric to index lexical tuning, this may not be an adequate tool for investigating coding in the current population of L2 learners for whom L2 neighbourhood size is obviously low. Alternatively, it may be possible to investigate letter identity coding by comparing identity and form priming effects. Identity priming refers to the condition where a target word is preceded by an identical prime word such as in the example *boat – BOAT*

(Bodner & Masson, 1997; Castles et al., 1999; Forster & Davis, 1984; Forster, Davis, Schoknecht & Carter, 1987; Perea & Rosa, 2000; Pratarelli, Perry & Galloway, 1994) whereas form priming refers to the condition where a target word is preceded by an orthographically related prime pseudoword such as the condition *doat – BOAT*. Both identity and form priming conditions classically lead to facilitation priming effects (at least under some conditions such as low neighbourhood size target words, see Theoretical Background section for more information). Indeed, both of these kinds of primes are supposed to pre- activate the target word representation due to letter overlap, which, according to the interactive activation model (McClelland & Rumelhart, 1981) increases activation level of the target and therefore boost its processing as compared with an unrelated condition (see Kinoshita & Lupker, 2003 on masked priming interpretations). Though these two prime conditions differ in terms of lexicality, one other major difference between them is that they differ in one letter, all position respected (Coltheart, et al., 1977). The hypothesis proposed is that the degree of *precision* of L2 orthographic representations may be investigated by comparing the degree of facilitation between identity and form priming conditions. The rationale is that any difference that would emerge between the two conditions may reflect a fine- tuned coding word recognition mechanism that is the ability of the system to distinguish one letter- different prime words. To our knowledge, only Dijkstra, Hilverink- Schulpen & van Heuven, 2010 (experiment 2) examined form priming effects in Dutch- English highly proficient bilinguals and found facilitation priming effects when English (L2) target words were preceded by orthographically related prime pseudowords. To date, there are no published studies looking at both identity *and* form priming in bilinguals or in L2 low-proficient learners that I am aware of.

The second aspect of the present study was to investigate whether this L2 coding mechanism would differ depending on one sublexical variable that we termed "orthographic typicality" of the word. Though this variable has been described in the monolingual literature as measuring the frequency of sublexical orthographic sequences such as bigrams or trigrams (Hauk, Patterson, Woollans, Watling, Pülvermüller & Rogers, 2006), it may be defined somewhat differently in the bilingual literature: from a L2 learner's point of view, some L2 words may be considered to be very specific to the L2 while others may be seen as more legal in the L1. As an example, French native speakers who learn English as a L2 may find the English word *think* very specific to English since it contains two typical orthographic structures "th-" and "-ink" which are illegal in French. In contrast, the English word *house* may be considered as non-specific of the English language since all orthographic patterns (i.e., bigrams or trigrams) also occur in the French language. Two kinds of studies have examined this variable in bilingual word recognition. On the one hand, orthographic typicality has been shown to modulate language switch costs. Language switch effects refer to the fact that target processing is slowed down when the preceding item is of a different language as compared to when preceded by a same- language item word (Dijkstra & van Heuven, 2002; Green, 2002). This effect has been reported to be reduced when the target item contain an orthographic marker which makes it language- specific (Beauvillain & Grainger, 1997; Orfanidou & Sumner, 2005; Thomas & Allport, 2000). On the other hand, Vaid and Frenck- Mestre (2002) showed in a language decision task (i.e., say whether the word belongs to the L1 or L2) that words with language- specific bigrams (i.e., typical to the L2) were responded to faster than words that did not have any language orthographic marker (i.e., non- specific to the L2). It is not so surprising that language markers may have an influence on a task such as the language decision task. However, the question remains unclear to whether these sublexical orthographic markers directly affect word recognition processes and the precision of letter identity coding. For instance, in L2 learners, language- specific letters could take longer to be processed at the letter level due to lower subjective frequency (i.e., less exposure). Another question is how models of bilingual word recognition deal with the particular case of language- nonspecific letters which contain diacritics in one language (e.g., "é" in French)[12]. Similarly, larger units such as graphemes which are functional units only in L2 may need more time to be processed as compared to graphemes that are shared across languages. This hypothesis would however only fit with a version of the BIA+ model that includes a graphemic parser comparable as the one from the BIAM (Diependaele et al., 2010) and CDP+ (Perry et al., 2007) models. So, the extent to which these types of sublexical orthographic markers may affect word recognition latencies in the lexical decision task could be tested in the present study. In terms of lexical tuning, some preliminary hypotheses may be made as regard with the BIA+ model. If we consider that fine- tuning of lexical representations emerges depending on vocabulary growth, and especially on the increase of lexical competitors (i.e., neighbour words), we could make the hypothesis that target word representations whose orthography is nonspecific to the L2 would be more finely- tuned as compared to those words that have a language- specific orthography. Indeed, language- nonspecific words would tend to be more related to the L1 lexicon in terms of cross- language neighbours, and inhibitory

[12] It is also important to know for both mono- and bilinguals whether diacritic letters are processed differently from orthographically identical letters (e.g., "e" and "é" in French) or whether they come to be integrated as a special case of invariance at the level of abstract letter identity.

links between languages may therefore develop. As suggested by Castles et al. (2007), emergence of lateral inhibition in the lexicon could be directly related to the transition from coarse- to fine- tuned coding of letter identity. Conversely, words that are more specific to the L2 may have a more coarse- grained tuning given the fewer inhibitory links that may be created. The possibility that the orthographic sequences that compose these L2 specific words may be less well mastered by L2 learners could also result in less precise letter identity coding.

Therefore, the present study aimed to examine identity and form priming effects in two populations of L2 school learners in order to assess the precision of the letter identity coding mechanism in L2 and the extent to which it depends on the orthographic typicality of the L2 words. The two groups of participants were all native French speakers: 1) adult University students who had learned English from Secondary Grade 6 during the seven years before entering University, but who did not have any practice of the English language at the time of testing and 2) Grade 8 children who had been learning English at school for two and a half years.

The first goal was to test whether priming within the L2 could be observed in these low-proficiency L2 speakers and to examine the mechanisms underlying L2 word recognition. Three priming conditions were used in a L2 lexical decision task: identity (e.g., *boat* - *BOAT*), form (e.g., *doat*- *BOAT*) and unrelated (e.g., *mice* – *BOAT*) priming conditions. This study offers the first tentative test for the existence of both identity and form facilitation priming effects which would reflect the existence of a L2 orthographic representation and pre- activation of the target word. It would also confirm whether or not the priming paradigm is a good tool for investigating word recognition in L2 learners whose exposure and proficiency in L2 is low. The degree of *precision* of L2 orthographic representations was under examination as a second goal by comparing the degree of facilitation between identity and form priming conditions. The rationale was that any difference that would emerge may reflect a fine- tuned coding word recognition mechanism, which is able to distinguish one letter- different words. The third goal was to explore the role of sublexical orthographic properties in word recognition and whether this precision of letter coding would depend on orthographic typicality of the words. To this respect, two factors were manipulated: orthographic typicality of the target words and, for those experimental items that contained English specific graphemes, graphemic complexity of the form priming condition. As for orthographic typicality, English (L2) target words were manipulated so that half of them were English specific (i.e., they contained English specific orthographic patterns such as complex typical graphemes th-, -ght, -ea that do not occur in the French (L1) language) whereas the other half were English non- specific (i.e., they were completely legal according to French). If the level of precision of orthographic representations differed according to the orthographic typicality of the English (L2) words, then we may expect an interaction between orthographic typicality of target words and priming condition. We could hypothesize that a high level of precision as revealed by a difference in the amount of facilitation effect between identity and form priming conditions could be observed in the English non- specific targets only. Alternatively, if the level of precision of L2 orthographic representations is not affected by orthographic typicality, at least in the populations tested, then priming effects may not be modulated according to orthographic typicality. The second factor that was explored only concerned those English specific target words that contained L2 specific graphemes that do not occur in French (L1) such as -ow, -ght or –ea. This manipulation came from the observation that orthographic typicality could be considered as a vague concept given even English specific words contain both English specific and non- specific graphemes (e.g., *boat* contains the English specific grapheme "oa" but English non- specific graphemes "b" and "t"). Though there is no study to my knowledge that manipulated graphemic complexity within form priming in monolinguals, this variable is considered here in order to explore the role of English specific complex graphemes in lexical access. Among English specific target words, half were preceded by form pseudoword primes whose letter change corresponded to a simple grapheme (e.g., *voat – BOAT*) while the other half was preceded by a form prime whose letter change was embedded in a complex grapheme (e.g., *bowt* - *BOAT*)[13]. This manipulation was made so as to explore whether form priming effect could be modulated according to the complexity of the grapheme that was changed between the prime and the target. The hypothesis was that the precision of L2 orthographic representations could be lower for complex graphemes as compared to simple graphemes. In that case, a difference between identity and form priming effects could be observed only for those English specific words whose letter change corresponded to a simple grapheme; whereas, form primes whose letter change with the target was embedded in a complex grapheme may be performed as well as

[13] Reference is made here to the literature on syllabic priming effects using prime/target consistency (cv – CV or cvc- CVC) or inconsistency (cvc – CV or cv- CVC) in syllabic structure (Ferrand, Segui & Grainger, 1996, see also Brand, Giroux, Puijalon & Rey, 2007 on syllable- onsets using a letter detection paradigm),. For instance, using priming conditions such as *bal*- *BALCONY* versus *ba*- *BALCONY*, these authors demonstrated the role of syllables as a functional unit of word recognition. Though the present focus was on the grapheme rather than the syllable, and the methodologies differed (here, primes were presented in their entirety), the general idea of assessing priming effects according to the consistency of the unit shared by prime and target is common between us (b ow t – B OA T vs. b o s t – B OA T).

identity priming condition, a finding which would reflect a low level of precision for English specific complex graphemes.

In sum, the precision of L2 orthographic representations in L2 school learners was assessed in the present masked priming study by comparing identity and form priming effects. Our interest also included the extent to which orthographic typicality of the L2 words may affect this precision.

Method

Participants

A total of 29 French adult (mean age: 22;3) and 36 Grade 8 children (mean age: 14;2) participated in the study. There were all native French speakers. Adult participants were recruited at the University of Lille North of France. They had studied English for at least seven years during Secondary school. None of them studied Modern languages at the University, had ever lived in a bilingual environment nor spoke English in their daily life. Children participants were recruited in two schools in Paris (Collège La Grange aux belles) and Nantes (Collège St Jacques de Compostelle), France. They attended Secondary Grade 8 and had started English teaching at Secondary Grade 6 as common in the French school system. Adults scored 90% correct on the proficiency test (mean correct: 44 out of 50 items, SD: 6) while Grade 8 children reached 60% correct (mean correct: 30 out of 50 items, SD: 10).

Materials

A total of seventy-two English target words (mean frequency: 507 occurrences per million, Children Printed Word Database, CPWD, Masterson, Stuart, Dixon & Lovejoy, 2003) were selected (see Appendix p 324). The choice of an English as a L1 database for children at Elementary school was based on the observation that L2 vocabulary learnt in a school context, and associated word frequencies may be best captured by a children database. Moreover, there is no database for English as a L2 for French learners that we are aware of. Target words were also chosen according to children textbooks and were thus supposed to be encountered during Secondary school. The word length varied from four to five letters. There were classified into two orthographic typicality categories according to a French native speaker perspective: 1) English specific words and 2) English non- specific words. English specific words were constructed so that they contained at least one English specific bigram such as th- or -gh, which was checked to be very low frequent according to the rules of the French language. This criterion was based on the findings by Westbury & Buchanan (2002) that "minimal bigram frequency" or "the frequency of the least likely bigram in a word" (Lemhöfer, Dijkstra, Schriefers, Baayen Zwitserlood & Grainger, 2008, p. 15) is the relevant variable in investigating sublexical orthographic typicality effects. As expected, English specific and non- specific words differed in terms of French minimal bigram frequency[14] (English specific words: mean at 6, SD: 9; English non- specific words: mean at 196, SD: 142, $t(70) = 8.017$, $p < .0001$). These two categories also differed in terms of their mean whole word bigram frequency (English specific words at 493, SD: 402; English non- specific words at 875, SD: 551, $t(70) = 3.365$, $p < .001$). However,

[14] We used a bigram frequency list provided on www.lexique.org by New, Pallier, Ferrand & Matos (2001).

English specific and non- specific target words were matched according to whole word bigram frequency according to the English rules (English specific words at 2285, SD: 1227; English non- specific words at 2671, SD: 1388, $t(70) = 1.248$, n.s., using the MCWord database, Medler & Binder, 2005), English lexical frequency (English specific words at 485 o.p.m, SD: 640; English non- specific words at 528 o.p.m., SD: 742, $t < 1$, n.s., CPWDatabase, Masterson et al., 2003) and length (both English specific and non-specific words at 4.22 letter long, SD: .42, $t < 1$, n.s.).

For each English target words, three priming conditions were constructed: 1) identical priming condition (*boat – BOAT*), 2) form priming condition (*doat – BOAT*) and 3) unrelated priming condition (*werd – BOAT*). In the form priming condition, position of letter change was controlled so that it corresponded to either the initial position (first letter) or the middle position (third or fourth letter) in the word. In the English specific target word condition, the letter changed between the prime and the target was manipulated so that it corresponded to either a simple grapheme such as in the example *doat – BOAT* or a complex English specific grapheme such as in the example of *cowt – COAT*. This manipulation was made so that to explore whether form priming effect could be modulated according to the complexity of the grapheme that was affected by priming. One variable was controlled for the English non- specific target words in order to prevent the influence from a third variable in examining priming effects: cross- language shared neighbourhood. Shared neighbourhood has been shown in monolingual word recognition literature to influence form priming effects: the presence of a shared neighbour such as *SPORT* in the condition *snort – SHORT* decreases the facilitation priming effect in comparison with a condition of prime/target pairs that do not have a shared neighbour (van Heuven, Dijkstra, Grainger & Schriefers, 2001). Though there is yet no evidence for the role of cross- language shared neighbourhood in bilingual word recognition, this variable was controlled so that prime/target pairs in the form priming condition either had no shared neighbour or had a very low frequent one. Out of the 36 English non- specific target words, 20 had a French shared neighbour. However, these French shared neighbours were always low frequent words so that the mean frequency of these shared neighbours were at 1.87 o.p.m. with a range from 0.07 to 7.03 o.p.m. (Lexique, New et al., 2001). The identical priming condition included words as primes whereas the form priming condition only included pseudowords as primes. Therefore, the unrelated priming condition was constructed so that half primes were words whereas the other half was pseudowords. This manipulation was also maintained across the two orthographic typicality categories of English target words. Word frequency of the unrelated prime words was matched across the two target categories (English specific words at 550 o.p.m, SD: 841; English non- specific words at 532 o.p.m. SD: 936, $t < 1$, n.s.).

Similarly, seventy- two pseudowords were created for the purpose of the lexical decision task. They were created by changing one letter from a French word, all positions respected. Half were considered as English specific pseudowords whereas the other half was considered as English non- specific pseudowords. These two categories were created based on the same criterion than for the target words, that is the minimal bigram frequency according to the French language. As for the words, they were preceded by three kinds of primes: an identity priming condition, a form priming condition and unrelated one. All primes in the identity condition were pseudowords. Therefore, half primes for the form priming condition were words (mean lexical frequency for English specific words at 577 o.p.m, SD: 565; for English non- specific words at 625 o.p.m, SD: 601) whereas the other half were pseudowords, and all primes for the unrelated condition were English words (mean lexical frequency at 609 o.p.m., SD: 602[15]).

Three lists were created so that participants only saw the target word once but all priming conditions. In each list, there were equal numbers of English specific and non-specific target words and of the three priming conditions.

Procedure

A fixation point was presented for 1 000 ms, followed by a forward mask of ####### for 800 ms. The prime word was then presented for 57 ms, followed by the target word which remained on the screen for 1000 ms or disappeared when a response was made. The participants had to perform a lexical decision task in English (L2). They were asked to press a button with their dominant hand when the word they saw was a English word or to press another button with their nondominant hand to decide that the target was not a real English word. Participants were asked to respond as quickly and accurately as possible. Because their vocabulary is limited, it was emphasized in the instructions that they would press "yes" as soon as they recognized a word.

The session lasted around 10 minutes and was preceded by a training session which included 10 items. Testing took place in March- April 2011 for adult participants and in June for Grade 8 children.

[15] Mean lexical frequency was reported for the whole targets whatever orthographic typicality given the same unrelated prime words were used for English specific and non- specific words. Care was taken in the procedure so that participants never saw the same prime word twice.

Results

A total of 15 target words, out of which 8 English specific target words, were too poorly recognised by the children group (mean error range from 78% to 37%) and were thus removed. Reaction times higher than 2.5 standard deviations from mean reaction times were discarded (< 3 % of accurate word data). Results of adults and children are presented in Table 1. Given that homogeneity of variances constraint was rejected, $F(1,63) = 5.869$, $p < .02$, separate analyses were conducted for each group of participants. Orthographic typicality and priming condition were entered as within-subject variables in the participant analysis (F_1). In the item analysis (F_2), orthographic typicality was entered as a between- subject variable while priming condition was entered as within- subject variable.

Adults

Reaction times

The main effect of orthographic typicality was significant, $F_1(1,28) = 21.942$, $p < .001$, partial $\eta^2 = .44$, $F_2(1,55) = 4.37$, $p < .05$. This reflected that English non-specific target words were responded to faster than English specific target words (24 ms). In addition, the effect of priming condition also reached significance, $F_1(2,56) = 16.808$, $p < .001$, partial $\eta^2 = .38$, $F_2(2,110) = 12.39$, $p < .001$. Priming effects were further explored by using planned comparisons. Subjects responded to faster in orthographically related conditions (identity and form priming conditions combined) as compared to the unrelated condition, 34 ms, $t = 7.276$, $p < .0001$. More, there was a significant difference between the form and the identity priming conditions, 31 ms, $t =$

2.839, $p < .01$. The interaction between priming condition and orthographic typicality was not significant, all Fs < 1, n.s.

Errors

Neither effects of priming condition nor of orthographic typicality were significant [priming, $F_1(2,56) = 1.09$, $p = .34$, n.s., $F_2(2,110) = 1.47$, $p = .23$; orthographic typicality, $F_1(1,28) = 1.47$, $p = .24$, n.s., $F_2(1,55) = 1$, $p = .32$, n.s.]. The interaction between orthographic typicality and priming condition did not reach significance either, all Fs < 1, n.s.

Grade 8 children

Reaction times

The main effect of priming condition was significant, $F_1(2,70) = 4.812$, $p < .02$, partial $\eta^2 = .12$, $F_2(2,110) = 7.48$, $p < .001$. Priming effects were further explored by using planned comparisons. Subjects responded to faster in orthographically related conditions (identity and form priming conditions combined) as compared to the unrelated condition, 21 ms, $t = 2.065$, $p < .05$. More, there was a significant difference between the form and the identity priming conditions, 32 ms, $t = 2.281$, $p < .05$. The main effect of orthographic typicality was however not significant, and neither was the interaction between priming condition and orthographic typicality was not significant, all Fs < 1, n.s.

Errors

Neither effects of priming condition nor of orthographic typicality were significant [priming, $F_1(2,70) = 1.923$, $p = .15$, n.s., $F_2(2,110) = 2.6$, $p = .079$; orthographic typicality, $F_1(1,35) = 1.388$, $p = .25$, n.s., $F_2 < 1$, n.s. The interaction between orthographic typicality and priming condition did not reach significance either, all Fs < 1, n.s.

Table 1. Mean reaction times in ms and percentages of errors (and standard deviations) for each group of participants (adults, Grade 8 children) depending on orthographic typicality (English specific and non- specific) and priming condition (identity, form and unrelated priming).

	Adults		
	Identity priming	Form priming	Unrelated priming
English specific			
Reaction times	629 (87)	656 (97)	671 (83)
Errors	3.1 (6.5)	6 (7.7)	4.8 (6.7)
English non- specific			
Reaction times	598 (95)	633 (75)	654 (85)
Errors	6 (10)	6.9 (9.5)	5 (9.3)
	Grade 8 children		
	Identity priming	Form priming	Unrelated priming
English specific			
Reaction times	725 (139)	747 (123)	760 (118)
Errors	13.1 (14.3)	15.8 (13.6)	17.7 (18.3)
English non- specific			
Reaction times	717 (123)	758 (137)	755 (118)
Errors	11.8 (13.1)	12.7 (13.8)	15.7 (17.1)

Exploratory analysis of English specific target words

Priming effect did not seem to interact with orthographic typicality. Yet, another variable had been manipulated in order to assess the degree of precision of L2 orthographic representations, namely the graphemic complexity. In the form priming condition, half of English specific target words were preceded by pseudowords for which the letter changed was embedded in a complex grapheme (multi- letter grapheme, *bowt – BOAT*); the other half of these items was preceded by pseudoword for which the letter changed corresponded to a simple grapheme (single- letter grapheme, *doat – BOAT*). Given some target items had been removed from the analyses due to poor accuracy, there were sixteen items in the complex grapheme condition while only twelve in the simple grapheme condition. An analysis of variance (Anova) was conducted on the reaction times by participants. Graphemic complexity and priming condition were entered as within- subject variables. Given there were little items per condition, the analysis was conducted on the two groups combined in order to maximize statistical power. This decision was also supported by the fact no difference in the priming patterns emerged across groups and that this was an exploratory analysis. Table 2 represents mean RTS (and standard deviations) for English specific word targets according to graphemic complexity and priming condition.

Table 2. Mean reaction times according to grapheme complexity of English specific target words (simple vs. complex graphemes) and priming condition (identity, form and unrelated priming).

	Identity priming	Form priming	Unrelated priming
Simple Graphemes			
Reaction times	676 (166)	712 (160)	716 (154)
Complex Graphemes			
Reaction times	682 (143)	699 (130)	723 (120)

Though the interaction between graphemic complexity and priming was not significant, $F_1 < 1$, n.s., we explored the priming patterns across the two kinds of graphemic complexity by using post- hoc Fisher T tests (note that this is one of the less conservative post- hoc t tests and this issue should be addressed in future studies). For the simple grapheme condition, targets were responded to 36 ms faster in the identity condition as compared to the form priming condition, $p = .01$ as well as 40 ms faster when compared to the unrelated priming condition, $p < .01$. There was however no difference between the form and unrelated priming condition, $p = .88$, n.s. For the complex grapheme condition, targets were responded to 41 ms faster in the identity condition as compared to the unrelated priming condition, $p = .013$. Interestingly, the 24 ms facilitation from form priming as compared to unrelated priming did not reach significance, $p = .18$, and neither was the 17 ms difference between the identity and the form priming condition, $p = .24$.

Discussion

In all, the priming pattern was comparable in both groups of participants: a facilitation priming effect was found for orthographically related forms, that is identity and form priming conditions, as compared to an unrelated condition. Yet, a difference also emerged between the identity and form priming conditions, in favour of a fine-tuned letter identity coding mechanism. Interestingly, this pattern was found no matter the orthographic typicality of the English target word, whether English specific or non-specific, which reveals a similar coding mechanism for both kinds of words. An exploratory analysis seemed to suggest that form priming may have been processed a little differently according to the type of the letter changed between the prime and the target: while the form simple grapheme condition (e.g., *bost – BOAT*) was processed differently from the identity priming condition (36 ms, $p < .01$) the form complex grapheme condition (e.g., *bowt- BOAT*) was not processed differently from the identity condition (17 ms, n.s.), indicating a fine- tuning for the former condition only. Another unexpected finding came from the orthographic typicality which emerged for the adults only, showing a facilitation effect for the English language- specific items as compared to the English non- specific items.

Before discussing each of these findings, it should be noted that the different vocabulary levels and error rates in the lexical decision task observed in the two groups confirm that the University students who have learned English for at least seven years were indeed more proficient than the Grade 8 Secondary school adolescents. The present study constitutes the first attempt to examine priming effects in young L2 learners. First, the findings suggest that orthographic representations in L2 may be pre-activated by means of a masked priming paradigm, which has proven to be an appropriate methodological tool for the investigation of L2 visual word recognition, even with a population of young L2 learners. This facilitation priming effect for orthographically related forms is in line with the monolingual literature (Ferrand & Grainger, 1992, 1993, 1994; Forster & Davis, 1984, 1991; Forster & Taft, 1994) when several conditions are respected such as low target neighbourhood size or low shared prime/target neighbourhood. The former condition is inherent to participants with low proficiency in L2 and who therefore knew few neighbours of the target words (e.g., a situation that is very close to the one encountered by young monolingual children, Castles, Davis & Letcher, 1999); the latter condition was controlled across languages, especially for items from the English non- specific condition whose orthographic structure is similar to the L1 and could have had French neighbour words.

Second, the finding of a difference between identity and form priming conditions reflects in our view the high level of precision of the letter- identity coding mechanism. It has been suggested in developmental visual word recognition research that word recognition mechanisms evolve as the lexicon grows (Castles et al., 1999, 2007). More precisely, the letter identity and letter position coding mechanisms have been reported to change from a coarse- to a fine- tuned coding level. This lexical tuning hypothesis assumes that coding becomes more and more precise in order to enable discrimination between newly learned words in the lexicon. The rationale here was that any difference in the amount of facilitation between identity and form priming conditions would reflect the sensitivity of the coding system to one letter- different prime words. The findings show that this high degree of precision could be observed as early as after two years of L2 learning since the pattern was comparable between the two groups of participants.

The lexical tuning hypothesis, which was proposed for monolingual children, suggests that those coding changes arise pending on vocabulary growth. Alternatively, it may be that word recognition coding systems may rather depend on *maturational changes* in the perceptual processing involved in reading. The case of L2 school learners attending Grade 8 who have started learning a L2 at Secondary Grade 6 is a fruitful example to test this distinction. While children at Secondary school do not have much vocabulary in L2 and have not encountered many L2 written words, they have already developed a word recognition coding system in their L1 as efficient to the one developed by adult readers (Castles et al., 1999, 2007). The fact that a fine- tuned coding mechanism was found in this group of L2 learners lets us suggest that they benefited from their L1 reading experience when accessing L2 words, an idea which is in line with cross-language transfer studies on reading skills (Deacon, Wade- Woolley & Kirby, 2009).

Interestingly, this level of tuning did not seem to depend on the orthographic properties of the L2 target words since the same priming pattern was observed in both English non- specific and specific conditions. This manipulation of orthographic typicality was an exploratory issue, which would merit further investigations (see Study 4 in Chapter 2). Orthographic typicality in a L2 has not received great attention apart from some language switching studies (Grainger & Beauvillain, 1987; Orfanidou & Sumner, 2005; Thomas & Allport, 2000) and one language decision study (Vaid & Frenck- Mestre, 2003) which globally showed that language membership of L2 words was more easily accessed when one specific language marker was present in the word (i.e., what are termed here English specific words). Yet, there is no study to date that looked at whether lexical access would differ according to the orthographic structure of words, an effect that could have been hypothesized in the Grade 8 children who have been learning English for only two years. However, the results seem to suggest that, even when composed of complex letter sequences for a L2 learner, words in L2 have an orthographic representation in the lexicon that is as precise as for words that look like L1 words. Exploratory analyses on the role of the graphemic complexity manipulated in the form priming condition may moderate this claim though. It was observed that when the letter change between the prime and the target was embedded in a complex English specific grapheme (e.g., graphemes such as -oa, -ck as in a priming condition *bowt-BOAT*), there was no difference between identity and form priming conditions, although a difference was observed when the letter change was a simple grapheme (e.g., *bost-BOAT*). It would be highly premature to draw any conclusions from this analysis but this effect may shed some light on the role of sublexical units in word recognition such as graphemes, especially when these units are language specific.

A final finding in the present study comes from the observation of a differential effect of the orthographic typicality of the target words among the two groups of L2 learners. While Grade 8 children responded equally rapidly to English non- specific and specific target words, adults responded faster for English non- specific as compared to English specific words. This finding was unexpected for two reasons. On the one hand, Grade 8 children, rather than adults, would be predicted to be faster for those words whose orthographic structure is more legal in French as compared to those words that are composed of complex language specific letter sequences. This could have been expected given the low proficiency of Grade 8 children who may possess less precise orthographic representations for English specific words. On the other hand, English non- specific words could have been responded to more slowly than English specific words by adult participants, given the higher degree of cross- language neighbourhood of these words. Indeed, these English words have higher numbers of French neighbours than English specific words and this could have induced longer reaction times. This result is therefore difficult to explain and merits further investigation (see Chapter 2 on sublexical orthographic representations).

As a quick conclusion, this study appears to show that the masked priming paradigm may be used even with L2 low- proficiency learners in order to assess lexical access and word recognition mechanisms. As early as after only two years of L2 exposure, there seems to be a fine- tuned letter identity coding mechanism, as revealed by the different amount of facilitation between identity and form priming conditions. This fine- tuned coding was found for L2 words with either English specific or non-specific orthographic properties, though exploratory analyses revealed interesting findings regarding the role of complex graphemes in priming. In all, this orthographic priming effect is consistent with bilingual models of word recognition that predict the pre- activation of orthographic representations by means of orthographically related targets (Dijkstra & van Heuven, 2002; van Heuven et al., 1998). Yet, the data also point to the need for a deeper analysis of the sublexical orthographic level, which is not fully described in BIA or BIA + models –only the likelihood for an intermediate Onset- Nucleus- Coda level is discussed-, in order to accommodate the orthographic typicality findings and unexpected observations on the role of graphemic complexity (see General Discussion for further theoretical considerations on how to consider these data with respect to BIA+ model).

Orthographic priming has therefore been shown within the L2 in a population of L2 school learners and lexical representations seems to be finely- tuned as early as after only two years of L2 learning. The up-coming studies 2 and 3 raise the question of lexical interactions across languages, an issue largely addressed in highly proficient bilinguals. Assessing cognate processing (Study 2) and cross- language orthographic neighbourhood effects (Study 3), our goal was to test the extent to which lexical access could be language- nonselective in L2 school learners.

Study 2. On cognates

"Respect music and art!" As ingenuous as this sounds, this sentence is interesting for the fact that French speakers would not need to know much about the English language to understand it. It is composed of three cognate words, either orthographically identical (e.g., *art* and *respect*) or similar, also called neighbour cognates (e.g., *music* spelled *musique*). Cognate words refer to those words that share form and meaning across two (or more) languages. In highly proficient bilinguals who have balanced – or almost - proficiency between the two languages, these cognate words have been shown to be facilitated during lexical access when compared to control matched monolingual words (Costa, Caramazza & Sebastián-Gallés, 2000; De Groot & Nas, 1991; Dijkstra, Grainger, & van Heuven, 1999; Dijkstra, Miwa, Brummelhuis & Baayen, 2011; Dijkstra, van Jaarsveld, & ten Brinke, 1998; Gollan, Forster & Frost, 1997; Jared & Szucs, 2002; Kim & Davis, 2003; Lemhöfer & Dijkstra, 2004; Lemhöfer, Dijkstra & Michel, 2004; Schwartz, Kroll & Diaz, 2007; Sunderman & Schwartz, 2008; van Hell & Dijkstra, 2002). This effect has been interpreted as evidence in favour of language- nonselectivity during bilingual lexical access. The rationale is that if lexical access was selective to the language, there would be no reason for cognate words to be recognized faster than control words matched on several variables such as length, frequency or neighbourhood. The reason for cognates to be speeded up is that they belong to both languages and this indicates that the nontarget language is active during the task. Note that according to the BIA+ model (Dijkstra & van Heuven, 2002), cognate words could benefit from a special status in the bilingual lexicon. The inclusion of a semantic representational level enabled the authors to explain the standard facilitation effect found in the lexical decision task by postulating a strong feedback from semantics to the orthographic level.

The present experiment aimed to test for language- nonselectivity in lexical access in L2 school learners who have little vocabulary and exposure to the L2. Our goal was to assess whether this principle of bilingual lexical access is present from the beginning of L2 acquisition. To our knowledge, a single study has examined this issue very recently by means of cognate words. Brenders, van Hell & Dijkstra (2011) investigated cognate effects in Dutch- English L2 school learners of Grade 5, 7 and 9. They used both an English (L2, experiments 1 and 3) and Dutch (L1, experiment 2) lexical decision task. They found a cognate facilitation effect in the L2 task as early as in Grade 5, but no effect in L1, in either group of participants. The cognate facilitation effect found in L2 became an inhibition effect when interlingual homographs were added to the list (experiment 3). This was interpreted as reflecting the confusion beginner L2 speakers may feel given the ambiguity of language membership.

Our goal was to test for cognate effects in an English (L2) lexical decision task in a population of French learners of English at Secondary school. The rationale was that a cognate facilitation effect, as recently reported by Brenders et al. (2011), would support the language- nonselective lexical access hypothesis. Our study was also designed in order to overcome some limitations from standard studies of cognate processing. First, though control monolingual words are matched on several variables to cognate words, such as frequency, length or neighbourhood, it seems to us that one other variable, further called as orthographic typicality, could affect the lexical access process, especially in L2 learners who have only a few years of exposure to the L2. By definition, cognate words have an orthographic structure that is legal in both L1 and L2. The control words chosen as a comparison may however have a very specific orthography to the L2. Though this may not affect lexical access in highly proficient bilinguals, this variable could affect L2 beginners whose exposure to the L2 is low and whose knowledge of the specific L2 orthographic patterns may be still weak. Therefore cognate processing will be compared using two classes of monolingual English control words: words whose orthography is largely legal in French (L1) or words that contain at least one orthographic sequence that would not occur in French. The second choice we made in the present study was to keep a low proportion of cognate words within the experiment. It is interesting to observe that in most cognate studies, half of the words were cognates while the other half was control words. It seems possible that this high proportion of cognates would lead to response strategies in participants as may occur with other type of ambiguous words such as pseudohomophones (McQuade, 1991).

Finally, it was important to make sure that L2 words were accessed via the orthographic pathway in this group of young L2 learners. Following Coltheart et al. (2001)'s view, lexical frequency effects were tested, which were supposed to reveal the use of a direct lexical orthographic route to reading (Dufau, Lété, Touzet, Glotin, Ziegler & Grainger, 2010; Sprenger- Charolles, Siegel, Béchennec & Sénéchal, 2003). Since L2 learners at Secondary school have extensive use of L1 reading, and reading skills are known to transfer across languages (Deacon, Wade- Woolley & Kirby, 2009), it is predicted that our participants would show a frequency effect within the L2, a result that would indicate the use a direct orthographic route to access these L2 words.

In sum, the present study aimed to test the language- nonselective lexical access hypothesis in young L2 learners[16] by using cognate words. In order to control for the potential influence of orthographic typicality of the control monolingual words, these control words were composed of two types of items: English non- specific words that are similar to cognate words in terms of orthographic sublexical components to French and English specific words that contain more English specific orthographic sequences which do not occur in French. First, we hypothesized that a cognate effect – as compared with all control words- would reflect language- nonselectivity in lexical access. As commonly interpreted, this effect would reflect the influence of the nontarget language during the task and therefore the co- activation of both languages. Then, if the locus of the cognate effect was lexical (i.e., interpreted as a cumulative frequency effect due to the co- activation of the two languages), then a cognate *facilitation* effect was expected to emerge when compared to monolingual control words –whatever sublexical characteristics-, as previously found in highly proficient adult bilinguals (Dijkstra et al., 1999) and more recently in young L2 learners (Brenders et al., 2011) In contrast, if no cognate effect was observed, then closer examination of the data would be useful. It could be that the cognate facilitation effect found in standard cognate studies –which do not control for orthographic typicality- actually reflects a sublexical effect, in that cognate words tend to have a less L2 specific orthography –or more likely to occur in L1- as compared to common L2 words. If the cognate facilitation effect reflects some sublexical influences, then it may be that the cognate effect is observed only compared to English specific words. Finally, we tested for lexical frequency effect by presenting low and high frequency words within each of the three status conditions, to make sure

[16] Given the step by step approach taken in the present doctoral work and the observations made, it follows that only one level of proficiency was tested in the present study.

that the use of a lexical orthographic code could be evidenced during L2 lexical access.

Method

Participants

A total of 27 children attending Secondary school participated in this study. These children were French native speakers (mean age: 13;3) and attended two schools in Paris, France in Grade 8: Collège César Franck (20 children) and Collège La Grange aux Belles (7 children). Children had around two years of formal English teaching at Secondary school with varying exposure to the oral English language in Elementary school. Participants reached 64% of accuracy on the proficiency test (32 correct out of 50 items, SD: 11).

Materials

Twenty French-English cognate words, supposed to be known by French school learners, were selected (see Appendix p 332). They varied from three to- seven- letter long with mean length of five letters. As monolingual English control words, two conditions were created, each comprising twenty items: 1) English non- specific words and 2) English specific words. The English non- specific condition referred to those English words whose orthographic constituents are legal in the French language. Oppositely, the English specific condition comprises English words that contain at least one sublexical unit (i.e., a bigram) that does not occur in French (i.e., letter sequences such as -tch, sh). The three categories were matched one- to- one on length. For each status, two frequency conditions were created, low versus high frequency, each comprising ten items per status. All of these item characteristics may be read in Table 3.

Note that written frequency was taken from the Children as a Printed Word Database (CPWD, Masterson et al., 2003), a database for English as L1 monolingual children. An Anova was performed in order to control that frequency did not differ among the three status conditions. Frequency was entered as a dependent variable while both frequency condition (low, high) and status (cognates, English specific and English non- specific) were entered as between- subject variables. A main effect of frequency condition was observed, $F(1,54) = 150.295$, $p < .001$, which reflected that high frequency items were indeed more frequent than low frequency items. However, there was no effect of status, $F(2,54) = 1.359$, $p = .266$, n.s. nor any interaction between the two factors, $F < 1$, n.s. confirming the correct matching of frequency across all conditions.

Table 3. Characteristics of the experimental items (length in terms of mean number of letters; mean frequency for both Low and High Frequency conditions; and mean Bigram Frequency in L1 and L2).

	Length	Low Frequency Condition	High Frequency Condition	Bigram Frequency in L1	Minimal Bigram Frequency in L1	Bigram Frequency in L2
Cognates	5.10 (1.2)	25.6 (8)	219.4 (72)	1000.49 (563)	410.50 (199)	1059.67 (653)
English non-specific	5.10 (1.2)	45.2 (19)	212.9 (54)	1062.31 (419)	391.95 (291)	1685.00 (990)
English specific	5.10 (1.2)	61.7 (30)	239.9 (100)	476.03 (320)	43.85 (84)	1302.52 (952)

In order to make sure that 1) cognates were indeed comparable to English non-specific words in terms of sublexical orthography and that 2) both cognates and English non- specific words differed from English specific words on this same criterion, French bigram positional frequency of these English words was calculated using the Lexique Database (New et al., 2001). As can be seen in Table 3, the French mean bigram frequency of cognates and English non- specific words was higher than for English specific words. An analysis of variance showed a main effect of status, $F(2, 57) = 10.46$, $p < .001$, which reflected higher bigram frequency for both cognates and English non-specific as compared to English specific words (both ps $< .001$), and no difference between these two (n.s.). As an even better measure according to Westbury & Buchanan (2002), the minimal bigram frequency (the least frequent bigram that compose a word) was much lower for English specific words than for both English non- specific and cognate words, an observation that reflects that unusual orthographic patterns tended to occur in this condition. The Anova again showed a main effect of status, $F(2, 57) = 19.48$, $p < .001$. Again, this effect reflected lower minimal bigram frequency for English specific words as compared to both cognates and English non- specific words (both ps $< .001$), while no difference between these two conditions (n.s.). Finally, we wanted to make sure all these words were typical of the English language and therefore matched on English mean positional bigram frequency of these words, a measure provided by the MCWord database (Medler & Binder, 2005). The Anova though showed a marginal effect of status, $F(2, 57) = 2.58$, $p = .085$. Though cognate words were matched with English specific words, which in turn were matched with English non- specific words (n.s.), English specific words had a marginally higher mean English bigram frequency as compared to cognate words ($p = .085$).

In order to keep a low proportion of cognate words within the experiment, another twenty filler items were added to the stimuli. These filler were high frequency English words (mean frequency: 1381, SD: 940).

For the purpose of the task, a total of eighty pseudowords were created. They were created by changing one letter from the real words, a method supposed to avoid any list composition effect influencing word/nonword discrimination.

Procedure

A fixation point was presented for 1 000 ms, followed by a forward mask of ######### for 1000ms. The target word was then presented for 3000 ms or disappeared when a response was made. The participants had to perform a lexical decision task in English (L2). They were asked to press a button with their dominant hand when the word they saw was an English word or to press another button with their nondominant hand to decide that the target was not a real English word. Participants were asked to respond as quickly and accurately as possible. Testing took place in November, in a quiet room provided by the schools. The session lasted around 15 minutes and was preceded by a training session which included 10 items. Testing took place between November 2009 and January 2010.

Results

Five English words were poorly recognised (mean accuracy score lower than 60%) and were thus removed. Among these words, two belonged to the English non-specific condition (e.g., *false* and *cloud*) while the other four belonged to the English specific condition (e.g., *egg*, *shiny*, *skirt*, *sick*). Reaction times higher than 2.5 standard deviations from the mean reaction times per participant were discarded (< 5 % of word data). This cleaning procedure was chosen given the huge variability in participants' mean reaction times (from 617 ms to 1551 ms). An analysis of variance (Anova) was conducted on word reaction times and errors on both participants ($F1$) and items ($F2$) analyses. Status and frequency were entered as within- subject variables in the participant analysis, and as between- subject variables in the item analysis. Results may be found in Table 4.

Reaction times

The main effect of frequency was significant on the participant analysis, $F_1(1,26) = 4.921$, $p = .035$, partial $\eta^2 = .16$, $F_2 < 1$, n.s., which indicated shorter latencies for high frequency English words as compared to low frequency items (41 ms). The main effect of status was also significant on the participant analysis, $F_1(2,52) = 7.200$, $p < .01$, partial $\eta^2 = .22$, $F_2 < 1$, n.s. Planned comparisons revealed that cognates were processed more slowly than both control words (English non- specific and specific conditions), 57 ms, $t = 2.557$, $p = .017$. However, there also was a significant difference between English non- specific and English specific conditions, $t = 3.127$, $p < .01$ which reflected slower reaction times for English specific condition as compared to English non- specific condition (41 ms). The interaction between frequency and status was not significant, $F_1(2,52) = 1.351$, $p = .268$, $F_2 < 1$, n.s.

Table 4. Mean reaction times and percentages of errors (and standard deviations) for word targets in Grade 8 participants, according to word frequency (low versus medium) and status (cognate, English non- specific and English specific).

	Cognates	English non-specific	English specific	Mean
Low Frequency				
RT	**981** (270)	**938** (233)	**963** (246)	**961 ms**
Errors	16.9 (22)	10.2 (14)	18.4 (16)	
High Frequency				
RT	**976** (326)	**863** (187)	**920** (218)	**920 ms**
Errors	15.7 (16)	8.9 (11)	6.4 (8)	
Mean	**979 ms**	**901 ms**	**942 ms**	

Errors

Neither effect of frequency or status reached significance [frequency: $F_1(1,26) = 2.786$, $p = .11$, $F_2 < 1$, n.s.; status: $F_1(2,52) = 1.916$, $p = .157$, n.s., $F_2 < 1$, n.s.]. The interaction between frequency and status was however significant, $F_1(2,52) = 6.286$, $p < .01$, partial $\eta^2 = .20$, $F_2 < 1$, n.s. We conducted Bonferroni post-hoc T-tests in order to investigate this interaction. This revealed a frequency effect for the English non-specific condition only (11.8%, $p < .01$).

Discussion

The goal of the present study was to test for the cognate effect in young L2 learners who have been studying English for two years. The rationale was that a difference between cognate and monolingual L2 control words of matched frequency and length would support the language- nonselective lexical access hypothesis. The data reveal a main effect of status which reflected different processing times for cognate words as compared to monolingual control words (English specific and non- specific) and this effect would indeed support nonselectivity in lexical access. It seems then that the French (L1) nontarget language could have exerted an influence during this L2 lexical access task. However, the data also showed an unexpected finding: cognate words were processed more *slowly* than control monolingual words (English non-specific and specific words) among these participants attending Grade 8 Secondary school. This finding goes against most cognate studies (Brenders et al., 2011; Dijkstra and colleagues, 1998, 1999, 2011; Lemhöfer & Dijkstra, 2004; Lemhöfer, Dijkstra & Michel, 2004; van Hell & Dijkstra, 2002). First, an attempt could be made to account for this diverging result in terms of the level of proficiency and exposure to the L2 of the participants. Most studies that have found a facilitation effect assessed highly proficient adult bilinguals. In contrast, the participants here were school age adolescents attending Secondary Grade 8, who had been learning English for around two years. Highly proficient bilinguals may benefit from the co- activation of semantic representations for each language of the cognate word, which in turn activate more strongly the corresponding cognate orthographic representation and facilitate its lexical retrieval. L2 school learners of low proficiency could instead suffer from the language ambiguity that is conveyed by cognate words. This was suggested by Brenders and colleagues to account for the cognate inhibition effect found when combining cognates and interlingual homographs within the same experiment (Brenders et al., 2011; experiment 3). Yet, these same authors who examined a very similar population to the one studied here *did* find a cognate *facilitation* effect in a lexical decision task when no homographs were added in the list (experiment 1), while inhibition was observed here. One difference that could have accounted for this diverging result is the proportion of cognate words included in the materials. While half of their words were cognates (the other half being monolingual control words), cognates only represented a quarter of the word stimuli in the present study. An argument is made here for different response strategies. A participant may have noticed in Brenders et al.' experiment that half of the words they saw were ambiguous and existed in both their L1 and L2. As a result, the possibility that these cognate words were a “trap” may not have occurred to the participants and they may have rapidly accepted them as words, even though some of these cognates were ambiguous to them. When only a quarter of words are cognate words as was the case in the present experiment, participants may have questioned language membership more and this doubt may be reflected by longer reaction times. Note that though consequences differed, list composition effects have also been shown with other types of words such as pseudohomophones (McQuade, 1991). This hypothesis could find support within the BIA framework. Considering the existence of language nodes which represent language membership information may explain these data. When a common English (L2) word is accessed, the corresponding English (L2) language node receives activation, and send inhibition top- down to words belonging to the other language, here the French (L1) language. Yet, cognate words are particular with respect to language membership. We may consider that the French (L1) language node associated to cognate words (*silence*) is activated faster by the cognate than the English (L2) language node in French- English low- proficient bilinguals or L2 young learners. This French (L1) language node therefore sends stronger inhibition back to words from the English language than does the English (L2) language node to French words. Given the task was an English (L2) lexical decision task, the strong L1 language node activation associated to the inhibited L2 word nodes probably implies some ambiguity in retrieving cognate words' membership to the L2. The fact that the status effect, and particularly the cognate inhibition effect, was observed for the reaction time data, but not for the errors, strongly suggests that cognates were known to belong to the L2, but were just slowed down in responding due to the ambiguity and decision biases. It should be noted here that this explanation resembles the one suggested to account for the null cognate effect that is sometimes reported in L1 tasks (strong activation of L1 language node which prevents L2 language node to act during lexical access). An alternative explanation for this unexpected inhibition cognate effect results from the lack of cross- language homophony in the cognate words. Out of twenty cognate words, only three may be considered as homophonic across French and English (*film*, *piano*, *garage*) and two nearly- homophonic (*hotel* and *excuse*); in contrast, the remaining fifteen items had clear inconsistent orthographic- to- phonology correspondences across languages. For instance, the cognate word *silence* contains the grapheme "i" which has a different phonological mapping in French ("i" → /i/) and English ("i" →/aI/). Similarly, while "en" is a complex grapheme in French ("en" →/ã/), this is not the case in English ("en" → /e/ /n/). Though Dijkstra and colleagues (1999) reported cognate facilitation for both homophonic and nonhomophonic cognates (SOP and SO categories) in highly proficient bilinguals, a recent study by Dijkstra, Miwa et al. (2010, experiment 1) showed in a L2 lexical decision task that identical cognates –but not neighbour cognates- whose phonological overlap across languages was high were more facilitated as compared to control words than identical cognates with a low phonological overlap. it is possible that the lack of cross- language homophony of the cognate word more strongly affects the patterns in L2 school learners. Though this particular issue will not be addressed in the present work, the more general issue of phonological activation in L2 and cross- language interactions was investigated and may be found in Chapter 3 (Studies 6 and 7).

The second main interest in the present study was the finding of an orthographic typicality effect, revealed by longer reaction times for English specific words (i.e., words that contained L2 specific letter sequences) as compared to English non- specific words (i.e., words whose orthographic structure was legal in French). To my knowledge, this has not been investigated in the bilingual word recognition literature and very little in the monolingual literature. One study by Hauk and colleagues (2006) using ERP correlates investigated typicality effects in English speakers and showed that words and pseudowords with atypical orthography (*yacht*) elicited stronger brain activation as early as 100 ms after stimulus onset as compared to words and pseudowords with typical orthography (*cart*). The behavioural result however was not significant for the word items. One possibility is that the locus of this effect is rather sublexical, not lexical. One lexical variable that has been largely investigated is orthographic neighbourhood. If the locus was lexical, it might be expected that English *non- specific* words (e.g., *house*) would be processed more slowly than English specific words (e.g., *skirt*) since the former should have more cross-language orthographic neighbours (see van Heuven, Dijkstra & Grainger, 1998 for orthographic neighbourhood size effects in bilinguals). Yet, the opposite effect was found here with shorter reaction times for English non- specific as compared to English specific words. It is therefore suggested that the underlying mechanism is sublexical, either from the orthographic representations for English specific words being underspecified[17] and slow to access, or from the need to access words whose letter sequences, or more precisely graphemes, are very English specific. The way orthographic typicality effects may be integrated into models of bilingual word recognition is discussed in the General Discussion. A final finding was that of an overall frequency effect in the reaction time data. As hypothesized, this suggests that participants could rely on the lexical orthographic code to access the English words (Coltheart et al., 2001; Dufau et al., 2011; Sprenger-Charolles et al., 2003). This result also confirms that frequencies provided by an English as L1 database (i.e., the CPWD database, Mastersen et al., 2003) can be an appropriate tool for investigating visual word recognition in English as a L2.

To conclude, a cognate inhibition effect was demosntrated in a group of Grade 8 English learners indicating language- nonselectivity in lexical access. In addition, an orthographic typicality effect was observed in the reaction time data, displaying a facilitation effect for English non-specific words as compared to language specific. Given the direction of the cognate effect, contradictory with standard cognate studies, and possibly reflecting strategic biases due to language ambiguity, only one group of L2 school learners was tested in Study 2. So, Study 3 used another measure of cross-

[17] Though, this interpretation does not seem to be supported by Study 1. Priming effects did not interact with orthographic typicality, in favour of a comparable lexical tuning across the two types of English words.

language interactions, namely the cross- language orthographic neighbourhood effect.

Study 3. Cross-language Priming.

As previously presented, a large body of research from the past decades has provided evidence that lexical access is initially “language- nonselective” in highly proficient adult bilinguals, that is the word forms of both languages can be activated during word recognition, especially in the initial steps of lexical access (Dijkstra, Van Heuven & Grainger, 1998; Dijkstra & van Heuven, 2002). The focus of the present work is to determine whether this lexical organisation can be observed from the first steps of L2 acquisition that is in participants whose L2 lexicon is rudimentary and language exposure and proficiency can be regarded as low.

Two lines of evidence have been reported in support of the language nonselectivity hypothesis. The first comes from the investigation of cognate and interlingual homograph word processing (Beauvillain & Grainger, 1987; Bowers, Mimouni & Arguin, 2000; Costa, Caramazza & Sebastián- Gallès, 2000; de Groot, Delmaar & Lupker, 2000; de Groot & Nas, 1991; Dijkstra & van Hell, 2003; Dijkstra, van Heuven & Grainger, 1999; Gollan, Forster & Frost, 1997; Jared & Szucs, 2002; Kim & Davis, 2003; Lemhöfer & Dijkstra, 2004; Lemhöfer, Dijkstra & Michel, 2004; van Hell & Dijkstra, 2002; Voga & Grainger, 2007). This was tested in the previous study by means of cognate words and results contradicted findings from studies of highly proficient bilinguals and one recent study by Brenders and colleagues (2011) on young school L2 learners from Grade 5 to 7. The influence of strategic decision processes may have influenced the identification process, leading to unexpected results as regard to the standard cognate facilitation effect.

Another line of evidence comes from the consideration of cross- language orthographic neighbourhood effects (Bijeljac-Babic, Biardeau & Grainger, 1997; Dijkstra, Hilberink- Schulpen & van Heuven, 2010; French & Ohnesorge, 1996; Grainger & Dijkstra, 1992; Grainger & O'Regan, 1992; Midgley, Holcomb, van Heuven & Grainger, 2008; van Heuven, Dijkstra & Grainger, 1998). Orthographic neighbourhood, or more precisely substitution neighbourhood, refers to all words that can be formed when changing one letter from a target word, all positions respected (Coltheart, Davelaar, Jonasson & Besner, 1977). For example the English word *fare* has several neighbour words such as *bare*, *care*, but also *fire*, *fate* and *farm*. Same- alphabet languages tend to share orthographic neighbours across languages; as a result, the word *fare* also has several French neighbours such as *gare*, *mare*, *fade* and *fane* (i.e., meaning respectively *train station*, *pond*, *tasteless* and *to wither*). Two main factors related to orthographic neighbourhood have been shown to influence word recognition in monolinguals as well as bilinguals: orthographic neighbourhood size (i.e., the number of orthographic neighbours of a target word) and neighbourhood frequency (Bijeljac-Babic, Biardeau & Grainger, 1997; Dijkstra, Hilberink-Schulpen & van Heuven, 2010; French & Ohnesorge, 1996; Grainger & Dijkstra, 1992; Grainger & O'Regan, 1992; Midgley, Holcomb, van Heuven & Grainger, 2008; van Heuven, Dijkstra & Grainger, 1998).

Neighbourhood size is supposed to be small for most words known by L2 school learners and it was therefore not investigated. The focus of the present study was on the orthographic neighbourhood *frequency* effect or the finding that recognizing words that have a higher frequency neighbour is longer than recognizing those that do not have it (Grainger & Segui, 1990). Bijeljac- Babic and colleagues (1990) first reported in

French- English bilinguals both within and cross- language neighbourhood frequency effects in a masked priming study. They showed inhibition priming effects when low frequency target words were preceded by same, as well as different- language, higher frequency orthographically related prime words as compared to unrelated prime words. This effect was found from L1- to- L2 (experiment 1) and from L2- to- L1 (experiment 2) and this latter effect was found to be robust only for highly proficient bilinguals. More recently, Dijkstra and colleagues (2010, experiment 2) replicated this finding in Dutch- English bilinguals (late L2 learners) while attempting to tease apart effects due to sublexical letter overlap between prime and target (i.e., facilitation effect arising from the share of letters) from those due to lexical competition between orthographically similar neighbour words (i.e., inhibition effect arising from word competition). In a similar priming paradigm as Bijeljac-Babic and colleagues, Dutch (L1) target words were preceded by either English (L2) prime words or pseudowords. Facilitation priming effects were observed for the pseudoword priming condition whereas inhibition effects were found for the word priming condition. These effects were significant only for the first session of presentation, and this was explained as reflecting a long lag repetition priming effect (Grainger & Jacobs, 1999). Identifying a target word would result in an increased resting activation level for this word on the one hand and a decreased inhibition effect of this target word's competitors. A similar pattern was found from a Dutch L1- to- L1 experiment (Dijkstra et al., 2010, experiment 1), which indicated common word recognition mechanisms within and across languages. Overall, the influence of orthographic neighbourhood characteristics from the nontarget language over word recognition in the target language was interpreted as reflecting a language- nonselective lexical access.

The present study aimed to test for the language- nonselectivity lexical access hypothesis in three groups of school L2 learners of varying number of years of L2 learning: 1) Grade 6 school children who have just started to learn English as a L2, 2) Grade 8 school children who have two years of English as a L2 learning and 3) Adult University students who have learned English for seven years. The present study was composed of two parts examining respectively L2- to- L1 and L1- to- L2 priming. In both cross- language experiments, a low frequency target word was preceded by a higher frequency prime word of the other language, either orthographically related or unrelated. On the basis of the BIA and BIA+ models of bilingual processing (Dijkstra et al, 1998, 2002), an inhibition priming effect would reflect the existence of lexical competition between the two words, whatever the language they belong to, which would support the language- nonselective lexical access hypothesis. Given the lower proficiency in English (L2) of the younger groups, it is possible though that L2 primes may not be sufficiently frequent to inhibit L1 target words. In that case, a cross- language inhibition effect may only arise in the adult group.

Part 1: L2- to- L1 priming

Finding an inhibition priming effect in the L2- to- L1 priming direction may be the strongest support of language- nonselectivity, given the potential difficulty for a nondominant L2 word to exert inhibition onto the dominant language of the L1. Indeed, Bijeljac-Babic and colleagues (1997) only observed null priming effects in a so- called “monolingual” population, whose characteristics are in fact the same as our University student participants. It is suggested that by using materials specifically constructed for L2 school learners, this study may be in better position to test for language-nonselectivity. The null effects obtained by Bijeljac-Babic and colleagues may indeed reflect a combination of facilitation from letter overlap and inhibition from lexical competition, since facilitation priming effects are normally expected when the prime is a pseudoword (Forster & Shen, 1994). By presenting English prime words more frequent than the ones used in Bijeljac- Babic's study (mean frequency in the present study: 860 o.p.m, SD: 1848; mean frequency in their study: 273 o.p.m, SD: 486, U Mann Whitney = 332, $Z = 2.540$, $p = .011$, CPWD, Masterson et al., 2003), and French target words less frequent (mean frequency: 8.21 o.p.m, SD: 10.7, mean frequency: 15.09 o.p.m., SD: 15.29, U Mann Whitney = 363.5, $Z = 2.125$, $p = .034$, for respectively the present stimuli and theirs, Lexique 3.1, New et al., 2001), therefore increasing the contrast between prime and target frequency, a stronger inhibition from L2- to- L1 may be expected (Segui & Grainger, 1990a on the difference between absolute versus relative prime/target frequencies; see though a recent debate about this issue, Nakayama et al., 2008). In addition, given there is no published study to date that reported inhibition priming effects in children attending Secondary school, a within- language condition from L1- to- L1 has been added.

Experiment 1a

The present experiment tested L1- to- L1 and L2- to- L1 neighbourhood frequency priming effects in three groups of L2 school learners, Grade 6, Grade 8 children, and University students. Evidence for inhibition priming effect would be taken as reflecting a language- nonselective lexical access in this population.

Method

Participants

The present study was performed by three groups of L2 learners. First, a group of 50 Grade 6 children (mean age: 11;7) participated in the study. They were recruited in three different schools from the North region in France (Collège Verlaine, Lille; Collège Sévigné, Roubaix and Collège Chasse Royale, Valenciennes). They were pupils from one same classroom for whom the English teacher was our contact for testing. The second group of participants was composed of 27 children attending Grade 8 Secondary school (mean age: 13;8). These children attended two schools in the North region (Collège Verlaine, Lille; Collège Sévigné, Roubaix). All children participants were learning English as a L2 since Grade 6 Secondary School. While Grade 6 children were only starting L2 learning (they had only a few months of classes), Grade 8 children had around two years and a half of formal English teaching at Secondary school. We should note that, though written exposure in L2 starts from Grade 6 Secondary, oral exposure is present since Elementary school and the degree of exposure strongly varies for each participant, due to the varying Elementary schools they came from. The third group of participants was composed of 26 University students (mean age: 22; 4) who were recruited at the University of Lille North of France. They had studied English for at least seven years during Secondary school. None of them studied Modern languages at the University. They were all French native speakers and none of them had ever lived in a bilingual environment nor spoke English in their daily life. Unfortunately, no proficiency test was performed by these participants.

Materials

Thirty six French target words (mean frequency: 8.21 o.p.m., SD: 11, Lexique 3.1, New, Pallier, Ferrand & Matos, 2001) were selected (see Appendix p 337). Note that words with diacritics were avoided in the present stimuli selection, as well as in other studies involving the French language. The word length varied from 3 to 6 letters. These French target words were preceded by orthographically related prime words of either same language or different language. For example, the French target word *gant* (*glove*) was preceded by either the French primes *tant* and *loin* for respectively related and unrelated conditions, or the English primes *want* and *cold*.

The French prime words were matched in length and written frequency (mean frequency: 189 o.p.m., SD: 220, and mean: 183 o.p.m., SD: 205 for related and unrelated conditions respectively, Lexique 3.1). The English prime words were selected according to children textbooks and were thus supposed to be encountered during Secondary school. For each target, a same- length unrelated English prime word was selected. English written word frequencies were found using the Children Printed Word Database (CPWD, Masterson et al., 2003), an English as a L1 database for children at Elementary school. This choice was based on the observation that L2 vocabulary learnt in a school context, and associated word frequencies may be best captured by a children database. English primes were also matched on length and written frequency (mean frequency: 860, SD: 1848, and mean: 741, SD: 1044 for respectively related and unrelated conditions)

Thirty six pseudowords were created for the purpose of the lexical decision task. They were created by changing one letter from a French word, all positions respected.

There were preceded by either English or French prime words, either related or unrelated.

Four lists were created so that the target word was preceded by the English related prime word in list 1 or unrelated in list 2; or by the French related prime word in list 3 and unrelated in list 4. There was equal number of English and French primes, as well as of related and unrelated prime words in each list. Participants performed either lists 1 and 2, or lists 3 and 4 together so that they saw the related and unrelated priming condition for each target. List order was counterbalanced across subjects and this gave rise to a control factor further called session that represented the first versus second presentation of the targets.

Procedure

A fixation point was presented for 1 000 ms, followed by a forward mask of ####### for 800 ms. The prime word was then presented for 57 ms, followed by the target word which remained on the screen for 1000 ms or disappeared when a response was made. The participants had to perform a lexical decision task in French (L1). They were asked to press a button with their dominant hand when the word they saw was a French word or to press another button with their nondominant hand to decide that the target was not a real French word. Participants were asked to respond as quickly and accurately as possible. The relevance of the English language in the experiment was mentioned in the instructions by telling participants they might see some English. The reason for this choice was that both Grade 6 and Grade 8 participants participated in the study in the context of English classes and it was ethically important to let them know they indeed participated in a study whose interest was for English learning. The session lasted around 15 minutes and was preceded by a training session which included 10 items. Testing took place between January and April 2009 for both children groups and in March 2009 for adults.

Results

As for the whole doctoral work, we checked homogeneity of variances among the three groups of participants in order to decide whether the groups could be combined into a common statistical analysis[18]. Given that it was not the case, $F(2,94) = 7.187$, $p < .01$, separate analyses were conducted for each group of participants. This decision seemed even more appropriate given that both children groups had much higher error rates than the adult group, an observation which led us to remove some items.

Adults

The French word *lest*, meaning *ballast*, was poorly recognised (mean error: 67%) and was thus removed. Reaction times higher than 2.5 standard deviations from the mean reaction times were discarded (<1% of word data). An analysis of variance (Anova) was conducted on reaction times and errors on both participants (F1) and items (F2) analyses. Session, prime language and relationship were entered as within- subject variables on both analyses. Table 5 represents mean RTS and percentage of errors (and

[18] Though a combined analysis is more standard in the field, the fact that our groups differed in many factors (age, but also L1 reading experience, L2 proficiency and exposure), separate analyses were thought to be more adequate when variances across groups were not homogeneous (Levene test).

standard deviations) for word targets in adult participants.

Table 5. Reaction times in ms and percentages of errors (and standard deviations) in the adult participants by session (first session vs. second session), prime language (English vs. French) and orthographic relationship (related vs. unrelated).

	First session			
	English		French	
	Unrelated	Related	Unrelated	Related
Reaction times (ms)	720 (105)	747 (89)	701 (81)	706 (73)
Errors (%)	12 (10)	16.7 (12)	8 (10)	13.7 (11)
	Second session			
	English		French	
	Unrelated	Related	Unrelated	Related
Reaction times (ms)	660 (85)	663 (70)	739 (69)	662 (77)
Errors (%)	8.7 (10)	9.5 (11)	7.3 (9)	7.9 (11)

Reaction times

There was a main effect of session, $F_1(1, 25) = 66.033$, $p < .001$, partial $\eta^2 = .73$, $F_2(1, 34) = 91.099$, $p < .001$, which reflected faster reaction times for the second session as compared to the first one (63 ms). There was a main effect of relationship which was significant for the participant analysis only, $F_1(1, 25) = 6.038$, $p = .021$, partial $\eta^2 = .19$, $F_2 < 1$, n.s. This result reflected an overall inhibition priming effect, that is reaction times were longer for the related condition as compared to the unrelated priming condition (15 ms). The effect of prime language was also significant for both participant and item analyses, $F_1(1, 25) = 5.016$, $p = .034$, partial $\eta^2 = .17$, $F_2(1, 34) = 9.688$, $p < .01$. This reflected faster reaction times for the French prime language as compared to the English prime language condition (20 ms). None of the interactions reached significance [session * prime language, $F_1(1,25) = 1.574$, $p = .22$, n.s., $F_2(1, 34) = 1.306$, $p = .26$, n.s.; session * relationship, all Fs < 1, n.s; prime language * relationship, all Fs < 1, n.s.; session * prime language * relationship, $F_1(1,25) = 2.932$, $p = .10$, n.s., $F_2 < 1$, n.s.].

Errors

There was a main effect of session, $F_1(1, 25) = 12.989$, $p < .01$, partial $\eta^2 = .34$, $F_2(1, 34) = 10.792$, $p < .01$, which reflected fewer errors for the second session as compared to the first one (4.2%). There was a main effect of relationship, $F_1(1, 25) = 11.324$, $p < .01$, partial $\eta^2 = .31$, $F_2(1, 34) = 4.797$, $p = .04$. This result reflected an overall inhibition priming effect, that is more errors for the related condition as compared to the unrelated priming condition (3 %). The effect of language did not reach significance for the participant analysis but was significant as a trend for the item analysis, $F_1(1, 25) = 2.698$, $p = .113$, n.s., $F_2(1, 34) = 3.072$, $p = .089$. None of the interactions reached significance [session * prime language, all Fs < 1, n.s.; session * relationship, F_1 $(1,25) = 2.109$, $p = .159$, n.s., F_2 $(1\ 34) = 1.935$, $p = .173$, n.s; prime language * relationship, all Fs < 1, n.s.; session * prime language * relationship, all Fs < 1, n.s.].

In all, a significant inhibition priming effect was observed on both reaction time and error data. In addition, there was a significant effect of prime language which reflected faster reaction times when preceded by same- language primes as compared to different- language prime words.

Grade 8 participants

Eleven items had to be removed from the data due to high error rates (mean percentage of errors on these items: 46%, range from 26% to 70%). This could be explained by the low frequency of our word target items. The same data clearance on reaction times than for adults was performed, as well as similar analyses. Results may be found in Table 6.

Table 6. Mean reaction times in ms and percentages of errors (and standard deviations) for word targets in Grade 8 participants by session (first session vs. second session), prime language (English vs. French) and relationship (related vs. unrelated).

	First session			
	English		French	
	Unrelated	Related	Unrelated	Related
Reaction times (ms)	802 (120)	794 (121)	823 (147)	783 (100)
Errors (%)	18.9 (16)	16.5 (16)	16.4 (18)	23.6 (20)
	Second session			
	English		French	
	Unrelated	Related	Unrelated	Related
Reaction times (ms)	746 (126)	723 (98)	741 (92)	731 (117)
Errors (%)	10.6 (12)	14.6 (16)	15.2 (16)	14.7 (17)

Reaction times

There was a main effect of session, $F_1(1, 26) = 42.563$, $p < .001$, partial $\eta^2 = .62$, $F_2(1, 24) = 44.304$, $p < .001$, which reflected faster reaction times for the second session (735 ms) as compared to the first one (65 ms). There was a main effect of relationship which was significant for the participant analysis, $F_1(1, 26) = 4.330$, $p = .047$, partial $\eta^2 = .14$ and significant as a trend for the item analysis, $F_2(1, 24) = 3.298$, $p = .08$. This result reflected an overall facilitation priming effect, that is reaction times were faster for the related condition as compared to the unrelated priming condition (20 ms). The effect of language was not significant, all Fs < 1, n..s, and neither were the interactions [session * prime language, all Fs < 1, n.s.; session * relationship, all Fs < 1, n.s; prime language * relationship, all Fs < 1, n.s.; session * prime language * relationship, $F_1 < 1$, n.s., $F_2(1, 24) = 1.125$, $p = .30$, n.s].

Errors

There was a main effect of session, $F_1(1, 26) = 8.328$, $p < .01$, partial $\eta^2 = .24$, $F_2(1, 24) = 7.909$, $p < .01$, which reflected higher accuracy for the second session as compared to the first one (5.1%). No other main effect was significant [prime language, $F_1(1, 26) = 1.035$, $p = .32$, n.s., $F_2 < 1$, n.s.; relationship, $F_1(1, 26) = 1.543$, $p = .23$, n.s., $F_2 < 1$, n.s] nor interaction [session * prime language, all Fs < 1, n.s.; session * relationship, all Fs < 1, n.s; prime language * relationship, $F_1 < 1$, n.s., $F_2(1, 24) = 1.675$, $p = .21$, n.s.; session * prime language * relationship, $F_1(1, 26) = 2.423$, $p = .13$, $F_2(1, 24) = 1.591$, $p = .22$, n.s.].

In all, a significant facilitation priming effect was observed in the reaction time data, that is faster latencies for the related priming condition as compared to the unrelated condition.

Grade 6 participants

The same eleven items as for Grade 8 participants were discarded due to high error rates (mean percentage of errors on these items: 50%, range from 25% to 72%). Further, six participants had less than 60% of accuracy of the word data and were therefore removed from the analyses, leading to a remaining fourty- four participants in this group. Again, the same data clearance was used for the reaction times analyses. Results may be found in Table 7.

Table 7. Mean reaction times in ms and percentages of errors (and standard deviations) for word targets in Grade 6 participants by session (first session vs. second session), prime language (English vs. French) and relationship (related vs. unrelated).

	First session			
	English		French	
	Unrelated	Related	Unrelated	Related
Reaction times (ms)	894 (189)	921 (195)	908 (204)	889 (179)
Errors (%)	21.6 (20)	24.6 (19)	20.3 (15)	24.1 (19)
	Second session			
	English		French	
	Unrelated	Related	Unrelated	Related
Reaction times (ms)	845 (155)	821 (165)	841 (150)	837 (188)
Errors (%)	19.1 (21)	17.2 (17)	17.8 (16)	11.9 (17)

Reaction times

There was a main effect of session, $F_1(1, 43) = 20.923$, $p < .001$, partial $\eta^2 = .33$, $F_2(1, 24) = 27.240$, $p < .001$, which reflected faster reaction times for the second session as compared to the first one (67 ms). No other main effects reached significance, all *F*s < 1, n..s. In addition, there was no significant interaction either [session * prime language, all *F*s < 1, n.s.; session * relationship, $F_1 < 1$, n.s., $F_2(1, 24) = 1.675$, $p = .21$, n.s.; prime language * relationship, all *F*s < 1, n.s.; session * prime language * relationship, $F_1(1, 43) = 1.986$, $p = .17$, $F_2(1, 24) = 3.843$, $p = .06$].

Errors

There was a main effect of session, F_1 $(1, 43) = 15.930$, $p < .001$, partial $\eta^2 = .27$, F_2 $(1, 24) = 13.834$, $p < .01$, which reflected higher accuracy for the second session as compared to the first one (6.2%). No other main effect was significant [prime language, $F_1 < 1$, n.s., $F_2(1, 24) = 1.209$, $p = .28$, n.s.; relationship, all *F*s < 1, n.s.]. The interaction between session and relationship reached significance on both participant and item analyses, $F_1(1, 43) = 4.493$, $p = .04$, partial $\eta^2 = .09$, $F_2(1, 24) = 4.641$, $p = 041$. Post hoc comparisons reflected a significant difference between related priming conditions across the two sessions. While the unrelated priming conditions were similar across the two sessions (20.9% and 18.4% of errors for the first and second sessions respectively), the related condition clearly differed (24.4% and 14.5%s of errors for the first and second sessions respectively, $p < .01$). This can be interpreted as an inhibition priming effect in the first session, as compared to a facilitation priming effect in the second session. No other interaction reached significance, all *F*s < 1, n.s.

In all, a significant interaction between session and relationship that reflected an inhibition effect for the first session while a facilitation effect for the second session was observed on the error data. No priming effect was observed on the reaction times though.

Discussion

Experiment 1 investigated orthographic priming effects from L1- to- L1 and L2- to- L1 in a lexical decision task in three groups of L2 learners: University students, Grade 8 and Grade 6 children. In the adult group, a significant inhibition priming effect was observed on both reaction time and error data. This effect was supposed to reflect lexical competition, as assumed by the BIA+ model (Dijkstra & van Heuven 2002). Given that no interaction was observed, this effect therefore revealed both within and cross- language inhibition priming, a finding which indicates similar word recognition mechanisms across the two languages in this group of L2 learners. Therefore, the pattern in this group supports the language- nonselective lexical access hypothesis in a group whose proficiency and exposure to the L2 is lower than that in previous studies of bilingual word recognition (Bijeljac- Babic et al., 1997; Dijkstra et al., 2010). This result will be followed up in experiment 1b. Furthermore, there was a significant effect of prime language which reflected faster reaction times when preceded by same- language primes as compared to different- language prime words. This additional finding reflecting language switching cost is discussed in the summary of this study.

In the Grade 8 children, an overall facilitation priming effect in the reaction time data was obtained and may be interpreted as the facilitation exerted by letter overlap between the prime and the target words. Given that the locus of the facilitation priming effect is supposed to be sublexical, this result cannot be interpreted in terms of language- nonselectivity in lexical access. In the Grade 6 children, an interaction between session and relationship was found on the error data, both by- participants and by- items, revealing more errors for the related condition as compared to the unrelated condition in the first session, and the opposite pattern in the second session. Though this interaction resembles the one found by Dijkstra et al (2010) in their reaction time data, that is a frequency neighbourhood inhibition effect in the first session, followed by a sublexical facilitation priming effect in the second session, the fact that this effect only appeared in the error data seems to go against this hypothesis. Moreover, given this was not observed in the Grade 8 children group, the source of this interaction remains unclear. In this same group, again a null priming effect was observed. It seems unlikely to account for this null effect by suggesting a mix of facilitation and inhibition priming effects, given that older children of Grade 8 showed a facilitation priming effect. One preliminary explanation relates to the French target words used in the study. Error rates were quite high considering that the task involved a French (L1) lexical decision task (20% of errors on word responses after data cleaning). This high error rate may result from both the low frequency of the targets which may render them unknown, or too little exposure to the written orthography. The target words' orthographic representations may have been too poorly specified to be primed. In sum, there was no hint of an inhibition priming effect in these two groups of L2 school learners, either within language from L1- to- L1 or across languages from L2- to- L1. One possibility is that lexical competition as a word recognition mechanism has not yet developed as early as Secondary Grade 6. Indeed, there is no published study that assessed lexical competition in children and this issue remains unresolved even in the monolingual literature. Before discussing these findings, exploratory analyses were conducted in order to further understand the data. One possible spurious variable that could have impeded any inhibition priming effect to be detected in Grade 8 children is the prime frequency. Due to material constraints -finding French target words that have both French and English high frequency neighbour words- a wide range of frequencies of the prime words, especially for the English (L2) prime words, were chosen as stimulli. Though all were found to be learned at school according to children textbooks, some English words may not have been familiar enough for these beginning L2 learners.

Follow-up study: Exploring the prime frequency effect

Given this interpretation, exploratory analyses of within and cross- language priming effects were conducted by taking into account the effect of prime frequency on the three groups of participants so as to compare their profiles. For both English and French primes, two categories of prime frequencies were created and priming effects were examined according to this additional variable. Targets were classified into one prime frequency category depending on prime language. In English, eighteen targets were classified into the high frequency prime condition [bail*- horde*- boue- aire- nage- gant- bouse- taxe- cime*- alto*- sole- bal- bol- gel- net*- sou*- cap*- coq] while seventeen were classified into the low frequency prime condition [proue- planer- morse- forger- loue- tarte- ruse- dune- rame- fard*- colon- houx*- coût- soute*- cuite- lacer- pin]. Note that less items were included into each category in the children group, given items had been removed due to high error rates[19]. A mean comparison was performed and confirmed that the two conditions differed in the right direction in terms of prime frequency (High frequency prime condition: 1596, SD: 2423; Low frequency prime condition: 104, SD: 82), U- Mann- Whitney = 0, Z = 5.033, $p < .001$, as well as familiarity (High frequency prime condition: 5.25, SD: .67; Low frequency prime condition: 4.47, SD: .85), U- Mann- Whitney = 68, Z = 2.789, $p < .01$. However, they also differed in length (High frequency prime condition: 3.72 letters, SD: .67; Low frequency prime condition: 4.59 letters, SD: .80), U- Mann- Whitney = 67, Z = 2.822, $p < .01$ and target frequency (High frequency prime condition: 12.15 o.p.m., SD: 13.66; Low frequency prime condition: 4.48 o.p.m., SD: 4.06), U- Mann- Whitney = 86.5, Z = 2.179, $p < .05$.

In French, the same conditions were created: seventeen words were categorized into the high frequency prime condition [aire- bal- bol- boue- cap*- cime*- coq- coût- cuite- fard*- gant- gel- net*- pin- sou*- soute*- tarte] and eighteen into the low frequency prime condition [alto*- bail*- bouse- colon- dune- forger- horde*- houx*- lacer- loue- morse- nage- planer- proue- rame- ruse- sole- taxe]. Mean comparison confirmed that items in the high frequency prime condition indeed had higher prime frequency than items from the low frequency prime condition (High frequency prime condition: 343, SD: 237; Low frequency prime condition: 53, SD: 29), U- Mann- Whitney = 0, Z = 5.033, $p < .001$. However the two conditions created for the French primes did not differ in terms of prime familiarity (High frequency prime condition: 4.87, SD: .95; Low frequency prime condition: 4.87, SD: .78), U- Mann- Whitney = 150, $Z < 1$, n.s. In addition, the targets themselves differed in terms of length (High

[19] The items that were not considered for the children are marked with an asterisk.

frequency prime condition: 3.71 letters SD: .77; Low frequency prime condition: 4.56, SD: .70), U- Mann- Whitney = 69, $Z = 2.756$, $p < .01$, as well as target frequency (High frequency prime condition: 13.61 o.p.m., SD: 13.39; Low frequency prime condition: 3.53 o.p.m., SD: 3.38), U- Mann- Whitney = 49.5, $Z = 3.40$, $p < .001$.

For both adult and children participant groups, an analysis of variance (Anova) was conducted on reaction times on both participants (F_1) and items (F_2) analyses. Prime language, prime frequency and relationship were entered as within- subject variables on the participant analysis. For the item analysis, prime frequency was entered as a between- subject variable while language and relationship as within- subject variables. In order to maximize the possibilities of observing any interaction between prime frequency and priming condition, the two children groups were combined. This was also possible given they had the same number of items. The analysis for the adult group was conducted separately. Table 8 shows these results. Figure 4 represents the post-hoc findings for the adult participants while Figure 5 shows the results for the children participants (Grade 6 and Grade 8 children combined).

For the adults, an effect of prime language was observed, $F_1(1, 25) = 5.214$, $p < .05$, partial $\eta^2 = .17$, $F_2(1, 66) = 3.316$, $p = .073$. Again, this reflected longer reaction times for the English primes as compared with French primes (20 ms). In addition, an effect of prime frequency emerged by- participants and as a trend by- items, $F_1(1, 25) = 9.977$, $p < .01$, partial $\eta^2 = .28$, $F_2(1, 66) = 3.088$, $p = .083$. Subjects responded to faster for those targets from the high frequency prime condition than for those from the low frequency prime condition (24 ms). This is not surprising given that targets could not be matched according to frequency and there were little higher in the high frequency prime condition (i.e., mean frequency: 12.15 o.p.m., SD: 13.66 and mean: 13.61 o.p.m., SD:

13.39 for English and French prime conditions respectively) as compared to the low frequency prime condition (i.e., mean frequency: 4.48 o.p.m., SD: 4.06 and mean: 3.53 o.p.m., SD: 3.38 for English and French prime conditions respectively). The effect of relationship almost reached significance by participants, $F_1(1, 25) = 4.010$, $p = .056$, partial $\eta^2 = .14$, $F_2 < 1$, n.s. and reflected the inhibition priming effect above-mentioned.

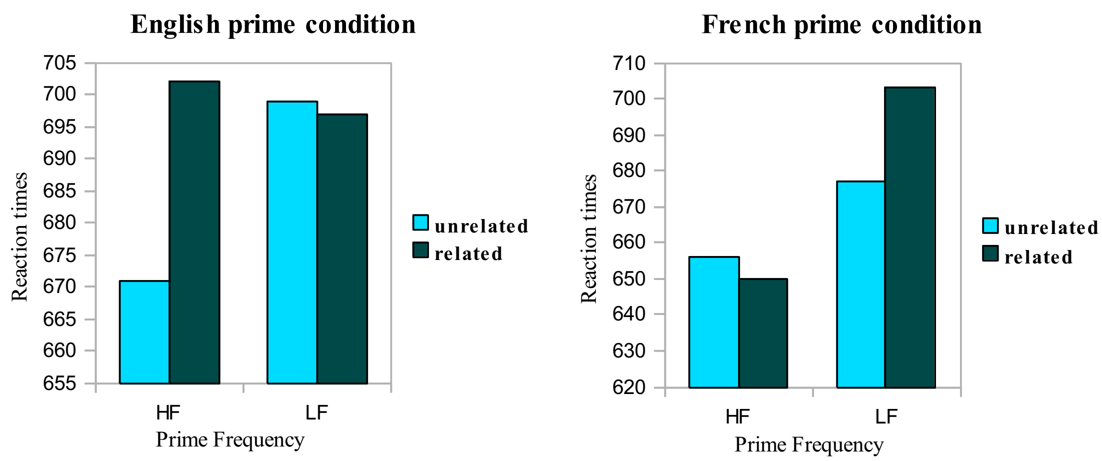
Interestingly, there was an interaction between prime language, prime frequency and relationship, $F_1(1, 25) = 4.188$, $p = .051$, partial $\eta^2 = .14$, $F_2(1, 66) = 8.555$, $p < .01$. This interaction reflected 1) for English primes, the presence of a trend for an inhibition priming effect for high frequency prime condition (31 ms, $p = .058$) as compared with null effect for the low frequency prime condition (- 2 ms, n.s.) but 2) for French primes, a non- significant inhibition priming effect for low frequency prime condition (26 ms, n.s.) while null effect for the high frequency prime condition (- 6 ms, n.s.). None of the other effects reached significance, all Fs < 1, n.s.

In summary, while prime frequency exerted an expected influence on priming effect for the English prime condition (a rather inhibition priming effect for the high frequency prime condition only), its influence revealed to be very confusing for the French prime condition.

Table 8. Results of the post- hoc analyses. Mean reaction times (in ms) for adults, Grade 8 and Grade 6 children according to language prime (English vs. French), prime frequency (high frequency vs. low frequency) and relationship (related vs. unrelated).

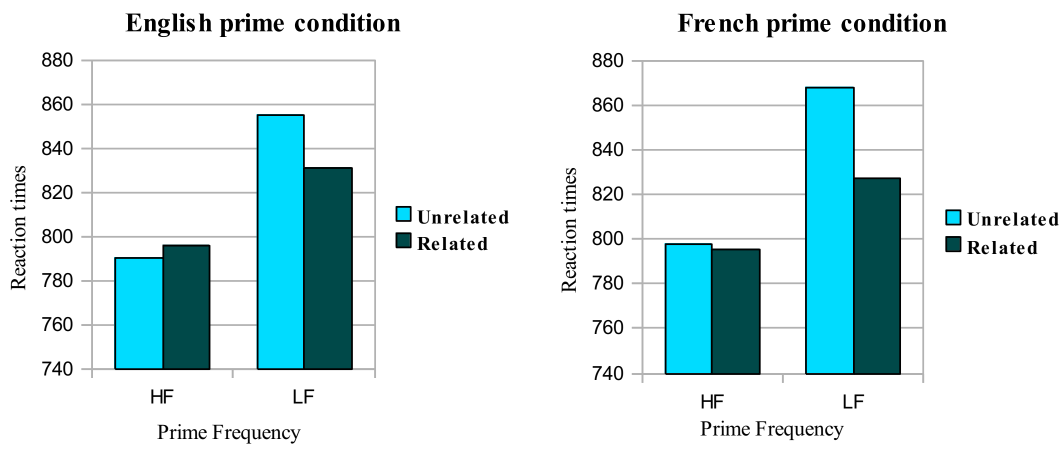
	Adults			
	English		French	
	Unrelated	Related	Unrelated	Related
High Frequency priming condition	671 (75)	702 (98)	656 (74)	650 (69)
Low Frequency priming condition	699 (119)	697 (82)	677 (66)	703 (68)
	Grade 8 Children			
	English		French	
	Unrelated	Related	Unrelated	Related
High Frequency priming condition	736 (120)	750 (115)	757 (115)	744 (111)
Low Frequency priming condition	803 (116)	763 (99)	815 (129)	769 (113)
	Grade 6 Children			
	English		French	
	Unrelated	Related	Unrelated	Related
High Frequency priming condition	845 (225)	841 (183)	838 (172)	846 (180)
Low Frequency priming condition	907 (183)	898 (175)	921 (186)	885 (188)

Figure 4. Representation of the post- hoc analyses for the adult group.



In the children, an effect of prime frequency was observed, $F_1(1,69) = 21.233$, $p < .001$, partial $\eta^2 = .26$, $F_2(1, 46) = 13.95$, $p < .001$. This reflected again faster reaction times for the high frequency prime condition as compared to the low frequency prime condition (53 ms) and was explained by the absence of correct matching between the two post- hoc conditions. In addition, there was a significant interaction between prime frequency and relationship by- items only, $F_1(1,69) = 2.673$, $p = .11$, $F_2(1, 46) = 5.07$, $p < .05$. This reflected a facilitation priming effect for the low frequency prime condition (30 ms, $p = .035$) as compared with a null effect for the high frequency prime condition (- 2 ms, n.s.).

Figure 5. Representation of the post- hoc analyses for the children participants.



Several comments can be made about the results of these exploratory analyses on the influence of prime frequency, which remained difficult to interpret, especially for the adult participants. Though not the focus of the present work, the pattern found for the within- language priming condition, or L1- to- L1 priming in the adult group, remains rather inconclusive. No effect emerged for either prime frequency condition. This is likely to be due to the low statistical power given the large number of variables entered in this exploratory analysis. However, this null effect does not seem so surprising given that the inhibition priming effect found in the previous analysis seemed to be largely due to the English prime condition. One possibility for this absence of effect for the L1- to- L1 direction comes from the lack of target word matching across both prime frequency conditions in terms of written frequency and length. Due to huge constraints in creating the materials –target words were chosen if they had high frequency neighbour words in English *and* French-, some variables could not be controlled in the present experiment, even if they have been reported to exert an influence on inhibition priming effect in monolinguals (neighbourhood size, shared neighbourhood, see Kinoshita & Lupker, 2003 for a review). Thus, this analysis sheds some light on the difficulty in examining in one unique experiment both within and cross- language priming effects with the same rigorous methodology as in monolingual research and points to the need for multiple controls when examining priming effects. For the English prime condition, an inhibition priming effect was observed in the adults when French targets were preceded by English high frequency prime words; whereas, null effects appeared when preceded by English low frequency primes. The pattern observed therefore went in the expected direction: stronger lexical competition is induced when high frequency words are presented as primes. Yet, one question may arise related to the differential effect found for the French and English prime language. Why would the effect occur for English prime words, but not for French prime words? One possibility is that more variables may have influenced the L1- to- L1 priming effect than from L2- to- L1. Another possibility comes from the fact that latencies were longer in the L2- to- L1 priming condition (see the prime language effect from experiment 1a) and that this increased time of processing may have allowed more time for inhibition to emerge.

For the children, still no inhibition priming effect emerged from these post hoc analyses. Yet, there were some hint of a role for prime frequency, a lexical variable, in determining the direction of the priming effect. Indeed, a facilitation priming effect emerged for the low frequency prime condition, but no effect was observed for the high frequency prime condition. It could be hypothesized that the null effect of the high frequency prime condition may reflect a mix of facilitation from letter overlap and inhibition from lexical competition. Contrary to the adults, this interaction did not seem to depend on prime language. Though no clear- cut evidence for cross- language nonselective lexical access may be found in this first experiment with children, there is some evidence for the influence of prime frequency, regardless of whether the prime is in L1 or L2.

In all, evidence for cross- language interactions were found among the adult participants, and to a lesser extent, among the children. Before concluding in favour of language- nonselectivity in lexical access in the adults, one should remain aware of the fact that the procedure used in this study slightly differed from the one used in Bijeljac-Babic et al. (1997) since the relevance of the English language was mentioned, although not emphasized, in the instructions. According to the BIA and BIA+ models, non-linguistic variables such as participants' expectations are not likely to affect identification mechanisms per se. Yet, another theoretical view, namely the "language mode hypothesis" (Grosjean, 1998, 2001) would assume instead that this specific context could have favoured cross-language interactions by activating the English (L2) nontarget language during the task. Indeed, Grosjean and colleagues suggest that the relative activation of bilingual languages may be conceptualized as continuous and depend on various factors such as expectations and instructions among others. Several experiments on adult bilinguals have shown that language nonselectivity in bilingual lexical access is independent of context effects: effects of the nontarget language are likely to occur even in a pure monolingual mode. Nevertheless, it is important to note that most studies that assessed this hypothesis tested highly proficient bilinguals and used materials such as cognate or interlingual homographs that actually exist in both languages (Dijkstra & van Hell, 2003; Lemhöfer, Dijkstra & Michel, 2004). Activation of the nontarget language cannot be suppressed in highly proficient bilinguals but it might be that activation of the nontarget language can be increased in lower proficiency L2 speakers with adequate instructions. In this helpful situation, our adult participants seem to show similar effects to higher proficiency bilinguals, and one possible reason could have been our instructions. Because a pure monolingual context is highly desirable in order to conclude for language- nonselectivity in lexical access, this issue was further considered in the follow-up study 2, where another adult group with similar characteristics was tested using new task instructions.

Experiment 1b. Instruction control

Method

Participants

A total of 24 University students (mean age: 23;1) participated in this experiment. They were comparable with the adult participants tested in experiment 1a: they reported not to practice the English language, nor to have ever lived in a bilingual environment. They had learned English at Secondary school and considered themselves as low proficient L2 speakers.

Materials and Procedure

Materials were exactly the same as experiment 1a. The procedure was kept constant except for the instructions. No mention of the English language, neither during recruitment of the participants nor during the testing session, was done. Testing took place between February and April 2010.

Results

The same data clearance was observed than for the adult participants of Experiment 1: the French word *lest* which was also poorly recognized was removed (mean error: 58 %). Reaction times higher than 2.5 standard deviations from the mean reaction times were discarded (<1% of word data). Table 9 represents mean RTS and percentage of errors (and standard deviations) for word targets in this adult group. An analysis of variance (Anova) was conducted on reaction times and errors on both participants (F_1) and items (F_2) analyses. Session, prime language and relationship were entered as within- subject variables on both analyses.

Reaction times

There was a main effect of session, $F_1(1, 23) = 27.04$, $p < .001$, partial $\eta^2 = .54$, $F_2(1, 34) = 129.217$, $p < .001$, which reflected faster reaction times for the second session as compared to the first one (56 ms). The main effect of relationship was nonsignificant for neither participant nor item analyses, $F_1(1, 23) = 1.035$, $p = .32$, n.s., $F_2(1,34) = 1.404$, $p = .24$, n.s. However, the main effect of prime language almost reached significance for the participant analysis only, $F_1(1, 23) = 3.983$, $p = .058$, $F_2(1,34) = 1.758$, $p = .194$. This reflected faster reaction times for the French prime language as compared to the English language (12 ms). Interestingly, the interaction between prime language and relationship was significant for both analyses, $F_1(1, 23) =$

9.492, $p < .01$, partial $\eta^2 = .29$, $F_2(1,34) = 6.453$, $p = .016$. This reflected significant inhibition effect for the English prime language only, that is longer reaction times for the related condition as compared to the unrelated condition, 19 ms, $p = .019$. This difference did not reach significance for the French language (631 and 637 ms for respectively the related and unrelated priming conditions). None of the interactions reached significance [session * prime language, all Fs < 1, n.s.; session * relationship, $F_1(1,23) = 1.317$, $p = .26$, n.s., $F_2(1, 34) = 3.651$, $p = .064$; session * prime language * relationship, all Fs < 1, n.s.].

Table 9. Mean reaction times in ms and percentages of errors (and standard deviations) in adult participants (follow-up study 2: experiment 1b) according to session (first session vs. second session), prime language (English vs. French) and relationship (related vs. unrelated).

	First session			
	English		French	
	Unrelated	Related	Unrelated	Related
Reaction times (ms)	665 (84)	686 (104)	656 (97)	664 (106)
Errors (%)	16.9 (15)	13.1 (12)	11.7 (12)	13 (13)
	Second session			
	English		French	
	Unrelated	Related	Unrelated	Related
Reaction times (ms)	610 (72)	625 (74)	617 (77)	597 (74)
Errors (%)	7.2 (10)	11.7 (14)	7.7 (9)	7.4 (9)

Errors

There was a main effect of session, $F_1(1, 23) = 7.799$, $p = .01$, partial $\eta^2 = .25$, $F_2(1, 34) = 10.861$, $p < .01$, which reflected fewer errors for the second session as compared to the first one (5.2 %). There was a trend for significance for the prime language effect for the participant analysis only, $F_1(1, 23) = 3.781$, $p = .064$, partial $\eta^2 = .14$, $F_2(1, 34) = 1.760$, $p = .19$, n.s. This reflected fewer errors for the French prime language as compared to the English prime language (2.2 %). The main effect of relationship was not significant, all *F*s < 1, n.s. And neither were the interactions [session * prime language, all *F*s < 1, n.s.; session * relationship, all *F*s < 1, n.s.; prime language * relationship, all *F*s < 1, n.s.; session * prime language * relationship, $F_1(1, 23) = 2.462$, $p = .13$, n.s., $F_2(1, 34) = 1.746$, $p = 20$, n.s.].

In all, a significant interaction between prime language and relationship in the reaction time data revealed an inhibition priming effect in English while no effect in French.

Discussion

Before turning to the L1- to- L2 priming direction, a few intermediate conclusions can be drawn. First, language- nonselectivity in lexical access was shown by adult participants, who have learned English for seven years and may be characterized as low- proficiency L2 speakers. This finding contrasts with the null priming effect reported by Bijeljac- Babic and colleagues (1997) in a similar population, and shows that using stimuli specially created for L2 school learners maximize the possibilities of observing cross- language interactions. This result was replicated in two groups of participants with similar characteristics (experiments 1a and 1b). Moreover, this priming effect was reported independently of language instructions. Even when participants were not aware of the relevance of the nontarget language, namely English (L2), a significant inhibition priming effect was observed. This is in line with studies reporting little or no effect of language instructions and participants' expectancy (Jared & Kroll, 2001; van Hell & Dijkstra, 2002; van Wijnendaele, 2002, reported by Brysbaert, van Wijnendaele & Duyck, 2002) and with BIA+ model of bilingual visual word recognition. However, the findings contrast with the language mode hypothesis from Grosjean (1998, 2001) which postulates that these attentional factors should in contrast affect the relative activation of languages in bilingual participants. It should be noted that, as in Dijkstra et al. (2010), an inhibition priming effect was observed mainly on the first presentation of items to the participants (first session). Yet, finding an inhibition effect from L2- to- L1 among low- proficiency L2 speakers, when L2 words are presented as masked primes, with a short SOA of 57 ms and therefore not consciously perceived, represents strong evidence of a language- nonselective structure of lexical access, and it should be recalled that only two studies have reported a similar effect with the masked priming paradigm, in highly proficient bilinguals (Bijeljac-Babic et al., 1997; Dijkstra et al., 2010). Language- nonselectivity could however not be demonstrated among the Grade 6 and Grade 8 children. No effects were reported, for either language in experiment 1. Only some hint for the influence of prime frequency – whatever the language of the primes- on the modulation of facilitation priming effects was observed in the follow- up analysis. Despite my enthusiasm for examining these effects, it is not so surprising that this was an arduous mission given that lexical competition has not been demonstrated in such participant groups, even among monolinguals (see Janiot, 2011's doctoral dissertation for some new discoveries about this issue in monolingual children from Primary Grades 3 to 5).

A second observation that emerged from this first part examining L2- to- L1 priming is the finding of a language- switching effect. In the two adult groups (experiments 1a and 1b), there was a prime language effect which reflected faster reaction times when French (L1) targets were preceded by same- language (L1) prime words as compared to when preceded by different- language (L2) prime words. This effect has been reported by many researchers (Beauvillain & Grainger, 1987; Chauncey, Grainger & Holcomb, 2008; Grainger & O' Regan, 1992; Orfanidou & Sumner, 2005; Thomas & Allport, 2000; Von Studnitz & Green, 1997) but two diverging interpretations have been proposed (see Chauncey et al., 2008 for disentangling these two hypotheses). On the one hand, this effect has been attributed to a feedback effect from language nodes to the lexicon. When an item t from language X is processed, the word nodes corresponding to this language X are activated and so is the corresponding language node X. The BIA model postulates that this language node X in turn sends inhibition to the language node Y and to its corresponding word nodes. So, when item t+1 appears from language Y, both language node Y and the corresponding word nodes are below resting levels, which leads to longer recognition latencies. This effect is therefore interpreted within the word recognition system. On the other hand, another perspective suggests that the locus of this language switching effect is outside the lexicon, in the task/decision system (BIA +, Dijkstra & Van Heuven, 2002; see Green, 1998, 2002 for further account of language switch costs). This language switch cost and the instruction manipulation are further discussed along with the concept of the task/decision system in the summary of Study 3.

Finally, it should be reiterated how difficult the absence of priming effect found in the L1- to- L1 priming direction is to interpret. Despite a large number of studies revealing lexical competition in adult monolinguals, this effect was not present in experiment 1. This is not the focus of the present work, and one remark that can be made concerns the lack of control of numerous variables that are known to affect orthographic priming in L1. Yet, given the hard task of creating materials that were adequate for L2 school learners and that aimed to examine both L1- to- L1 and L2- to- L1 priming in one unique experiment (i.e., the French target word *PROUE*, *bow*, was preceded by *proie* in French, *prey*, and *proud* in English), more controls of neighbourhood were not feasible.

Part 2: L1- to- L2 priming

This second part of the present study aimed to test for the influence from L1 lexical representations to newly acquired L2 representations among: 1) University French speaking students who have been learning English during their education for about seven years; and 2) French speaking children who have been learning English as a L2 for around two years and a half at school. Previous studies that compared different levels of proficiency showed no evidence for an integrated lexicon in low proficiency L2 speakers. However, these studies investigated L2- to- L1 influences (Bijeljac-Babic et al., experiment 2; Dijkstra et al., experiment 2) and to my knowledge none looked at proficiency effects from L1- to- L2. It is conceded that it may appear trivial to investigate L1- to- L2 neighbourhood frequency effect. However, experiment 1 on Grade 8 children did not provide any evidence about L2- to- L1 cross-language *inhibition* priming effect. It was expected, on the contrary, to arise more clearly from the dominant to the nondominant language. Experiment 2 further examined the conditions in which cross- language interactions may arise in L2 school learners by creating two different categories of L1 prime frequencies (high vs. low frequency), manipulation which also maximized the possibilities of observing inhibition priming effects, especially in Grade 8 children for whom there is no published study on such an effect even in the monolingual literature. This would also add evidence about the effect of relative prime/target frequency on observing inhibition priming effects. The L1- to- L2 inhibition priming effect should be observed in adult participants if language-nonselective lexical access is hypothesized. Imbalance in the L1/L2 exposure and proficiency makes L1 lexical representations more subjectively frequent than L2 lexical representations – though L2 words were chosen to be sufficiently familiar to the participants – and these conditions should favour the emergence of lexical competition. The same pattern should theoretically emerge from Grade 8 children. However, because of the lower time of exposure to the L1, an effect of French (L1) prime frequency should be observed in these participants: an inhibition priming effect, if present, should be mostly observed for the high frequency prime condition. Again, session effects and interaction with priming patterns may be observed and were thus investigated (Grainger & Jacobs, 1999). Therefore, English (L2) target words were preceded by French (L1) prime words that were classified into two conditions of prime frequency: low versus high frequency prime words.

Experiment 2

Method

Participants

Two groups of L2 learners participated in this study, among which 22 University students (mean age: 21;7) and 19 children (mean age: 14;2). They were all French native speakers. The student participants were Undergraduate students from the University of Lille North of France. They have been exposed to the English language since beginning of Secondary school (approximately seven years of formal education) but did not practice the language since A-level nor have ever been living in a bilingual environment. The children participants attended a school in Paris (Collège Chaptal) in Secondary Grade 8. They had at least two years and a half of formal English teaching at Secondary school (from 3 to 4 hours of English per week) with varying exposure to the oral English language in Elementary school.

Materials

Thirty two English (L2) target words (mean frequency: 548 o.p.m., SD: 566, CPWD database) were selected (see Appendix p 343). The word length varied from 3 to 5 letters. These English (L2) target words were preceded by French (L1) prime words. Two conditions were constructed so that sixteen English target words were preceded by high frequency French orthographically related prime words (mean frequency: 652 o.p.m., SD: 1532, Lexique 3.1) and 16 English target words were preceded by low frequency French related prime words (mean frequency: 11 o.p.m., SD: 13, Lexique

3.1). For example, in the high frequency prime condition, the English target word *FIRE* could be preceded by the French prime word *rire* (*laugh*) whereas in the low frequency prime condition, the English target *WANT* could be preceded by the French prime word *gant* (*glove*). The two conditions were matched on target frequency (mean: 488, SD: 475, and mean: 608, SD: 655, for high and low prime frequency conditions respectively, $t < 1$, n.s.), target familiarity (mean: 5.20, SD: .58, and mean: 4.92, SD: .83 for high and low prime frequency conditions respectively, $t(30) = 1.111$, $p = .275$, n.s) and on length (mean letter long: 3.81, SD: .54 and mean: 4, SD: .73 for high and low prime frequency conditions respectively, $t < 1$, n.s.). For each target word, an unrelated French prime word was selected. This unrelated condition was matched one- to- one to the related condition in word length and frequency (mean frequency: 652 o.p.m., SD: 1705 and mean: 11 o.p.m., SD: 13 for high and low prime frequency conditions).

Thirty two pseudowords were created for the purpose of the lexical decision task. They were created by changing one letter from an English word, all positions respected. To parallel the target word manipulation, two categories of prime frequencies were created so that French prime words were either of high (e.g., *joie – JOIL*, meaning *joy*) or low (e.g., *daim – DARM*, meaning *deer*) frequency. Two lists were created so that the related prime word was seen in one list, the unrelated prime word in the other list. There was equal number of related and unrelated prime words in each list, and in each prime frequency category. List order was counterbalanced across subjects leading to a control variable called “session” referring to the first or second presentation of the items.

Procedure

A fixation point was presented for 1 000 ms, followed by a forward mask of

####### during 800 ms. The prime word was then presented for 57 ms, followed by the target word which remained on the screen for 1000 ms or disappeared when a response was made. The participants had to perform a lexical decision task in English (L2). They were asked to press a button with their dominant hand when the word they saw was an English word or to press another button with their nondominant hand to say the target was not a real English word. Participants were asked to respond as quickly and accurately as possible. Due to the rudimentary vocabulary of our two groups of participants, it was emphasized in the instructions that they would press "yes" as soon as they recognized the word, and "no" if they did not. The session lasted around 15 minutes and was preceded by a training session which included 10 items. Testing took place in February 2010 for the children, and between February and April 2010 for the adults.

Results

Combined analyses of adults and Grade 8 children were conducted given homogeneity of variances among the two groups was respected, $F(1,39) = 1.106$, $p = .30$, n.s. Reaction times higher than 2.5 standard deviations from the mean reaction time were discarded (<1% of the data). Table 10 represents mean RTS and percentage of errors (and standard deviations) for word targets in adult participants (above) and Grade 8 children (below). An analysis of variance (Anova) was conducted on reaction times and errors on both participants (F_1) and items (F_2) analyses. Session, prime frequency condition and relationship were entered as within- subject variables in the participant analysis while group was entered as a between- subject variable. Session and relationship were entered as within- subject variables whereas group and prime frequency condition were considered as between- subject variables in the item analysis.

Reaction times

A main effect of group was observed, $F_1(1,39) = 47.447$, $p < .001$, partial $\eta^2 = .55$, $F_2(1,29) = 373.8$, $p < .001$, and reflected faster reaction times for the adults as compared to the Grade 8 children (95 ms). The main effect of session was also significant, $F_1(1,39) = 78.480$, $p < .001$, partial $\eta^2 = .67$, $F_2(1,29) = 122.04$, $p < .001$, which reflected faster reaction times for the second session as compared to the first session (62 ms). Interestingly, the interaction between session and relationship was significant by participants only, $F_1(1,39) = 5.012$, $p < .05$, partial $\eta^2 = .11$, $F_2(1,29) = 2.70$, $p = .111$, n.s. This reflected a facilitation priming effect for the second session (16 ms, $p = .02$) while null effect for the first session (6 ms, n.s.). More, a significant interaction between prime frequency and relationship was observed by participants, $F_1(1,39) = 10.417$, $p < .01$, partial $\eta^2 = .21$, $F_2(1,29) = 1.48$, $p = .234$, n.s. This reflected a facilitation priming effect for the low frequency prime condition (17 ms, $p < .01$) while no effect for the high frequency prime condition (5 ms, n.s.). A final result was the interaction between group, prime frequency and relationship, which almost reached significance in the participant analysis, $F_1(1,39) = 3.890$, $p = .056$, partial $\eta^2 = .09$, $F_2(1,29) = 1.75$, $p = .20$, n.s. This reflected that the facilitation priming effect observed for the low frequency prime condition, as compared with the null priming effect for the high frequency prime condition, was significant for the Grade 8 children only. No other effect was significant, all *F*s < 1, n.s.

Table 10. Mean reaction times in ms and percentages of errors in the adult group (above) and Grade 8 children (below) according to session (first session vs. second session), prime frequency (high frequency primes vs. low frequency primes), and relationship (related vs. unrelated).

	Adult participants			
	First session			
	High Frequency prime condition		Low Frequency prime condition	
	Unrelated	Related	Unrelated	Related
Reaction times (ms)	628 (44)	645 (37)	637 (40)	648 (60)
Errors (%)	2 (4.6)	3 (6)	5.4 (7)	4 (6.9)
	Second session			
	High Frequency prime condition		Low Frequency prime condition	
	Unrelated	Related	Unrelated	Related
Reaction times (ms)	582 (40)	572 (64)	599 (98)	574 (52)
Errors (%)	1.1 (3.7)	2.5 (5.6)	4.3 (6.8)	5.6 (8.9)
	Grade 8 children			
	First session			
	High Frequency prime condition		Low Frequency prime condition	
	Unrelated	Related	Unrelated	Related
Reaction times (ms)	728 (62)	754 (54)	753 (68)	720 (51)
Errors (%)	5.3 (7.4)	8.2 (10.6)	9.1 (9.4)	8.4 (11.7)
	Second session			
	High Frequency prime condition		Low Frequency prime condition	
	Unrelated	Related	Unrelated	Related
Reaction times (ms)	678 (90)	670 (75)	681 (67)	657 (73)
Errors (%)	4.9 (9)	5.3 (8.1)	7.3 (12.7)	6.7 (8.7)

Errors

There was a significant effect of group by participants (as a trend) and by items, $F_1(1,39) = 3.50$, $p = .069$, $F_2(1,29) = 8.612$, $p < .01$, which reflected more errors for the Grade 8 children as compared to the adults (2.9 %). There also was a trend for more errors in the first session as compared to the second session (.6 %) by participants only, $F_1(1,39) = 3.81$, $p = .058$, $F_2(1,29) = 2.392$, $p = .13$, n.s. Furthermore, the main effect of prime frequency was significant by participants only, $F_1(1,39) = 7$, $p < .05$, $F_2(1,29) = 1.133$, $p = .3$, n.s. This reflected more errors for the low frequency prime condition as compared to the high frequency prime condition (2.3 %). None of the other effects reached significance, all *F*s < 1, n.s.

Discussion

Experiment 2 examined the influence of French L1 prime words on the processing of English L2 target words. First, a significant interaction between session and relationship was found which reflected opposing effects depending on session. More precisely, a significant facilitation effect was found in the second session whereas a null effect was found in the first session. Second, an interaction between prime frequency and relationship emerged by- participants: this reflected a facilitation priming effect for the low frequency priming condition but a null effect for the high frequency prime condition. So, though an effect of a lexical variable associated with the L1 prime word, namely prime frequency, interacted with relationship and modulated the cross-language priming effect, no *inhibition* priming effect emerged. The fact that this lexical variable affected the pattern of results is already an evidence for cross- language interactions in my view. Yet, some explanation must be provided in order to account for the difficulty in observing an inhibition priming effect, an index of lexical competition. It is suggested that the contrast between French L1 prime and English L2 target frequencies may not have been adequate: English targets may have been too frequent and thus too quickly accessed to leave time for inhibition from French prime competitors to arise. This interpretation is supported by the observation that, in both adults and Grade 8 children, first session reaction times in experiment 2 (i.e., a lexical decision task in English L2) were, surprisingly, 100 ms faster than reaction times in experiment 1a (i.e., a lexical decision task in French L1). Further studies examining various prime as well as target frequency conditions, as well as exploring the time course of inhibition at several SOAs should shed some light on these findings.

As also observed in the follow-up study 1 from experiment 1a, the significant interaction between prime frequency condition and priming effect adds another piece of evidence to support interaction between L1 and L2 lexical representations, confirming the role of prime/target relative frequency in inhibition priming effects (Segui & Grainger, 1990a). Globally, facilitation was found during the second session, while null effects were observed in the first session, possibly due to a mix of facilitation and inhibition effects, a pattern which is in line with Dijkstra et al.'s (2010) empirical findings and Grainger & Jacobs' (1999) theoretical account for long lag repetition effects in masked priming).

Summary

The present study was composed of two parts examining L2- to- L1 priming on the one hand –and L1- to- L1- and L1- to- L2 priming on the other hand. The aim was to test for language- nonselectivity in lexical access in L2 school learners by examining the extent to which lexical competition may be demosntrated across languages.

From L2- to- L1, two kinds of results pointed to an interaction of lexical representations across languages. First, a cross- language *inhibition* priming effect emerged for the adult participants, but not for either Grade 8 or Grade 6 children. This reflected longer reaction times for target words when preceded by related primes as compared to unrelated primes and this was hypothesized to reflect cross- language lexical competition. Second, the follow- up analysis 1 revealed that the *frequency* of the prime words affected the priming pattern for both children groups (Grade 8 and Grade 6 combined) and the adult group. Indeed, an interaction was found between prime frequency (High vs. Low frequency prime condition) and priming. For the adults, an inhibition effect was observed for French targets when preceded by High frequency prime words –significant as a trend- while null effect emerged when preceded by Low frequency prime words[20]. For the combined group of children, a null effect was observed for the High frequency prime condition while a significant facilitation effect emerged for the Low frequency prime condition –consistent for both L1- to- L1 and L2- to- L1. So, a clear cross- language inhibition priming effect only occurred for the adult group in both experiments 1a and 1b, and indicated language- nonselectivity in lexical access. For the children, no inhibition was observed; nevertheless, the influence of prime frequency indicated that prime words affected the recognition of target words from another language, an indicator of some interaction between the languages. From

[20] Note that the interaction between prime frequency and priming effect led to awkward results in the L1- to- L1 priming direction.

L1- to- L2, no inhibition emerged in either group. Yet, again, an interaction between prime frequency and priming, indicating a facilitation priming effect for the Low frequency prime condition as compared to a null effect for the High frequency prime condition, illustrated the influence of a prime variable on recognition of the target word.

Several explanations were suggested in each experiment in order to explain the absence of a clear- cut inhibition priming effect, especially among the children. The extent to which the pattern of results reflect characteristics of the study – word frequency, length of words, SOA or a combination of interacting variables- or the organisation of the lexicon remains unclear and further studies would be needed. Indeed, according to BIA and BIA+ models, proficiency effects can be understood via manipulations of L2 word frequency. Proficiency effects observed by Bijeljac- Babic and colleagues (1997) were successfully simulated by the BIA model by decreasing L2 word frequency –note that no top- down activation from language nodes to word nodes was needed. Yet, a recent theoretical proposal from Grainger, Midgley & Holcomb (2010) on vocabulary acquisition in late L2 learners –who learn in a school context- suggests that lexical competition across words from different languages could emerge after some time of exposure to the L2, once the L2 lexicon grows in autonomy in relation to translation equivalents from L1 –and makes direct connections to the semantic level. The focus of the present developmental extension to BIA was on the links between lexical and semantic forms and this particular mechanism –cross- language lexical competition- was unfortunately not very specified. It could therefore be that some time of exposure to the L2 is necessary before any cross- language lexical competition emerges. Note that this is not in line with observations from artificial language learning studies which indicated a very fast emergence of lexical inhibition between the newly acquired pseudoword and the existing lexicon (Bowers, Davis & Hanley, 2005; Gaskell & Dumay, 2003).

This study also underlines the difficulty in manipulating both within- and cross-language factors that are known to affect visual word recognition in the masked priming paradigm (see Kinoshita & Lupker, 2003 for a review on these variables and Li, 2002 for a reflection on this dilemma in bilingual literature). The study also shows that cross-language lexical competition is harder to observe in L2 school learners as compared to highly proficient bilinguals (Bijeljac- Babic et al., 1997; Dijkstra et al., 2010; van Heuven et al., 1998), an observation in line with the null effects reported in previous studies in comparable populations (Bijeljac- Babic et al., 1997; van Heuven et al., 1998). A recent study by Lemhöfer et al (2008) has actually shown that cross- language orthographic neighbourhood effects may only be found in particular studies whose design is especially created for this purpose – by keeping constant all other variables that could affect the data. Indeed, using a multiple regression methodology and using a large set of English (L2) words in a lexical decision task, they showed that the only cross- language variable that affected lexical decision reaction times was the cognate status of words. No cross- language orthographic neighbourhood effect emerged in this study. Given this recent analysis, and the fact that lexical competition has not been shown yet in monolingual children, our difficulty in observing *inhibition* priming effects is not so surprising. Nevertheless, the fact that a lexical variable affecting a prime word in one language, namely prime frequency, influenced target recognition in another language seems to be an appropriate indicator of cross- language interactions. This prime frequency effect in inhibition priming can easily be understood within the BIA model of visual word recognition (Dijkstra et al., 1998, 2002). The more frequent the prime word, the more inhibition it can send to its neighbour word, among which figures the target word. Though inhibition priming effects in the masked priming paradigm were first shown to be stronger in the case of high frequency as compared to low frequency primes (Segui & Grainger, 1990), one recent study by Nakayama, Sears and Lupker (2008) revealed that this prime frequency effect actually depended on primes' and targets' neighbourhood size. In the case of words with a large neighbourhood size, the authors showed that an inhibition priming effect was observed no matter the prime frequency (experiments 1 and 2); it was only for those words with low neighbourhood size that prime frequency influenced the degree of inhibition priming (experiment 3). This factor of prime and target neighbourhood size was not controlled –and could probably not be- in the present study and investigating its role in the case of bilingual visual word recognition goes beyond the focus of the present study.

The direction of the priming effect was also shown to interact with the number of target presentations. Indeed, the design of the present study implied that participants saw each target word twice – once preceded by its related prime word, the second time by its unrelated prime word. In experiment 2, a facilitation priming effect was observed in the second session while a null effect was reported in the first session. Though the variable of "session" is not commonly reported in statistical analyses in masked priming studies in monolingual word recognition, its interaction with the priming effect was already reported by Dijkstra et al (2010) in a bilingual study and can be explained within monolingual activation- based models of word recognition (see previous discussions and Grainger & Jacobs, 1996, 1999).

Another effect merits some more discussion: in experiment 1a, reaction times were longer in the different- language priming condition, that is L2- to- L1 priming, as compared to the same- language L1- to- L1 condition. This effect is similar to the well-known language switching effect, which was found in the lexical decision task, and refers to the longer latencies when the previous item is of different language as compared to when it is of same- language (Beauvillain & Grainger, 1987; Orfanidou & Sumner, 2005; Thomas & Allport, 2000).,The locus of this effect has received different interpretations, one of which can be termed as “lexical”. This “lexical” interpretation can easily be explained within the BIA model. In addition to the representational function of language nodes (language membership), these also have the role of (de)activating words from the nontarget language. The language switch cost is therefore due to the relative deactivation of the language Y – and corresponding words- after having processed language X. Another interpretation of the switching cost effect lies outside of the lexicon (Green, 1998; Thomas & Allport, 2000; Von Studnitz & Green, 1997) and is the one adopted by the BIA+ model. Each language is supposed to be linked with a specific task schema, whose purpose is to link outputs generated by the lexicosemantic system from the specific language to the responses to be generated. Task schemas are supposed to compete in that when one task schema is activated for a given language, the one for the other language is inhibited. Switch costs can be explained by the need for changing task schemas and recovering from the previous inhibition. The fact that this language switch effect was obtained in the masked priming paradigm where primes were very briefly presented (i.e., during 57 ms) and followed by a mask, and where targets were of one language uniquely, would tend to support the “lexical” locus of the effect given that it is hard to imagine that different task schemas would be used in such a design. This is the interpretation made by Chauncey et al. (2010) who found such an effect in an ERP paradigm. Note that the temporal course of this effect actually varied according to the target language (earlier onset when the target was in L2). Though not the focus of the present study, the experimental results reported here would seem to support the initial BIA interpretation of language switch effects as reflecting the influence of language nodes in determining the relative activation of words from a language. Given the study was not specifically designed to test these divergent interpretations, a note of caution should be inserted by acknowledging that both processes could possibly participate in the language switch effects found in the literature and that both interpretations may not be mutually exclusive.

A final result concerns the observation that cross- language inhibition priming effects in adults (experiments 1a and 1b) emerged regardless of what the participants were told about the relevance of the nontarget language. This relates to the previous comment on task schemas and asks to what extent non- linguistic factors such as participants' expectancy affects the language- nonselective lexical system. According to Grosjean (1998, 2000), attentional factors such as expectancy or recent language exposure should modulate the relative activation of a bilingual's languages. Another view defended by the BIA+ model by Dijkstra & van Heuven (2002) is that non-linguistic factors do not affect the identification system per se, but may modulate the task/ decision module. In the present experiment, language- nonselectivity was found when participants knew about the relevance of the nontarget language –which possibly increased the resting levels of this nontarget language- as well as when participants were in a pure monolingual mode (experiment 1b). Though a similar word recognition mechanism emerged in both studies, it should be noted that participants were much faster in the monolingual mode compared to the more "bilingual" mode. This finding strongly relates to those from van Wijnendaele (2002, reported by Brysbaert, van

Wijnendaele & Duyck 2002) who found in a L2- to- L1 phonological priming paradigm –using brief prime *and* target exposure- that instructions –manipulated as in our study- did not modulate the priming effect at all. As in the present study, they found though that participants from the “bilingual” mode made more target identification errors than those from the “monolingual” mode. Note, however, that these findings were apparently not successfully replicated by the team. So, as postulated by the BIA+ model, this non-linguistic factor did no directly affect the identification system per se but did modulate overall latencies –and possibly errors- in recognizing target words.

In all, the present study was designed to examine language- nonselectivity in lexical access by measuring cross- language orthographic neighbourhood effects. This principle of lexical organisation across languages was shown to be functional in the adult group, though these participants were probably of lower proficiency and exposure than the high proficiency bilinguals that have commonly been tested in the literature. In the Grade 8 and Grade 6 groups who had respectively two years and only several months of English as a L2 learning, some hints of cross- language interactions were observed, namely prime frequency effects, but no clear- cut lexical competition emerged in these participants.

Chapter 1. Intermediate Summary.

A brief summary is provided here in order for the reader to keep in mind what has been observed, and to help in comprehending the studies that follow. Up to now, it was shown in Study 1 that orthographic priming, and particularly identity and form priming effects, could be demonstrated in a L2 lexical decision task among Grade 8 children and adults who have learned English for two and seven years, respectively. Orthographic representations in L2 could be considered to be fine- tuned as early as after two years of English (L2) learning and this level of tuning did not apparently vary according to the orthographic typicality of the words –see though exploratory analyses on the role of graphemic complexity. This study also revealed that English non- specific words were processed faster than English specific words, an effect which was significant for the adult group only. The next two studies aimed to assess the language- nonselective lexical access hypothesis in several groups of L2 school learners, an issue that has commonly been tested in highly proficient bilinguals. Study 2 tested a group of Grade 8 children in a L2 lexical decision task and examined the processing of cognate words. This study revealed the unexpected finding of an *inhibition* cognate effect, which was hypothesized to reflect decision bias when faced with the ambiguity of language membership. Note that, again, an orthographic typicality effect reflecting a facilitation effect for English- non- specific as compared to English specific words was observed. Given the possible influence of decision biases in processing cognates, another study was conducted to assess the language- nonselective lexical hypothesis by testing cross-language orthographic neighbourhood effects. Globally, though language-nonselectivity could be demonstrated in the adult group – especially from L2- to- L1-, but the evidence for the children (Grade 8 and Grade 6) remained quite sparse. Though a cross- language inhibition priming effect could not be found in these groups, the observation of an interaction between prime frequency and priming –see follow- up study 1 and experiment 2- did point to some degree of interaction across the two lexicons.

In terms of theoretical contributions, our studies point for the need to examining developmental mechanisms that could affect language- nonselectivity both at the identification and the task/decision levels (Grainger, Midgley & Holcomb, 2010; Jacquet & French, 2002; Thomas, 2002). More studies could probably be conducted in order to further test the language- nonselectivity lexical access hypothesis in these groups of L2 school learners. Cognate processing may not be the most adequate tool to test for this hypothesis since these words inherently belong to both languages and a pure monolingual mode cannot therefore be created. Future studies should test cross- language orthographic neighbourhood effects, either by modulating the design of the present experiments – constructing a L2- to- L1 experiment without the L1- to- L1 condition in order to have larger leeway to control all parameters, decreasing the SOA or the target frequency in experiment 2 – or by imagining new designs –manipulating cross- language shared neighbourhood for instance (i.e., form priming conditions such as *tame – RAME* where the English shared neighbour *game* may be activated and reduce the expected form facilitation priming effect). Yet, the observation by several researchers that cross- language lexical interactions may only concern a small number of words in a given language and arise in very constrained contexts (Lemhöfer et al., 2008; Vitetitch, 2012) made us consider L2 orthographic representation acquisition in a more global framework. Indeed, L2 words that may be concerned by nonselective lexical access at the level of orthographic representations are those words whose orthography is legal in French, either cognate words or cross- language neighbour words. Many words may have a very specific L2- orthography and often do not have any cross- language neighbours. This is particularly true in the English language which has many specific graphemes and orthographic sequences. The coming chapter aimed to assess to what extent these sublexical orthographic characteristics may affect L2 lexical access, and how these variables could be incorporated to bilingual models of visual word recognition, which to our knowledge, did not raise this issue. An orthographic typicality effect was already reported in Studies 1 and 2 and this was further investigated in Study 4. In addition, Study 5 focused on a particular sublexical level: the grapheme unit.

Chapter 2.

Sublexical orthographic representations

Study 4. Typicality experiment.

When learning a L2, individuals are faced with an orthography which may sharply contrast with the one in L1. This can occur when learning a L2 whose alphabet differs (i.e., Roman, Cyrillic, Arabic, Greek etc.) but also when languages share the same alphabet. As regard to French speakers who learn English as a L2, they are faced with several new graphemes (especially complex graphemes such as –oa, -th, -ght), but also larger typical orthographic sequences (highly frequent rimes such as –ight, -ough) and different graphotactics rules (such as the possibility for words to end with a final double consonant). The present study aimed to assess the extent to which orthographic typicality – as referring in this bilingual context to the typicality of L2 words with regard to the L2 – may be a relevant variable when examining L2 lexical access.

Orthographic typicality has been referred to in the monolingual literature as "the frequency of [their] component letter pairs (bigrams) and triplets (trigrams)" (Hauk, Patterson, Woollans, Watling, Pülvermüller & Rogers, 2006, *p*. 818). It has been shown to be an early orthographic marker in electrophysiological studies (Hauk et al., 2006; Rogers et al., 2004). For instance, Hauk and colleagues (2006) presented words and pseudowords that varied in terms of orthographic typicality (e.g., cart vs. yacht for typical and atypical orthography respectively) in a lexical decision task associated with the examination of ERP components. The results showed a significant typicality effect in the ERP pattern at around 100 ms (prior the lexicality effect observed at around 200 ms), but the behavioural effect revealed an interaction between orthographic typicality and lexicality. Though lexical decisions to pseudowords (i.e., "no" responses) were affected by typicality (faster responses for typical vs. atypical pseudowords), no effect emerged for the word targets. In addition, the effect of bigram frequency in lexical access has been controversial, especially when using the measure of mean bigram frequency for words (Andrews, 1992; Biederman, 1966; Rapp, 1992; Rice & Robinson, 1975). More recently however, Westbury and Buchanan (2002) pointed to the fact that minimal bigram frequency, namely the least frequent bigram in a given word, not taking into account either the length or position of the bigram when coding its frequency, was likely to be the best measure of orthographic typicality. They showed that words whose minimal bigram frequency was low were processed faster in a lexical decision task - orthographic neighbourhood size controlled- than words whose minimal bigram frequency was high. Contrary to orthographic neighbourhood effects which tend to emerge only for low frequency words (Andrews, 1992, 1999), this effect only emerged for high frequency words, not for low frequency words.

Although the influence of sublexical orthographic characteristics remains the subject of debate in the monolingual literature (see though the recent interest in letter frequency effects, New & Grainger, 2011 and special issue on this topic, Carreiras & Grainger, 2004), it seems reasonable to believe that it may have an impact on L2 visual word recognition. In the bilingual literature, Vaid and Frenck- Mestre (2003) showed that words with language specific bigrams (i.e., specific to the L2) were responded to faster in a language decision task (i.e., say whether the word is a L1, or a L2) as compared with words that did not have any language orthographic marker (i.e., non-specific to the L2). Language switching studies have also shown that the language switch cost (i.e., longer lexical decisions in processing a target word when the previous item belongs to a different language as compared to the same language) is greatly reduced when the target word contains specific orthographic markers from one language (Beauvillain & Grainger, 1987; Orfanidou & Sumner, 2005; but see Thomas & Allport, 2000). In L2 learners who have little proficiency, these L2 specific words could represent a real challenge given the novel nature of some orthographic sequences, and be processed differently in lexical access from words whose orthography is non-specific and legal in both languages.

The preceding Studies 1 and 2 did reveal an orthographic typicality effect in adults (Study 1) and in Grade 8 children (Study 2; though not in Study 1[21]): English non- specific words such as *house* were processed faster than language specific words such as *right*. While our goal was to investigate potential sublexical orthographic effects, the possibility that some lexical variable may have influenced these findings cannot be ruled out. Apart from being orthographically more legal in French (L1), English non- specific words are likely to have more French cross- language neighbours as compared to language specific words. Two measures of neighbourhood have been shown to have an impact on monolingual *and* bilingual word recognition: neighbourhood size and neighbourhood frequency. In L2 word recognition, a large cross- language neighbourhood has been shown to inhibit target word recognition (Grainger & Dijkstra, 1992; Grainger & O'Regan, 1992; Midgley et al., 2008; van

[21] The fact that the effect was observed inconsistently in the Grade 8 children may have been due to differences between the two experiments. The null effect was observed in the experiment that used four- to- five letter long words (Study 1), while the English non- specific facilitation effect emerged when word length varied from three- to- seven letters (Study 2). Moreover, the frequency of English non- specific target words was lower when the effect was observed (mean frequency: 129 o.p.m in Study 1 vs. 485 o.p.m. in Study 2).

Heuven, Dijkstra & Grainger, 1998) and the presence of a higher frequency cross-language neighbour word (i.e., as a masked prime) is likely to inhibit target word recognition (Bijeljac-Babic et al., 1997; Dijkstra et al., 2010). If difficulties in processing novel and language specific graphemes arise in our participants, a disadvantage in processing *English specific* words might be expected, as found in the previous studies. This could be due to the presence of low frequency letters or bigrams in English specific words (e.g., presence of uncommon patterns in French such as "k", "wr", “th”), and or specific complex graphemes which do not exist in L1 (e.g., -oa, -ght, th-). An alternative lexical view would posit that if lexical competition arises across languages, then *English non- specific* words would take longer to be processed. This could be either due to a large cross- language neighbourhood size (van Heuven et al., 1998) or to the presence of a French higher frequency neighbour (Bijeljac-Babic et al., 1997; Dijkstra et al., 2010; see Study 3 for further evidence in similar populations). In order to better disentangle lexical from sublexical factors –which are not mutually exclusive- in L2 orthographic typicality effects, several variables were then taken into account in a multiple regression on decision latencies: 1) lexical variables such as word frequency, cross-language neighbourhood size, cumulated neighbourhood frequency and frequency of the more frequent neighbour word and 2) sublexical variables such as bigram frequency –mean and minimal bigram frequency in French.

So, orthographic typicality effects were investigated in a study entirely devoted to this issue. Two new groups of Grade 8 children and adults participated in the study, as well as Grade 6 children who have only started to learn English as a L2. The materials were constructed so as to be comparable with those used in the within- language priming Study 1: four- to- five letter- long words and similar word frequency. In order to maintain a balanced orthographic typicality in the overall list composition, orthographic typicality was also manipulated for pseudoword targets. The hypothesis was that English specific pseudowords, whose orthographic components are more typical of the L2 such as *dirth*, should be less easily rejected than language non- specific pseudowords such as *roise*, because of their resemblance to English words, and therefore stronger lexical ambiguity. Indeed, language- specific pseudowords should mainly activate English lexical representations (i.e., neighbour words) while language non- specific pseudowords should activate both English and French lexical representations (i.e., given the larger number of cross- language neighbours). This phenomenon on the one hand, plus the top- down inhibition from the French language node to English lexical representations would explain the globally reduced lexical activity in the English lexicon for language non- specific words (see French & Ohnesorge, 1996 on the influence of cross- language orthographic neighbourhood on nonword processing).

In all, orthographic typicality effects in words and pseudowords were investigated in a lexical decision task in three groups of participants: Secondary Grade 6 and Grade 8 children and an adult university student group.

Method

Participants

The present experiment was performed by three groups of L2 learners. First, a group of 20 Grade 6 children (mean age: 11;4) participated in the study. They were recruited in a school in Paris (Collège Paul Valery). They were pupils from one same classroom for whom the English teacher was our contact for testing. The second group of participants was composed of 34 children attending Grade 8 Secondary school (mean age: 13;6). These children attended two different schools from Paris (collège Paul Valéry, Collège La Grange aux Belles). All children participants were learning English as a L2 since Grade 6 Secondary school. While Grade 6 children were only starting L2 learning (they had only a few months of classes), Grade 8 children had around two years and a half of formal English teaching at Secondary school. We should note that, though written exposure in L2 starts from Grade 6 Secondary, oral exposure is present since Elementary school and the degree of exposure strongly varies for each participant, due to the varying Elementary schools they came from. The third group of participants was composed of 24 University students (mean age: 23;7) who were recruited at the University of Lille North of France by one research assistant. They had studied English for at least seven years during Secondary school. None of them studied Modern languages at the University. They were all French native speakers and none of them had ever lived in a bilingual environment nor spoke English in their daily life.

Materials

A total of sixty English words were selected according to children textbooks of English as a L2 (see Appendix p 346). Among these, half were classified into the English non- specific condition while the other half were in the English specific condition. In each condition, half words were four- letter long, the other half five- letter long. The English non- specific condition referred to those English words whose orthographic constituents are legal in the French language. Oppositely, the English specific condition comprises English words that contain at least one sublexical unit (i.e., a bigram) that does not occur in French (e.g., letter sequences such as -tch, sh-). The two conditions were matched on length, number of syllables and frequency (all $t < 1$, n.s.), the latter measure being taken from the Children as a Printed Word Database (CPWD, Masterson et al., 2003). Details of these items' characteristics can be found in Table 11. In order to make sure that English non- specific words differed from the English specific words in terms of sublexical orthography in French, French bigram frequency of these English words was calculated using the Lexique Database (New et al., 2001). As can be seen in Table 11, the French mean bigram frequency of English language non- specific words was higher than for English language specific words, $t(58) = 2.94$, $p = .005$. As an even better measure according to Westbury & Buchanan (2002), the minimal bigram frequency was much lower for English specific words than for English non- specific words, $t(58) = 7.73$, $p < .001$, an observation that reflects that unusual orthographic patterns tended to occur in this condition. Finally, we made sure that all these words were typical of the English language: they were also matched on English mean positional bigram frequency of these words, a measure provided by the MCWord database (Medler & Binder, 2005), $t < 1$, n.s.

Table 11. Characteristics of the items in Study 4.

		Length	Frequency	Number of syllables	Mean Bigram Frequency in French	Minimal Bigram Frequency in French	Bigram Frequency in English
Words	English specific	4.50	369.77 (409)	1.13 (.35)	616 (466)	52 (86)	2258 (1576)
	English non-specific	4.50	425.53 (532)	1.23 (.43)	965 (450)	441 (262)	2274 (1004)
Pseudo words	English specific	4.50			462 (231)	46 (82)	2158 (1281)
	English non-specific	4.50			900 (447)	343 (222)	1774 (968)

A total of sixty pseudowords were created for the purpose of the lexical decision task. They were created by changing one letter from one of the English items, all positions respected. Half were considered as English specific pseudowords whereas the other half was considered as English non- specific. These two categories were created based on the same criterion than for the target words, that is bigram frequency according to the French language. The French mean bigram frequency of English non-specific pseudowords was higher than for English specific pseudowords, $t(58) = 4.76$, $p < .001$ and the minimal bigram frequency was much lower for this latter condition as compared to the former, $t(58) = 6.88$, $p < .001$. All these pseudowords were typical of the English language in terms of English mean bigram frequency, $t(58) = 1.31$, $p = .20$, n.s.

Procedure

A fixation point was presented for 1 000 ms, followed by a forward mask of ######### for 1000 ms. The target word was then presented for 3000 ms or disappeared when a response was made. The participants had to perform a lexical decision task in English (L2). They were asked to press a button with their dominant hand when the word they saw was an English word or to press another button with their nondominant hand to decide that the target was not a real English word. Participants were asked to respond as quickly and accurately as possible. The session lasted around 15 minutes and was preceded by a training session which included 10 items. Testing took place in February and May 2010.

Results

Due to high error rates for many items in Grade 6 participants, this group was analysed separately from the other two groups. This can be explained by the fact testing took place in November, after only two months of L2 learning. In addition, we realized that a total of ten word targets (four English specific words and six English non-specific words) and eleven pseudoword targets (four English specific pseudowords and seven English non- specific) were bisyllabic items[22]. Given that this variable was likely to influence our data, these items were removed. A Levene test of homogeneity of variances confirmed that Grade 8 and adults participants could be analysed jointly, $F(1,55) < 1$, n.s.

Grade 8 children and adults

One participant from the Grade 8 group was removed due to high error rates (43%). In addition, seven words whose mean accuracy was less than 60% were removed. Reaction times higher than 2.5 standard deviations from the overall mean reaction times were removed (<1% of word data). Table 12 represents mean RTS and percentage of errors (and standard deviations) for word and pseudoword targets in Grade 8 and adult participants by orthographic typicality. An analysis of variance (Anova) was conducted on reaction times and errors on both participants (F_1) and items (F_2) analyses. Orthographic typicality was entered as a within-subject variable on the participant analysis, while group was entered as a between- subject variable. On the

[22] These bisyllabic words are marked with an asterisk in the appendix.

item analysis, group was entered as a within- subject variable while orthographic typicality was as a between-subject variable.

Words

Reaction times

The effect of group was significant, $F_1(1, 55) = 7.335$, $p < .01$, partial $\eta^2 = .12$, $F_2(1, 41) = 69.936$, $p < .001$. This effect reflected faster reaction times for the adult group as compared to the Grade 8 children group (73 ms). The effect of orthographic typicality was significant by- participants only, $F_1(1, 55) = 7.518$, $p < .01$, partial $\eta^2 = .12$, $F_2(1,41) = 1.082$, p = .30, n.s. This reflected faster reaction times for the English non- specific condition as compared to the specific condition (21 ms). The interaction between orthographic typicality and group did not reach significance, $F_1(1, 55) = 2.852$, $p = .10$, $F_2(1, 41) = 1.779$, $p = .19$, n.s.

Errors

The effect of group was significant, $F_1(1, 55) = 7.684$, $p < .01$, partial $\eta^2 = .12$, $F_2(1, 41) = 18.842$, $p < .001$ and reflected higher errors for the Grade 8 children as compared to the adult participants (7 %). The orthographic typicality effect was nonsignificant for either analyses, all *Fs* < 1, n.s., and neither was the interaction between orthographic typicality and group, $F_1(1, 55) = 2.477$, $p = .12$, n.s., $F_2(1,41) = 1.489$, $p = .23$, n.s.,

Table 12. Mean reaction times and errors (standard deviations) according to lexicality (words vs. pseudowords) and orthographic typicality (English non- specific vs. specific) for both adults and Grade 8 participants.

	Adults			
	Words		Pseudowords	
	English non-specific	English specific	English non-specific	English specific
Reaction times (ms)	688 (105)	725 (111)	910 (186)	900 (199)
Errors (%)	5.6 (10.2)	8.2 (9.1)	3.8 (6.2)	9.8 (7.3)
	Grade 8 children			
	Words		Pseudowords	
	English non-specific	English specific	English non-specific	English specific
Reaction times (ms)	775 (102)	783 (102)	902 (152)	903 (149)
Errors (%)	14.2 (11.9)	13.1 (8.6)	7.9 (8.2)	10.4 (8.4)

In order to better apprehend the locus of the orthographic typicality effect, a correlational analysis as well as multiple regression analysis were conducted in the reaction time data for both orthographic typicality conditions. Note that these analyses were conducted on all data, without averaging per participant (Stone, Vanhoy & Van Orden, 1997). For the English specific words, group was entered as a categorical variable while target frequency, mean French bigram frequency and mean minimal French bigram frequency were entered as continuous variables. For the English non-specific words, these same variables were entered in the analysis. Furthermore, some cross- lexical variables were added to the analysis: cross- language neighbourhood size, cumulated neighbourhood frequency and frequency of the most frequent neighbour word. The target words *fast* and *rain* were considered as outliers given their huge cross-language neighbourhood cumulated frequency –and high frequency neighbour- and were therefore removed from the English non-specific condition (see Appendix for further details). Results can be found in Table 13 and 14.

Table 13. Correlations between all stimuli characteristics and with reaction times (ms) for both English non- specific (above) and English specific (below) words.

		1	2	3.	4	5	6	7
Reaction times (ms)	1		**-.013**	**-.075**	.058	.03	-	-
Group	2	**-.015**		-.01	.014	-.005	-	-
Target freq.	3	**-.076**	-.007		-.023	**.147**	-	-
Mean L1 big. Freq.	4	.026	.013	**.369**			-	-
Mean L1 min. big. Freq.	5	.014	0	.038	**.57**		-	-
CL N- size	6	-.090	0.01	.051	**.185**	**.575**		-
CL cumulated N freq.	7	**-.125**	-.005	-.016	**-.528**	**-.203**	**.314**	
Most freq. CL neighbour	8	**-.084**	-.006	**.241**	**-.417**	**-.086**	**.179**	**.752**

Note. Target freq. = target frequency; Mean L1 big. Freq. = mean L1 bigram frequency; Mean L1 min. big. Freq. = mean L1 minimal bigram frequency; CL N- size = cross-language neighbourhood size; CL cumulated N freq. = cross- language cumulated neighbourhood frequency; Most freq. CL neighbour = most frequent cross- language neighbour.

Table 14. Multiple regression analyses for English specific and non- specific words on the reaction times.

	English specific words			English non- specific words		
	β	SE β	F	β	SE β	F
Group	.133	.029	20.25***	.155	.033	22.392***
Target freq.	-.081	.03	7.33**	-.098	.044	4.979*
Mean L1 big. Freq.	.057	.03	3.692’	.014	.057	< 1
Mean L1 min. big. Freq.	.039	.03	1.691	.024	.056	< 1
CL N- size				-.066	.049	1.808
CL cumulated N freq.				-.014	.063	5.155*
Most frequent CL N				.066	.060	1.215

Note. Values are presented in standardized regression coefficients (β) and standard errors (SE).

Target freq. = target frequency; Mean L1 big. Freq. = mean L1 bigram frequency; Mean L1 min. big. Freq. = mean L1 minimal bigram frequency; CL N- size = cross- language neighbourhood size; CL cumulated N freq. = cross- language cumulated neighbourhood frequency; Most freq. CL N = most frequent cross- language neighbour.

*: $p < .05$; **: $p < .01$; ***: $p < .001$. Note that ’: $p = .055$.

These exploratory analyses need to be taken with caution given the great complexity of the methodology of the multivariate analysis (Tabachnick & Fidell, 2006)[23]. Yet, they do yield some interesting observations on what may underlie the processing of L2 words. For both types of English words, word frequency was found to be a significant predictor of participants' reaction times. Correlational patterns also supported this finding (English specific words: $r^2 = -.08$, $p < .05$; English non- specific words: $r^2 = -.08$, $p < .05$) and showed that the more frequent the English words, the faster the reaction times.

The mean bigram frequency in French of these English target words almost reached significance for the English non- specific words, but surprisingly, the minimal bigram frequency in French of these words was nonsignificant for both types of words. So, English word processing did not seem to be affected by words' sublexical features according to French (L1). So, for the English specific words which had a L2 typical orthography, there was no account of the inhibition effect when compared to English non- specific words, in terms of a L2 specific sublexical orthography. Nevertheless, one lexical variable did affect the reaction times for the English non- specific words. The multiple regression analysis showed that cross- language cumulated neighbourhood frequency, that is the cumulated frequency of all French neighbours of an English word, also predicted significant variance in English non- specific word reaction times. As can be observed from the Table 13, the correlation between reaction times and cross- language cumulative neighbourhood frequency was negative ($r^2 = -.13$, $p < .001$) and revealed that the higher the cumulative frequency across languages, the faster the reaction times. Though only this variable emerged in the regression analysis, examination of the correlational pattern shows that the three cross- language lexical

[23] The choice of the relevant variables may strongly influence the results obtained. Problems of collinearity between the variables may also impact the statistical analyses.

variables correlated with each other. So, whatever the exact lexical variable that influenced our data is, the interesting point is the direction of the relationship, which could actually explain the orthographic typicality effect obtained.

Pseudowords

Reaction times

Neither effects of group of orthographic typicality nor the interaction between the two were significant, all Fs < 1, n.s.

Errors

The effect of group was significant by- items only, $F_1(1, 56) = 1.90$, $p = .17$, n.s., $F_2(1,47) = 6.764$, $p < .05$ and reflected that adults were more accurate than Grade 8 children (2 %). There also was a main effect of orthographic typicality significant by- participants, $F_1(1, 56) = 12.32$, $p < .001$, partial $\eta^2 = .18$ and as a trend by- items, $F_2(1,47) = 3.469$, $p = .069$, which reflected higher errors for the English specific as compared to non- specific condition (4 %). The interaction between orthographic typicality and group almost reached significance on the item analysis only, $F_1(1,56) = 2.12$, $p = .15$, n.s., $F_2(1, 47) = 3.478$, $p = .068$. This trend reflected that the orthographic typicality effect was stronger in the adults (6%, $p < .01$) than in the Grade 8 participants (2.5 %, $p = .12$).

Grade 6 children

Two participants were removed due to high error rates (respectively 79% and 50%). Only words whose mean accuracy was over 60% were kept, leading to only twenty- two words out of the initial sixty words. The matching on these words revealed to be satisfying since ten of these words were English non- specific while the remaining twelve were English specific condition. They were quite matched on length (mean English non- specific condition: 4.3, SD: .48; mean English specific condition: 4.67, SD: .49, $t(20) = 1.75$, $p = .095$) and on written frequency (mean English non- specific condition: 607, SD: .665; mean English specific condition: 626, SD: .518, $t(20) < 1$, n.s.). Results can be found in Table 13.

Words

Reaction times

The effect of orthographic typicality was significant, $F_1(1, 17) = 9.728$, $p < .01$, partial $\eta^2 = .36$, $F_2(1, 20) = 5.363$, $p < .05$. This effect reflected faster reaction times for the English non- specific condition as compared to the English specific condition (111 ms).

Errors

The effect of orthographic typicality was nonsignificant for either analyses, $F_1(1, 17) = 2.067$, $p = .17$, n.s., $F_2(1, 20) = 1.125$, $p = .30$, n.s.

As for the older groups, we aimed to conduct exploratory analyses on the participants' reaction times in order to investigate which stimuli characteristics could have influenced the results. Yet, no correlations were found between reaction times and any other variables, neither for English specific or English non- specific words. As therefore expected, no effect emerged in the regression analysis.

Table 15. Mean reaction times and errors (standard deviations) according to lexicality (words vs. pseudowords) and orthographic typicality (English non- specific vs. specific) for Grade 6 participants.

	Grade 6 children			
	Words		Pseudowords	
	English non-specific	English specific	English non-specific	English specific
Reaction times (ms)	919 (187)	1030 (267)	1097 (321)	1067 (306)
Errors (%)	12.2 (8)	16.2 (10)	10.9 (11)	16.2 (18.6)

Pseudowords

Reaction times

The effect of orthographic typicality was nonsignificant for either analyses, all Fs < 1, n.s.

Errors

The effect of orthographic typicality almost reached significance for both analyses, $F_1(1, 17) = 3.659$, $p = .072$, $F_2(1,47) = 3.462$, $p = .069$. This reflected a trend for higher error rates for English specific pseudowords as compared to for English non-specific pseudowords (5 %)

Discussion

The present study aimed to test for orthographic typicality effects in a L2 lexical decision task in three groups of L2 school learners: Grade 6 and Grade 8 Secondary school children and adults. An orthographic typicality effect was found in reaction times in the adults and Grade 8 combined, as well as in the Grade 6 children[24]: an advantage in the reaction time data was found for English non- specific words (*house*) as compared to the English specific words (*right*). This experiment enables to shed some light on the previous results from Study 1 and 2. In Study 1, an orthographic typicality emerged for the adults, but not for the Grade 8 children. In Study 2 where only Grade 8 children were assessed, an orthographic typicality effect emerged. So, the pattern for the Grade 8 children was a little unclear. Though the effect was numerically larger in the adult group (37 ms) than in the Grade 8 children group (8 ms), no interaction between orthographic typicality and grade was found in the present study. Yet, it is not possible to conclude here that this orthographic typicality effect increases with the level of proficiency/ exposure given that the Grade 6 children also obtained a large facilitation effect for the English non-specific words (111ms). The difficulty in observing a clear-

[24] Note that checks were made as to whether the pattern found in the Grade 8 and adults combined could also emerge when considering the same items used for the Grade 6 children. When using the same items a grade effect was significant, $F_1(1,55) = 6.228$, $p < .05$, $F_2(1,20) = 40.267$, $p < .001$ reflecting faster reaction times for the adults as compared with the Grade 8 children. Importantly, the typicality effect was also significant by- participants only, $F_1(1,55) = 5.648$, $p < .05$, $F_2 < 1$, n.s.. This reflected again an advantage for the English non- specific words (705 ms) as compared to the English specific words (726 ms). The interaction did not reach significance, all Fs < 1, n.s. Yet, we should report here that the facilitation effect was of 25 ms for the adults and of 12 ms for the Grade 8 children.

cut orthographic typicality effect in the Grade 8 children remains problematic. One possible explanation is that this group of participants is heterogeneous and that competing effects tend to flatten the typicality effect. As compared with Grade 6 children who have all just started L2 learning and adults who have all followed a long education (they have all followed English classes until A- level), the Grade 8 group is composed of children of varying future educational profiles.While some of these children may drop out school at the legal age of sixteen years old, others may continue up to higher educational levels. Taking into account more variables that measure participants' orthographic skills and assessing a group of highly proficient bilinguals could also help in understanding the profiles of the present participant groups and the mechanisms underlying this effect.

Another relevant finding was that all participants made more errors when rejecting English specific pseudowords as compared to English non- specific ones. This result shows that participants were more confused when the fake words had an orthography which can be considered as L2- specific according to French learners' point of view as compared to when fake words resembled their L1. This should be controlled in the future in a group of English monolinguals to check that this effect was not an artefact of the materials – such as the influence of non-controlled within- language neighbourhood variables. Of relevance here is also the fact that this effect only emerged as a trend for the Grade 6 children, who have had less exposure to the L2. Overall, this result is in keeping with the data from Commissaire et al (2011) who used a sublexical orthographic processing task (i.e., which is more word- like? *dake* or *daik*), and who showed that French learners of English as a L2 had an implicit knowledge of English orthography from Secondary Grade 6, albeit it at a lower level than was present among older Grade 8 children.

So, while sublexical effects during lexical access in monolinguals are still a matter of debate, an orthographic typicality effect clearly emerged in the present study, reflecting the importance of the characteristics of the orthographic structure in L2 word processing. While very few studies manipulate this variable in bilingual research (Beauvillain & Grainger, 1987; Orfanidou & Sumner, 2005; Thomas & Allport, 2000; Vaid & Frenck- Mestre, 2002), the influence of orthographic typicality does not seem surprising given the big challenge L2 learners must face when dealing with a set of graphemes and larger orthographic sequences which are legal in the L2 only. The extent to which this effect represents a facilitation effect from those words that have a more typical orthography according to L1 statistics or an inhibition effect from words that have a very L2 specific orthography cannot be answered unless a baseline group is created[25]. This baseline or "neutral" group with regard to orthographic typicality would be relevant only if orthographic typicality is considered as a continuum –more or less specific to a language- and not as an all- or- none variable –specific to the L2 if it contains an illegal orthographic pattern according to L1 or non- specific if it does not.

The locus of the effect was also of interest in this study. If difficulties in processing novel and language specific graphemes arose among the participants, a disadvantage in processing English specific words would be observed. Alternatively, if cross- language orthographic neighbourhood influenced L2 word recognition, then

[25] Note that this type of neutral word can also be created when taking into account cross- language orthographic neighbourhood. For instance, Grainger & O'Regan (1992) used the terms "patriots" for those words that had more neighbours in the target language, "traitors" for those words that had more neighbours in the nontarget language, and "neutral" words for those words that had equal number of neighbour words across the target and nontarget languages.

English non- specific words would be disadvantaged. The finding of longer latencies for English specific as compared to non- specific words seems to suggest that the locus of this effect was sublexical, and that the effect was due to the presence of orthographic sequences that are illegal in L1 in English specific words, leading to an additional cost during lexical access. However, an exploratory regression analysis may moderate this interpretation. If the locus of the effect was sublexical, it could have been expected that mean bigram frequency in French would predict decision latencies on English specific words, an effect which did not emerge. Indeed, words that had less L1 representative orthography –lower mean bigram frequency or minimal bigram frequency- could have taken longer to be processed. In addition, an effect of cross- language cumulative neighbourhood frequency predicted significant variance in English- non- specific word processing: English words which had more frequent neighbourhood in French –a variable which strongly correlated with the frequency of the more frequent neighbour word, $r^2 = .75$ and to a lesser extent, with neighbourhood size, $r^2 = .31$- were processed faster than those with a lower frequency cross- language neighbourhood. The locus of this effect could be considered as lexical –note though that this lexical variable also correlated with bigram frequency sublexical variables- but it does not correspond to the hypothesis made earlier. Based on the IA (McClelland & Rumelhart, 1981) and BIA+ (Dijkstra & van Heuven, 2002) models of visual word recognition, it is assumed that neighbourhood, especially frequent neighbours, would exert *inhibition* on target processing due to the lexical competition that is hypothesized in this framework. The finding of a *facilitation* of cross- language neighbourhood seems apparently contradictory for both above- mentioned models and empirical data from monolinguals (Nakayama et al., 2008; Sears, Hino & Lupker, 1995) and bilinguals (Bijeljac- Babic et al., 1997; Midgley et al., 2010; van Heuven et al., 1998). However, neighbourhood effects in the lexical decision task have actually been revealed to be quite inconsistent across studies and some researchers such as Andrews (1989, 1992) did find neighbourhood facilitation effects.

In this respect, a few limitations in this study should be acknowledged that demand an even deeper interpretation. First, while cross- language neighbourhood measures were considered, the number of L2 neighbour words that our participants knew was not. This within- language variable has been shown to affect lexical decisions in highly proficient bilinguals (Lemhöfer et al., 2008; Midgley et al., 2010; van Heuven et al., 1998) and it was expected that the low level of proficiency of L2 school learners would make this control variable less relevant. However, some L2 neighbour words of the target words used in this study may have been frequent enough to be known (see rime neighbours such as *night*, *light* or *right*) and could have influenced the findings. A second limitation comes from the multiple activations that may be reported in the lexical decision task. Given the presentation time of the target, there is time for different sources of information to get activated during the lexical decision task: orthographic but also phonological or semantic features of the words (Gibbs & Van Orden, 1998; Plaut, 1999). Specifically, a phonological hypothesis could also be assumed when manipulating words' orthographic typicality. If orthography- to- phonology correspondences take longer to be activated for novel L2 specific graphemes, then a disadvantage for English specific words would be expected. Indeed, a word such as *night* not only contains L2 specific orthography –the presence of "ght"- but also novel and specific correspondences to phonology – "ght" → /t/ - that must be acquired when learning English. Again, an alternative hypothesis is also possible given the cross-language inconsistency of L2 non- specific grapheme- to- phoneme correspondences. English non- specific words whose orthography is more legal in French may contain orthographic sequences for which phonological counterpart is different across French and English. For instance, the word *house* contains the grapheme "ou" which has a different phonological mapping: "ou" → /u/ in French but "ou" → /aʊ/ in English. Note that within- language print- to- sound inconsistency (e.g., "ou" in English maps onto /aʊ/ but also /ɒ/ as in "cough" or /ʌ/ as in "touch") raises even more problems when learning a L2, especially when learning the English language, which is particularly inconsistent (Ziegler et al., 1997). Third, another limitation from this experiment comes from the observation that orthographic sublexical effects arise very early during word processing (around 100 ms after stimulus onset for orthographic typically according to Hauk et al., 2006) and it may turn out to be difficult to be observed in the lexical decision task using behavioural data only. Indeed, the influence of orthographic sublexical effects in the lexical decision task remains unclear in monolingual literature (Hauk et al., 2006; Lemhöfer et al., 2008; Westbury & Buchanan, 2002) while these low- level effects more easily arise in tasks focused on a letter level (i.e., grapheme effect in the letter detection task, Rey et al., 2000; letter frequency effect in the letter/nonletter discrimination task or in the letter search task, New & Grainger, 2011; Pitchford, Ledgeway & Masterson, 2008 respectively).

In all, an effect of orthographic typicality was reported for all groups of participants, but the precise locus of this effect remains unclear. While the advantage for English non- specific words as compared to English specific words seems in favour of an orthographic sublexical account, exploratory analyses revealed that the effect could also be accounted by a lexical variable, namely cross- language orthographic neighbourhood. Several limitations of the lexical decision task such as the multiple information sources to be- activated, or the difficulty to capture early sublexical effects, are likely to be solved by the use of electrophysiological data (see Hauk et al., 2006 for the use of ERP recordings) or tasks that better tap sublexical effects such as the letter detection task (Rey et al, 2000), or the letter/ nonletter discrimination task (New & Grainger, 2011). Yet, the concept of orthographic typicality could also be regarded as too vague. An interesting observation mentioned by Orfanidou & Sumner (2005) is that even L2 specific words contain both specific and non- specific elements. For instance, the English specific words *night* contains language specific sequence of "ght" but language non- specific sequence of "ni". By assessing Greek- English bilinguals, these authors were able to somewhat overcome this barrier: language specific words were composed of letters that only occur in one of the languages only[26] (i.e., *ΣΙΩΠΗ*, silence; *GLOVE*) while language non- specific words contained letters that occur in both languages (i.e., *KOPH*, girl; *MAKE*). It remained, however, difficult for the authors to create a complete language specific condition: this condition contained only language specific *consonants*, but they could not avoid the presence of language- shared *vowels*. In addition, the concept of typicality is a little confusing given it is not clear at what sublexical orthographic level this should be considered. Is a word language specific because of the presence of low- frequent letters, language specific graphemes, or even larger units such as rimes?

Given these observations, the decision was made to focus on a more precise

[26] Only some letters were language specific in the language specific condition given that most vowels are shared between the two languages (A, E, I, O).

sublexical level, namely the grapheme level, and to use a task that has been reported to capture such sublexical effects, the letter detection task. Note that the phonological hypotheses discussed above were further raised in Studies 6 and 7 from Chapter 3.

Study 5. Grapheme complexity.

Graphemes may be an interesting unit to investigate when one aims to study more precisely sublexical orthographic coding in L2 visual word recognition. Graphemes, the written correspondent of oral phonemes (Berndt, Reggia & Mitchum, 1987), may be constituted of only one letter, namely “simple graphemes”, or two or more letters, also called “complex graphemes”. Given French and English share the same Roman alphabet, simple graphemes, that is letters, are equivalent in the two languages (though they may differ in frequency, an issue that won't be addressed here). French native speakers who learn English as a L2 are also confronted with multiple complex graphemes, some of which already exist in French. For example, the complex graphemes “ou” or “ai” found in words such as *hour* or *hair* are also very common complex graphemes found in the French language (i.e., in highly frequent words such as *jour* meaning “day” or *maison* meaning “house”). Note however that the grapheme- to-phoneme correspondences associated with these two examples are inconsistent across languages (i.e., the grapheme “ou” in French corresponds to the phoneme /u/ and the grapheme “ai” to the phoneme /è/). Alternatively, the English language contains multiple complex graphemes that can be considered as language- specific, such as “ea”, “th” or “ow”.

In the last decades, a few studies have shown that graphemes are a relevant unit in orthographic coding. Pseudowords that contained complex graphemes such as *fooph* were named more slowly that those that contained simple graphemes such as *frolp*

(Joubert & Lecours, 2000; Rastle & Coltheart, 1998). A similar effect was found using a perceptual identification task for high and low frequency words containing either complex or simple graphemes (Rey & Schiller, 2005; see also Rey, Jabobs, Schmidt-Weigand & Ziegler, 1998). Interestingly for the present study, Rey, Ziegler and Jacobs (2000) showed that detecting a letter embedded in a complex grapheme (i.e., detecting the letter "A" in the word *beach*) was slower than detecting this same letter in a simple grapheme (i.e., such as the "A" in the word *black*). This effect was replicated in English and French (experiments 1a and 1b, respectively) and with high and low frequency words. These effects have been interpreted as reflecting the fact that graphemes are a functional perceptual unit: the grapheme complexity effect would occur because complex graphemes composed of multiple letters such as "ea" compete with their constituent single- letter graphemes "e" and "a". This competition would therefore slow down word identification. The absence of an interaction between the effect and word frequency adds evidence for the sublexical locus of this effect. Importantly, this graphemic complexity effect was shown to be independent of phonemic effects, although these also contribute to the complexity effect. For example, Rey et al. (2000, experiment 2) showed that the graphemic complexity effect was still present when manipulating phonemic similarity. Longer latencies for words containing complex graphemes such as *beach* could indeed have resulted from the fact the grapheme "ea" does not sound like the letter to be detected "A". By manipulating orthogonally graphemic complexity and phonemic similarity (i.e., giving rise to four categories: simple grapheme/phonemically similar to the letter: *slope*; complex grapheme/phonemically similar: *float*; simple grapheme/phonemically dissimilar: *prove* and complex grapheme/phonemically dissimilar: *cloud*), the authors showed that both effects did contribute to the findings, but that a grapheme complexity effect still emerged for the phonemically similar items (see also Rey & Schiller, 2005 for further evidence for the independence of both orthographic and phonological mechanisms).

While the Interactive Activation model (McClelland & Rumelhart, 1981) only postulated a sublexical *letter*- level, the Dual- Route Cascaded model (Coltheart et al., 2001) assumed that the grapheme was functional during the print- to- sound conversion only, that is, no orthographic grapheme level per se was included in the model. The most recent modifications made to these two models have however included a stage dedicated to grapheme parsing which is independent of the grapheme- to- phoneme conversion mechanism, called the two- layer associative network (TLA, Houghton & Zorzi, 2003). Indeed, the Bimodal Interactive Activation Model or BIAM presented Figure 2 (Diependaele, Ziegler & Grainger, 2010; Grainger & Holcomb, 2009; Grainger & Ziegler, 2011) as well as the Connectionist Dual Process model or CDP+ (Perry, Ziegler & Zorzi, 2007) now integrate local representations for graphemes. In these models, a grapheme level has been proposed between sublexical orthographic units (letters) and sublexical phonological units (phonemes). Though the grapheme- to- phoneme conversion module is similar to what appeared in former models (see Dual- Route Cascaded model, Coltheart et al., 2001), the novelty here lies in the inclusion of a graphemic buffer whose specific role is to convert letters into graphemes, and therefore compute grapheme identities and ordering. Following Houghton & Zorzi (2003), the mechanism of the graphemic buffer proposed in BIAM and CDP+ represents graphemes as local representations which are grouped following a graphosyllabic structure such as Onset – Vowel – Coda (for a precise description, see Perry et al., 2007). For each of these subsyllabic representations, graphemes are allocated several position- specific slots: three slots for the onset, one for the vowel and four slots for the coda. As an example, the word *check* would be represented as CH - - E CK - - - where CH takes the first onset slot (followed by two empty slots), E takes the vowel slot and CK takes the first coda slot (followed by three empty slots). Grapheme parsing is considered as a serial mechanism that operates from left to right which is seen as an attentional window that moves across the letters and converts them into graphemes. Thus, graphemes have been treated as sublexical orthographic units just like letters or syllables. Though graphemes are also functional units relevant to the orthography- to- phonology conversion, grapheme parsing has been described as an independent orthographic mechanism that would operate prior to the conversion to phonological units (Joubert & Lecours, 2000; Perry, Ziegler & Zorzi, 2007).

In the field of sublexical orthographic coding in a L2, only studies interested in sublexical orthography -to -phonology conversion using the masked phonological priming paradigm (Brysbaert, van Dyck & van de Poel, 1999; Brysbaert & van Wijnendaele, 2003; Duyck, Drieghe, Diependaele & Brysbaert, 2004; van Wijnendaele & Brysbaert, 2002; see Byrsbaert & Dijkstra, 2006 for a review on these findings) or examining the role of "orthographic typicality" (Grainger & Beauvillain, 1987; Vaid & Frenck- Mestre, 2002) appear to have been published. No studies have attempted to examine the issue of grapheme coding *per se* during L2 word recognition that I am aware of. Note however that the BIA+ model (Dijkstra & van Heuven, 2002) now considers the different sublexical units that may be relevant in word recognition by labelling this level as "sublexical orthographic level" and not as a "letter level" anymore, as in BIA (Dijkstra, van Heuven & Grainger, 1998). Though the authors mentioned the current attempt to model an intermediate sublexical level which would consider Onet- Nucleus- Coda units, there is however no more precision about these sublexical unit and whether they may be coded differently in a L2, especially when dealing with L2 specific units.

The present experiment therefore aimed at examining how graphemes are coded in a L2, and especially complex graphemes that are specific to the L2. In highly proficient bilinguals, sublexical orthographic processing in the L2 could be similar to those mechanisms used in L1, given that participants have had a long exposure to the language. Nevertheless, this issue seems of particular relevance when examining L2 learners, who have to learn a large range of new graphemes that only occur in the L2, but also to deal with graphemes that are also legal in their L1. Indeed, L2 learners are confronted by a large set of new graphemes when learning a new language and this is particularly the case when learning an opaque L2 such as the English language (Seymour, Aro & Erskine, 2003) whose orthography- to- phonology correspondences are inconsistent and for which many complex graphemes must be learned (e.g., -ea, -ee, -ow, -sh, -th). Simple and complex graphemes were presented here in a target detection task, as initially proposed by Rey and colleagues (2000). English specific and non-specific complex graphemes were presented in order to examine whether subtle differences in processing these graphemes could be observed, possibly depending on L2 exposure, which would reflect the quality of grapheme coding. Three groups of participants (i.e., adults, Grade 8 and Grade 6 children L2 school learners) had to detect whether a predetermined letter was present or absent from a following English (L2) target word which was presented very briefly. Three categories of letter- present trials were used: 1) the letter appeared in a simple grapheme such as the letter “a” in the word *bath*, further termed the “simple grapheme condition 1”; 2) the letter was embedded in a complex language non- specific grapheme such as the letter “a” in the word *hair*, further termed as “complex non- specific grapheme condition 2” and 3) the letter was embedded in a complex language specific grapheme such as the letter “a” in the word *ease*, further termed as “complex specific grapheme condition 3”.

First, it is predicted that graphemes may be coded as such as early as in Grade 6, given recent finding of Marinus & De Jong (2011) in monolingual children aged ten years old. The rationale was that the grapheme could be considered as a sublexical orthographic unit if a difference emerged between simple grapheme and complex grapheme conditions. If the target letter was detected more slowly when embedded in a complex grapheme as compared to when corresponding to a simple grapheme, this would reflect that graphemes are coded as an orthographic unit, different from a letter level.

Second, the graphemic analysis process itself was examined by comparing complex English non- specific from specific grapheme coding. English non- specific complex graphemes occur in French and should be processed as graphemes in our population, given their L1 reading exposure. If latencies for English specific graphemes were faster than for English non- specific graphemes, this would reflect the low level of knowledge that participants had of these language specific graphemes. This could be the case for Grade 6 children who have just started learning English as a L2. Oppositely, if similar latencies between the two complex graphemic conditions were observed, then no processing difference would be postulated, in favour of a well integrated English specific complex grapheme.

In sum, this study aimed to test in three groups of L2 school learners of varying L2 exposure to what extent the grapheme could be considered as a perceptual unit in L2 visual word recognition. It as also of interest to know whether English specific graphemes were processed differently from English non- specific graphemes, and whether this could differ among the groups.

Method

Participants

A total of 77 participants performed the task among which 21 adult Undergraduate students (mean age: 22;4), 30 children attending Secondary Grade 8 (mean age: 13;9) and 26 attending Grade 6 (11;7). The children groups were recruited in two schools in the area of Rouen (Collège Barbey D'Aurevilly, Rouen and Collège Gounod, Canteleu). They were pupils from one same classroom for whom the English teacher was our contact for testing. The adult group of participants was recruited at the University of Lille North of France. They had studied English for at least seven years during Secondary school. None of them studied Modern languages at the University. They were all French native speakers and none of them had ever lived in a bilingual environment nor spoke English in their daily life.

Materials

A total of sixty letter- present English (L2) word trials were constructed (see Appendix p 351). These trials were divided into three lists representing the three graphemic conditions: 1) simple grapheme where the target letter was presented as a single- letter in the word as in the word *make*; 2) complex non- specific grapheme where the target letter was embedded in a complex grapheme that occur in both English and French such as the word *hair* and 3) complex specific grapheme where the letter is embedded in a complex grapheme that is specific to the English language such as in the word *each*. Due to high level of linguistic constraints on stimuli construction, conditions 1 and 3 contained twenty- four stimuli each but condition 2 only contained twelve stimuli. This was due to the choice we made to use high frequency English words that would have been encountered by L2 school learners leading to a very limited choice of words containing language non- specific complex graphemes.

All the word stimuli were monosyllabic four to five letter monosyllabic words. Three target letters were chosen for the task: the vowels A, E and O. Again due to vocabulary constraints, two target- letter positions were used, either at the second or third position in the word. Note that for the complex specific condition (condition 3), no double vowels such as -oo or -ee were used. Stimuli were created on the basis of doublets (or triplets when an item could be created for the condition 2). As an example, for the letter "E" to detect, the item "*best*" was presented for condition 1 (letter length: 4; written frequency: 481; target letter position: 2) while the item "*read*" was presented for condition 3 (letter length: 4; written frequency: 349; target letter position: 2). This one- to- one matching enabled the three conditions to be matched on length, written frequency and target letter position. Frequency was estimated using the Children Printed Word Database developed for British monolingual children (CPWD, Masterson et al., 2003). These details can be found in Table 16. An analysis of variance confirmed that word frequency did not vary according to the three conditions, $F(2,57) < 1$, n.s. This was again confirmed by using nonparametric U Mann Whitney t-tests to compare each condition together (all Zs < 1, n.s.)

A total of sixty target- absent trials were used to perform the task. These items were constructed in a parallel fashion from the letter- present trials. In order not to induce any response strategy, the target- letters used in the experiment were also present in 68% of these letter- absent words.

Table 16. Characteristics of the items.

	Number of Items	Length	Letter- present target frequency	Letter- absent target frequency
Condition 1	24	4.42 (.50)	474 (825)	345 (478)
Condition 2	12	4.58 (.51)	221 (234)	208 (320)
Condition 3	24	4.42 (.50)	306 (320)	313 (381)

Note. Condition 1 refers to simple grapheme condition. Condition 2 refers to complex non- specific grapheme condition. Condition 3 refers to complex specific grapheme condition.

Procedure

A target detection task was performed following Rey et al. (2000)'s procedure. The target letter was first presented for 700 ms in upper-case in the middle of the screen followed by a fixation point during 1 000 ms. The target word then appeared in lower-case for 33 ms. It was replaced by a blank screen presented for 70 ms followed by 50 ms mask consisting of hashes. Participants had to press “yes” if they detected the target letter in the word with their dominant hand or “no” if they did not detect it with the nondominant hand. The experiment was preceded by a 10 trial training phase. The whole testing procedure lasted around 15 minutes. Testing took place in 2011.

Results

The Levene test of homogeneity of variances revealed that this condition was not respected across the groups, $F(2,74) = 4.933$, $p < .01$. Separate analyses were therefore conducted for each group. An analysis of variance (Anova) was conducted on reaction times and errors on both participants (F_1) and items (F_2) analyses. Graphemic condition was entered as a within- subject variable in the participant analysis, and as a between- subject variable in the item analysis. For each analysis, two effects were of interest and were investigated using contrast analyses: 1) The contrast between single grapheme condition 1 and complex grapheme conditions 2 and 3 and 2) The contrast between English non- specific condition 2 and English specific complex grapheme condition 3. Table 17 represents mean RTS and percentage of errors (and standard deviations) for letter- present targets in the three groups of participants.

Adults

Reaction times higher than 2.5 standard deviations from the mean participant reaction times were discarded (< 3 % of accurate word data).

Reaction times

The main effect of graphemic condition was significant for the participant analysis and as a trend for the item analysis, $F_1(2,40) = 3.461$, $p = .041$, $F_2(2,57) = 2.86$, $p = .065$. The simple grapheme condition 1 was responded to faster than combined complex graphemes conditions 2 and 3, 18 ms, $p = .044$. However, the difference between the English non- specific complex grapheme condition 2 and English specific complex grapheme condition 3 was not significant, 15 ms, p = .14.

Errors

There was no effect of graphemic condition, $F_1(2,40) = 1.668$, $p = .20$, n.s., $F_2(2, 57) = 2.27$, $p = .11$.

Table 17. Mean reaction times in ms and percentages of errors (and standard deviations) for each group of participants (adults, Grade 8 and Grade 6 children) according to graphemic condition.

	Condition 1	**Condition 2**	**Condition 3**
Adults			
Reaction times	588 (92)	598 (106)	613 (104)
Errors	5.1 (4.4)	3.6 (6.3)	6.8 (8)
Grade 8 children			
Reaction times	758 (146)	788 (188)	789 (147)
Errors	8.2 (5.9)	9.3 (12)	9.6 (8.3)
Grade 6 children			
Reaction times	881(178)	898 (178)	943 (189)
Errors	8 (6.5)	9.7 (9.8)	8.6 (7.3)

Note. Condition 1: simple grapheme condition. Condition 2: complex non- specific grapheme condition. Condition 3: complex specific grapheme condition.

Grade 8 children

Reaction times higher than 2.5 standard deviations from the mean participant reaction times were discarded (< 4 % of accurate word data).

Reaction times

The main effect of graphemic condition was nonsignificant on the participant analysis, $F_1(2,58) = 1.55$, $p = .22$, n.s., $F_2(2,57) = 1.433$, $p = .25$, n.s.

Errors

There was no effect of graphemic condition, all *F*s < 1, n.s.

Grade 6 children

Reaction times higher than 2.5 standard deviations from the mean participant reaction times were discarded (< 4 % of accurate word data).

Reaction times

The main effect of graphemic condition was significant for the participant analysis, $F_1(2,48) = 4.875$, $p = .012$, and as a trend for the item analysis, $F_2(2,57) = 3.134$, $p = .051$. The simple grapheme condition 1 was responded to faster than combined complex graphemes conditions 2 and 3, 40 ms, $p = .047$. Moreover, the English non- specific complex grapheme condition 2 was responded to faster as compared to the English specific complex grapheme condition 3, 45 ms, $p = .028$.

Errors

There was no effect of graphemic condition, all *F*s < 1, n.s.

Discussion

The effect of graphemic complexity was observed in both Grade 6 children and adults. In these two groups, finding the presence of a letter such as “A” was longer when this letter was embedded in a complex grapheme such as “oa” in the word *boat* than when this letter constituted a simple grapheme such as in the word *late*. The rationale of the present experiment was that longer latencies in finding a letter embedded in a complex grapheme condition as compared to a simple grapheme condition would reflect the cost in simultaneously processing letters and graphemes, leading to some competition between the two processes. This effect reflected that as early as Grade 6, graphemes constitute an orthographic coding unit, at a different level than letters themselves. When the participant had to recognize the letter “A” in a word such as *boat*, the word recognition system automatically coded each of the letters “b”, “o”, “a” and “t” at the letter level, as well as the graphemes “b”, “oa” and “t” at the grapheme level. This graphemic complexity effect has also been demonstrated in monolingual French adults (Rey et al., 2000) and more recently in children as young as ten years old (Marinus & de Jong, 2011). Surprisingly, this main effect of graphemic complexity did not emerge in the Grade 8 children group, an observation that will be discussed below.

A second finding emerged from the language specificity comparison. While no difference was found between English specific and non- specific complex grapheme in adults (mean language specific: 613 ms; mean language non- specific: 598 ms), the Grade 6 children group showed a 45 ms disadvantage for English specific complex graphemes (mean: 943 ms) as compared to language non- specific (mean: 898 ms). This finding is interpreted in adults as reflecting the fact that English graphemes were well integrated and similarly processed regardless of language specificity. This interpretation was supported by the contrast with the Grade 6 findings where an additional cost of processing was observed for the English specific complex graphemes. This may be explained by the fact that these beginners only had a few months of exposure to the English written language and had no great experience with dealing with these English typical graphemes.

A third observation was the null effect for the Grade 8 children. Indeed, the main effect of graphemic complexity was nonsignificant, even though reaction times in the simple graphemic condition were actually lower (758 ms) than on both English non-specific (788 ms) and specific (789 ms) complex graphemic conditions. As in Study 4, one possible explanation lies in the high variability that there may be in this intermediate group of L2 learners. This idea comes from the observation of the highest standard deviation among all groups in the English non- specific complex graphemic condition. It is possible that during L2 learning, aptitude differences among children increase as they get older. On the one hand, Grade 6 children may be a more homogeneous group with respect to English (L2) learning given that they have just started this acquisition. On the other hand, the adult group is composed of university students who have followed the same educational course. Grade 8 children have been learning English for at least two years during Secondary school and their level range has had time to increase and widen. Among them, some will follow higher studies while others will drop out of school at sixteen years old. Another explanation accounting for this null result -and maybe influencing the whole pattern of results- lies in the phonological aspect of this effect. Though the graphemic complexity effect has been shown to be independent of phonemic effects, these latter effects do contribute to the effect too. For example, Rey et al. (2000, experiment 2) showed that the graphemic complexity effect was still present when manipulating phonemic similarity. Longer latencies for words containing complex graphemes such as *beach* could indeed have resulted from the fact the grapheme "ea" does not sound like the letter to be detected "A". By manipulating orthogonally graphemic complexity and phonemic similarity, the authors showed that both effects contributed to the findings, but that a grapheme complexity effect still emerged for the phonemically similar items (see also Rey & Schiller, 2005). In the case of our study, two remarks may be made. Following Rey et al (2000), it could be argued that detecting a letter "A" in a word when embedded in a complex grapheme such as *hair* or *bear* is different from detecting it in a word such as *trap* given that only in the latter word does sound the "A" such as a /a/. However, this phonological effect could even be more complex given the task was in a L2. English (L2) is a particularly inconsistent orthography and has even been considered as an outlier by Share (2008). English is inconsistent at the phonemic level in the spelling direction (phoneme- to- grapheme correspondences or feedbackward inconsistency) and in the reading direction (grapheme- to-phoneme correspondences or feedforward inconsistency, see Ziegler, Jacobs & Stone, 1997 for statistics in monosyllabic words and Theoretical Background section for a description of both French and English). As an example directly relevant for the present study, the simple grapheme "a" may be read as an /a/ as in the word *trap* but also /ei/ as in *late* or even /o/ as in the word *ball*. Interestingly, only the first grapheme- to- phoneme correspondence corresponding to the association "a" - /a/ is correct in French. Thus, the first condition of simple graphemes was composed of words whose English grapheme- to- phoneme correspondences were either consistent with those existing in French (*trap*) or inconsistent with French (*late* or *ball*). The English non- specific complex grapheme condition could also represent a challenge for L2 learners given the inconsistency across languages of grapheme- to- phoneme correspondences. Among the graphemes used, only “ai” might be considered as consistent across languages –though this was not checked- in that its phonological counterpart in English strongly resembles, at least for French learners of English, its French phonemic correspondence. In contrast, the other graphemes used in the task such as “ou” or “oi” have a different phonological mapping in English (respectively /au/ and /o/ /i/) as compared to French. In all, these particularities of cross- language (in)consistency in orthography-to- phonology mappings may have contributed to the modulation of results, especially by increasing latencies on those words whose target letter had an inconsistent grapheme- to- phoneme mapping across French and English. This could have influenced the performance of Grade 8 and adult participants to a greater degree than that of Grade 6 participants who have little knowledge yet of English phonology (Commissaire et al., 2011).

In terms of theoretical modelling, it is suggested that bilingual models attempt integrating those sublexical units that have been demonstrated to be functional perceptual units in monolinguals, and now in L2 learners. A graphemic level which would comprise both grapheme parser and a grapheme- to- phoneme conversion system could be added in the model, as has been done in monolingual models (BIAm, Diependaele et al., 2010; and CDP+, Perry et al., 2007). Yet, in order to fully account for the findings here, this model should take into account developmental dynamics in that the representations of such graphemes need to evolve as L2 exposure increase. Such a level should also integrate the distinction between language specific graphemes whose representation would need to be constructed progressively and language non- specific graphemes whose links to phonemes would need to be differentiated according to L1 and L2. Neverthless, adding so many levels to a computational model goes against the constraint of process economy and would give hard work to modellers in order to integrate cross- language influences as well as developmental constraints (see Li, 2002 for a discussion of this dilemma between the increasing amount of behavioural variables known to affect word recognition and the formalism constraints of modelling). A verbal description of these graphemic units could possibly represent a first step in the developing of such a sublexical level.

In sum, the grapheme was shown to be a functional unit in L2 visual word recognition. The orthographic typicality effect of graphemes seemed to affect the three groups of L2 school learners differently. While English specific complex graphemes seemed to be processed similarly to English non- specific graphemes in the higher proficiency group, namely the adult group, this was not the case in the beginner group of Grade 6 children. For these children, English specific complex graphemes seemed to induce an additional processing cost as compared to non- specific graphemes, a finding which may indicate that these specific complex graphemes took longer to be accessed by these participants. As already evidenced in previous studies, the pattern in the Grade 8 children was difficult to understand given that no effect of grapheme complexity was shown at all.

Chapter 2. Intermediate Summary.

An attempt was made in Chapter 2 to investigate sublexical orthographic coding during L2 visual word recognition in several groups of L2 school learners. Though there is a huge gap on this topic in the bilingual literature, this issue seemed relevant given the large set of orthographic patterns L2 learners must acquire in order to read L2 words. The first investigation in Study 4 was about the influence of orthographic typicality during lexical access, a variable which has been shown to affect language decisions and language switch costs. As reported in Chapter 1, an advantage was found for English non- specific words which have a legal orthography in L1: these words were indeed accessed faster than English specific words which contain illegal orthographic patterns according to the L1 rules. Though this effect was first supposed to reflect the difficulty for L2 school learners in accessing these L2 specific sublexical units –due to a slower activation of these orthographic units-, other interpretations were suggested. These involved either a cross- language lexical facilitation for English non- specific words (the cumulated frequency of French neighbours of these English words was shown to affect decision latencies in that the more frequent the neighbourhood, the faster the reaction times), or phonological interpretations in terms of orthography- to- phonology conversion. In addition, the typicality effect was not equally strong for all groups of participants although no clear developmental path was observable. Given that the theoretical description of the concept was unclear, the decision was to continue this investigation by focusing on the sublexical grapheme level in a possibly more adequate task: the letter detection task. Study 5 therefore aimed to assess whether the grapheme was a functional unit in L2 visual word recognition, and how L2 specific graphemes could be processed as compared to non- specific graphemes. Globally, graphemes were found to be coded as units as early as after a few months of L2 learning, that is from Grade 6. In addition, while English specific complex graphemes took longer to be processed than English non- specific complex graphemes in the beginner group, this was yet not the case in the adult group. Again, the pattern found in the Grade 8 children remained unclear and several hypotheses in terms of participant characteristics and phonological influences, were suggested.

So, these two studies showed that investigating sublexical orthographic coding may be of relevance when one is interested in L2 acquisition. Though some of the patterns found were not always straightforward, they all pointed to the role of the sublexical features of L2 words, especially in terms of their specificity to the L2. The implications of these results for the theoretical models of bilingual word recognition are discussed in the General Discussion. These two studies however showed that, though orthographic coding *per se* was an issue to be expanded, disentangling orthographic from phonological effects was an arduous task when using behavioural studies. Besides, the approach taken in the present doctoral work was to raise several issues associated with L2 acquisition and some investigation of the orthographic- to- phonology interface could not be overlooked. This axis that was developed in my thesis also formed part of the projects that were developed within the Joint PhD program. One of the next studies was actually conducted during the year that was spent in the host University, the University of Dundee in Scotland. Given the challenges identified that must face L2 learners (novel language specific orthographic- to- phonology correspondences, cross-language inconsistent mappings) and the observations made in this chapter, the next step of the work was to examine these “phonological” issues in L2 learners. In the following chapter, the focus is on orthographic- to- phonological connections: an examination is made of the extent to which phonology is automatically activated during L2 visual word recognition, if sublexical orthographic- to- phonological correspondences were co-activated across languages, and whether these L2 correspondences were processed differently depending on whether they were consistent or not with those existing in the L1.

Chapter 3.

Sublexical orthography to phonology

Study 6. Pseudohomophone interference effect.

When learning a L2, not only do we access orthographic representations via the orthographic pathway but we also access the phonological lexicon via sublexical phonology –among which grapheme- to- phoneme conversion (see BIAM model by Diependaele et al., 2010, but also Coltheart et al., 2001 for a similar proposal with the DRC model and Dijkstra & van Heuven, 2002 for a comparable model in bilinguals). Phonological activation during visual word recognition has been shown to be quite automatic (i.e., though strategically repressible, McQuade, 1991), although its temporal course is still under debate. Some argue for slow phonological activation as compared to orthographic activation (Coltheart et al., 2001; Ferrand & Grainger, 1992, 1993) while others instead propose fast activation (*the fast phonological hypothesis*, Diependaele et al., 2010). Whether for children or adults, several difficulties may arise during access to phonological representations from print. Acquiring grapheme- to- phoneme correspondences on the one hand (i.e., including complex graphemes) and dealing with possible orthography- to- phonology inconsistency are two major barriers that individuals must overcome in order to quickly and accurately access the phonological lexicon (see Seymour, Aro & Erskine, 2003 for reading acquisition rates across thirteen languages varying in consistency). When learning a L2, these difficulties may even be heightened. Firstly, there may be new graphemic representations to learn. As already discussed in the previous chapter, French speakers encounter multiple new graphemes such as “oa”, “ght”, “th” when learning English as a L2. In turn, they also have to learn their corresponding phonemes, some of which do not exist in the L1 (/δ/ in *though* or /θ/

in *think*). Secondly, some L2 grapheme- to- phoneme conversion rules may be inconsistent with respect to L1 rules. As an example, the grapheme “ou” is associated with the phoneme /u:/ in French (e.g., *jour*, *day*), but with the phoneme /aʊ/ in English (e.g., *hour*). Thirdly, there may also be *within- language* inconsistency in the orthography- to- phonology mapping of the L2. The grapheme “a” has multiple phonemic representations in English: the phoneme /a/ which is similar across languages but also /eI/ in *take* or /o/ in *ball*. This feedforward inconsistency in English is known to affect reading acquisition in monolingual English speakers (Seymour et al., 2003; Ziegler, Perry et al., 2001) but this variable is likely also to affect L2 learners in their ability to acquire print- to- sound correspondences.

Research in the field of bilingualism has revealed that phonological representations in L2 are activated during visual word recognition, though possibly more slowly than in L1 (i.e., *the temporal delay hypothesis*, Dijkstra & van Heuven, 2002; but see van Wijnendaele & Brysbaert, 2002) and may interact with L1 representations (Dijkstra et al., 1999; Gollan et al., 1997; Haigh & Jared, 2007; Jared & Szucs, 2002; Kim & Davis, 2003; Nas, 1983; Schwartz et al., 2007). For instance, cognate words (e.g., *hotel*) and interlingual homographs (e.g., *car*) have been reported to be slowed down in the lexical decision task as compared to monolingual control words when they share the same phonological representations[27] across languages (but see Schwartz et al., 2007 for contradictory results in the naming task). In addition, grapheme- to- phoneme correspondences from both languages have been shown to be co- activated during lexical access. This has been demonstrated by phonological

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[27] Given strong phonetic differences across languages, this cross- language homophony should probably be considered as phonological overlap rather than phonological identity.

priming studies where recognizing target words from one language is facilitated by pseudoword primes that are homophonic to the target word according to the orthography- to- phonology rules from the other language (Brysbaert et al., 1999; van Wijnendaele & Brysbaert, 2002). Thus, language- nonselectivity that was initially demonstrated at the level of orthographic activation seems to operate at the lexical and sublexical phonological levels too.

In L2 learners, there is as yet no on- line study of phonological activation. Many studies have however been conducted with children learning a L2 in an immersion program from Kindergarten or Elementary school (who tend to become balanced bilinguals after a few years) using off- line metaphonological tasks such as phonological awareness tasks (i.e., that require the participant to consciously manipulate the oral language). Globally, they have revealed that phonological processing skills correlate across languages and that L1 phonological skills predict L2 comparable skills as well as L2 reading scores (Comeau, et al., 1999; Durgunoglu et al., 1993). In this same population, dealing with phonemic contrasts in the L2 that do not exist in L1 has been reported to affect both L2 reading and spelling acquisition (Richard Liow & Lau, 2006; Wade- Woolley & Geva, 2000). In the population of interest in the present study, namely, “L2 school learners” who learn the L2 in a standard school program from Secondary school, there is as yet no clear picture of the state of the knowledge that this population has regarding grapheme- to- phoneme correspondences in the L2. In the recent study by Commissaire et al. (2011), French speaking children were found to slowly learn these English correspondences. In a homophony judgement task, children from Secondary Grades 6 and 8 were asked to decide whether two pseudowords sounded the same or not (e.g., *blane – blain*). In order to tap L2- specific print- to-sound knowledge, most of the item pairs used were homophonic according to the English rules only, either by using English specific graphemes (e.g., -ow, -oa) or correspondences that were homophonic only in this language (e.g., “ane” and “ain” corresponding to the rime /ein/). Grade 6 children' scores did not differ from chance level and Grade 8 children only reached 58% accuracy in the task. It seems then that those L2 grapheme- to- phoneme correspondences that are very typical of the L2 need some time to be acquired in the context of L2 school acquisition.

The pseudohomophone interference effect is supposed to reflect the degree of automatic phonological activation in visual word recognition (Goswami, Ziegler, Dalton & Schneider, 2001). In monolinguals, this effect may be explained by the conflict that arises between the lexical phonological representation that is activated by the pseudohomophone (*brane* activates /b r eI n/) and the related lexical orthographic representation which does not correspond to the visual input (/b r eI n/ activates *brain*, not *brane*). Only Nas (1983) has examined the processing of pseudohomophones in the lexical decision task in bilinguals (see Dijkstra et al., 1999; Haigh & Jared, 2007; Jared & Szucs, 2002 about homophone processing). He found that pseudowords that sounded like Dutch (L1) words when using English (L2) print- to- sound correspondences took longer to be rejected than control orthographic pseudowords. This may be interpreted as reflecting the activation from L2 sublexical phonology to L1 lexical phonology and therefore interlingual connections within the phonological pathway to word recognition, from the nondominant to the dominant language.

The present study was conducted within the specific framework of the Scottish joint PhD with English speakers who learn French as a L2. Given the scarce empirical data in L2 school learners, phonological activation in L2, and more specifically lexical phonology, was investigated by testing the pseudohomophone interference effect in a L2 lexical decision task using two conditions: 1) L2 homophony using L1 grapheme- to- phoneme correspondences and 2) L2 homophony using L2 grapheme- to- phoneme correspondences. The first experiment that assessed cross-language homophony allowed testing for co- activation of grapheme- to- phoneme correspondences from both languages. Pseudohomophones were homophonic to French (L2) words according to English (L1) rules and an interference effect would arise if phonological sublexical units from both languages were activated in a parallel fashion. The second experiment assessing within- language homophony allowed testing for children's knowledge of L2 grapheme- to- phoneme correspondences and the extent to which interference could be observed within a L2, in this group of young L2 school learners..

Experiment 1. Cross- language homophony

A large set of recent data suggest that sublexical orthographic- to- phonological correspondences from both languages may be automatically and simultaneously activated (Brysbaert et al., 1999; Nas, 1983) in highly- proficient bilinguals, in favour of,language nonselectivity at the level of sublexical phonological representations, but less is known about those individuals who learn a L2 in a standard school context with little L2 exposure and a rudimentary vocabulary. The present experiment tested the pseudohomophone interference effect by using cross-language homophony. Pseudowords that sounded like real French (L2) words when using English (L1) correspondences (e.g., veat from the baseword *vite*, *fast*) were presented in a French lexical decision task, and were contrasted to orthographic control pseudowords that differed from one letter from the pseudohomophone (e.g., *voat*). The investigated issues were whether L1 grapheme- to- phoneme correspondences may be activated in a pure L2 visuo- linguistic task resulting in activated L2 lexical phonological representations.

Method

Participants

A number of 14 children (mean age: 12;10) participated in the study. They attended Secondary 2 (equivalent to year 9 in the English system) in Blairgowrie (Blairgowrie High School). Most children had started English at Primary school (Primary 5). None of them spoke French at home nor had a French linguistic environment. Testing took place in April 2010.

Materials

A total of twenty high frequency French words (mean frequency: 577, SD: 1738) were selected as basewords for the creation of the critical pseudoword stimuli (Lexique, New et al., 2001, see Appendix p 354). From these words, one pseudohomophone was created by modifying one or a few letters. These pseudohomophones sounded the same than their correspondent baseword when using English (L1) grapheme- to- phoneme correspondences and an attempt was made for it to be the case by using these L1 correspondences only. Orthographic control pseudowords were created by changing one letter from the pseudohomophone. Again, orthographic similarity between both types of pseudowords and the baseword was ensured by using the orthographic similarity index (Van Orden, 1987). Though most pseudowords were quite dissimilar orthographically from the French baseword, the two items, namely the pseudohomophone and the orthographic control, were matched according to orthographic similarity. As an example, the French word *vite* (*quick*) enabled the pseudohomophone *veet* to be derived whose phonological code (/v/ /i:/ /t/) is very similar to the baseword when applying English rules[28] and its orthographic control *voat* (/v/ /o:/ /t/). Both pseudohomophone and orthographic control share an orthographic similarity index of .38 with the baseword. So, though they share little orthographic overlap with the baseword, they share the same amount of similarity. Moreover, these pseudowords were matched according to English (L1) bigram frequency. To minimize possible strategic effects arising from exposure to pseudohomophones -and thus decreasing phonological activation during word recognition-, twenty filler pseudowords were added so that only a third of the pseudowords were pseudohomophones. These filler pseudowords were created by changing one letter from a real French word (*reau* derived from *beau*) and did not share any phonological overlap with real words.

For the purpose of the lexical decision task, sixty words (mean frequency: 348, SD: 339) were added to the task (see Appendix p 359). These words varied from four to six letters long, and were either mono- or bisyllabic.

Procedure

A fixation point was presented to the participants for 1000 ms followed by a mask presented for 1000 ms composed of several hashes. The target word then appeared for 3000 ms or was ended as the participant responded. Participants were asked to decide as quickly and accurately as possible whether the string of letters they saw was a

28 It is acknowledged that while one /i/ phoneme exists in French, several similar phonemes may occur in English such as short /i/ and long /i:/.

real French word or not. It was emphasized that as soon as they recognised the French word, they could answer “yes” whereas if they did not, they had to answer “no”.

In addition to the lexical decision task, a questionnaire was proposed to the children where figured all basewords from which pseudohomophones were derived (see Appendix p 361). Children were asked whether they had already seen this French word, and whether they knew their English translation. This test was constructed in order to make sure children knew these words, and therefore could have been influenced by its derived pseudohomophones. Again the same productive vocabulary test was proposed to the participants.

Results

One pseudohomophone revealed to be homophonic to an English (L1) word (*kea* from the baseword *qui*) and was therefore removed from further analyses. An Analysis of variance was conducted for both reaction times and errors. We should specify that these were the reaction times on correct rejections, that is on the “no” responses. In both participant and item analyses, pseudoword status was entered as a within- subject variable. Results may be found in Table 19.

Reaction times

The effect of pseudoword status was significant for both participant and item analyses, $F_1(1,13) = 17.901$, $p < .001$, partial $\eta^2 = .58$, $F_2(1,18) = 12.591$, $p < .01$. This effect revealed that participants were slower to correctly reject pseudohomophones than their orthographic controls (93 ms).

Errors

The effect of pseudoword status did not reach significance for either analyses, $F_1(1,13) = 2.228$, $p = .159$, $F_2(1,18) = 2.167$, $p = .158$.

Table 19. Mean reaction times in and errors in percentage (and standard deviations) for pseudohomophones (PsH) and control pseudowords.

	PsH	Controls	Difference
Reaction times (1)	985 (151)	892 (116)	93 ms
Errors (1)	19 (16)	13.4 (10)	5.6 %

The validity of these analyses was checked by taking into account responses made by the participants to the questionnaire. For each subject, the items that corresponded to a baseword which was said not to be known in the questionnaire were removed. For example, if the baseword *ville* was unknown to one participant, the corresponding items *veel* for the pseudohomophone condition, and *voel* for the orthographic control condition were removed from the analyses. The analyses yielded a similar pseudoword status effect in the reaction time data, $F_1(1,13) = 8.749$, $p = .011$, partial $\eta^2 = .40$, $F_2(1,18) = 12.591$, $p < .01$. Participants responded to 89 ms slower for the pseudohomophones (992 ms, SD: 180) as compared to the orthographic control pseudowords (903 ms, SD: 113). For the error analysis, the results were a little different given an effect of pseudoword status emerged for the item analysis only, $F_1(1,13) = 2.19$, $p = .163$, $F_2(1,18) = 6.156$, $p = .023$, which reflected 7.8 % more errors for the pseudohomophone condition (23.8 %, SD: 18) as compared to the orthographic control condition (16%, SD: 11).

Discussion

The present experiment revealed a cross- language pseudohomophone interference effect in the reaction time data: pseudohomophones that were homophonic to real French (L2) words according to English (L1) print- to- sound rules were responded to more slowly than orthographic controls, matched for orthographic similarity with the baseword. These results were confirmed when taking into account only those basewords that were declared to be known by the participants. An effect also emerged in the errors in the item analysis. It seems then that L1 sublexical phonology was automatically activated when dealing with L2 words, and that this sublexical phonology in L1 contacted the L2 lexical phonological representations of basewords. Given this strong evidence for cross- language interactions at the sublexical phonological level, an observation in line with those findings from highly proficient bilinguals, a second experiment was conducted in order to assess whether this interference effect could also be observed within the L2.

Experiment 2. Within-language homophony

Experiment 2 tested for the pseudohomophone interference effect using within-language (L2) homophony. Pseudowords that sounded like real French (L2) words (e.g., *dauner* from the baseword *donner*, *give*) were presented in a French lexical decision task, and were again contrasted to orthographic control pseudowords that differed by one letter from the pseudohomophone (e.g., *dainer*). We hypothesize that any pseudohomophone interference effect (i.e., longer latencies and/or higher error rate in the pseudohomophone condition as compared to the orthographic control condition) would reflect 1) automatic activation of phonology and 2) knowledge of French (L2) orthographic to phonological correspondences.

Method

Participants

A total of 24 Secondary school children participated in the experiment (mean age: 14;8). They came from two schools in Scotland, from St Andrews (St Leonards School) and Glasgow (Hyndland Secondary school) which welcome pupils from middle- to- upper socioeconomic background. Children were chosen by the teacher we were in contact with so that they came from different classes and had a variety of levels. They attended Secondary 3 or 4 (corresponding to years 10 and 11 in the English education system) and had started learning French from Primary 6 (year 6). Yet, some of them had exposure to French from Primary 5 (year 5). Children had on average 50% accuracy in the proficiency test (mean scores: 25 out of 50 items, SD: 9). Though children from the school in Glasgow (mean age: 15;6) were a little older than those from St Andrews (mean age: 14;4), their scores on the proficiency test did not differ (mean scores of 25, SD:9 for St Andrews; mean scores of 24, SD: 10 for Glasgow).

Materials

A total of twenty high frequency French words were selected as basewords from the Lexique database (New et al., 2001) for the creation of the critical pseudoword stimuli (see Appendix p 356). From these words, one pseudohomophone was created by modifying one or a few letters. These pseudohomophones sounded the same than their correspondent baseword when using French grapheme- to- phoneme correspondences and an attempt was made for it to be the case by using these L2 correspondences only. Orthographic control pseudowords were created by changing one letter from the pseudohomophone. To ensure that any difference that would arise in the task between pseudohomophones and orthographic control is due to the phonological overlap between the pseudohomophone and the word, careful attention was given to construct orthographic control pseudowords. For this, orthographic similarity between each of these critical pseudowords (i.e., pseudohomophone and orthographic control) and the baseword was ensured by using the orthographic similarity index (Van Orden, 1987). As an example, the French word *vent* (*wind*) enabled to derive the pseudohomophone *vant* whose phonological code (/v/ /ã/) is similar to the baseword when applying French rules and its orthographic control *vunt* (/v/ /in/). Both pseudohomophone and orthographic control share an orthographic similarity index of .72 with the baseword. More, we made sure that these pseudowords were matched according to English (L1) and French (L2) bigram frequency: if any difference may arise from the two pseudoword conditions, we need to assure that this is not due to one pseudoword being more word-like than the other. Mean English bigram frequency were at 1295 (SD: 794) and 1309 (SD: 919) for pseudohomophone and orthographic control conditions respectively. Mean bigram frequency in French was also comparable among the two conditions: 1057 (SD: 417) and 1043 (SD: 469) for pseudohomophones and orthographic controls respectively. To minimize possible strategic effects arising from exposition to pseudohomophones -and thus decreasing phonological activation during word recognition-, twenty filler pseudowords were added to so that only a third of the pseudowords were pseudohomophones. These filler pseudowords were created by changing one letter from a real French word (*reau* derived from the baseword *beau*, *beautiful*) and did not share any phonological overlap with real words. These were the same filler pseudowords as in Experiment 1.

For the purpose of the lexical decision task, sixty words (mean frequency: 346, SD: 340) were added to the task (see Appendix p 359). These words varied from four to six letters long, and were either mono- or bisyllabic. Most of them had been already used in Experiment 1 (except those words that figured now as basewords for the experimental items).

Procedure

The same procedure as in Experiment 1 was used. Again, a questionnaire was proposed to the children where figured all basewords from which pseudohomophones were derived (see Appendix p 361). Children were asked whether they had already seen this French word, and whether they knew their English translation. This test was constructed in order to make sure children knew these words, and therefore could have been influenced by its derived pseudohomophones. Testing took place in a quite room in each school, in December 2009 in St Andrews and March 2010 in Glasgow.

Results

An analysis of variance was performed on both reaction times and errors. For both participant (F_1) and item (F_2) analyses, pseudoword status was entered as a within-subject variable. Reaction times higher than 2.5 standard deviations from the mean reaction time were removed (% of data). Results may be found in Table 18.

Reaction times

There was no effect of pseudoword status on reaction time data, all *F*s < 1, n.s.

Errors

An effect of pseudoword status was observed in the participant analysis, $F_1(1,23) = 4.914$, $p = .037$, partial $\eta^2 = .18$, $F_2(1,19) = 1.006$, $p = .329$, n.s, revealing higher errors for the pseudohomophone condition as compared to the orthographic control pseudowords (5 %).

Table 18. Mean reaction times in ms and errors in percentage (and standard deviations) for pseudohomophones (PsH) and control pseudowords.

	PsH	Controls	Difference
Reaction times	949 (141)	940 (130)	- 9 ms
Errors	25 (14)	19.6 (14)	5.4 %

The validity of this analysis was further checked by taking into account responses made by the participants to the questionnaire. As in Experiment 1, both members of a pair of items (pseudohomophone and associated orthographic control pseudowords) were removed when a baseword was reported not to be known. The analyses yielded again an effect of pseudoword status in the errors, which was significant for the participant analysis, $F_1(1,23) = 12.367$, $p = .002$, partial $\eta^2 = .35$, and as a trend for the item analysis, $F_2(1,19) = 2.99$, $p = .10$, n.s. The participants made 8%

more errors on the pseudohomophones (29.6% errors, SD: 17) as compared to orthographic control pseudowords (21.5% errors, SD: 15). As for the general analysis, no effect was found for the reaction time data (all *F*s < 1, n.s.).

Discussion

The present experiment revealed a pseudohomophone interference effect on the error data in a French (L2) lexical decision task: more errors were made for the pseudohomophones that sounded like French (L2) words when using French grapheme-to- phoneme correspondence rules, than for orthographic control pseudowords that differed in one letter from pseudohomophones. Given that both pseudowords shared the same amount of orthographic similarity with the baseword, it is very likely that the disadvantage for pseudohomophones reflects the homophony with the basewords. However, given that this effect was only observed on the error data, not on the reaction time data, one alternative explanation needs to be discussed. As with pseudohomophone effects observed in monolinguals, it could be that the participants had poor orthographic knowledge of the French (L2) baseword, and that errors on the pseudohomophones reflect participants' confusion about the correct spelling of the word. This could be even more apparent in this experiment 2 given that the pseudowords created - pseudohomophones and orthographic controls- were more orthographically similar to their basewords, as compared to those pseudowords created in experiment 1 (mean pseudohomophone similarity with baseword: X and .71 for respectively experiments 1 and 2). Though a questionnaire was administered to the participants in order to assess for participants' knowledge of the basewords, an orthographic choice task would probably have been a better post- test measure of participants' knowledge of the baseword spellings. If those errors on pseudohomophones reflect poor knowledge of baseword spellings, this effect should be stronger for those pseudohomophones that had a high orthographic overlap with the baseword as compared to those that had low orthographic overlap. As an example, confusion about the spelling of L2 basewords should be more prominent in pseudohomophones such as *batau* which is very similar orthographically to its baseword *bateau* (*boat*, orthographic similarity at .89) as compared to items such as *cheau*, pseudohomophone of *chaud* (*warm*, orthographic similarity at .60). Thus, if this is true, the pseudohomophone interference effect should be stronger for High orthographic similarity items as compared to Low orthographic similarity items. A post- hoc analysis was therefore conducted to assess this alternative account of the pseudohomophone interference effect. Among the twenty pairs of items (pseudohomophone and orthographic control), half were categorized as “High orthographic similarity” (mean orthographic similarity: .81, SD: .08) and the other half as “Low orthographic similarity” (mean orthographic similarity: .62, SD: .05), $t(18) = 5.993$, $p < .001$. An anova was run by entering pseudoword status and orthographic similarity. It revealed a trend for an interaction between the two variables, $F(1,23) = 3.431$, $p = .077$, which reflected a significant pseudohomophone interference effect for the Low orthographic similarity condition only (9.2 %, $p < .01$). This interaction was however nonsignificant when the analysis was performed on those items whose basewords were declared to be known by the participants, $F(1,23) = 1.337$, $p = .259$, n.s. Given that this nonsignificant interaction could have resulted from a statistical artefact (i.e., from another variable such as baseword frequency), and was not in the hypothesized direction, this appear to support the account of the pseudohomophone interference effect as reflecting a phonological effect.

Summary

These two experiments shed some light on phonological activation in a L2 in young L2 school learners. Both experiments revealed a pseudohomophone interference effect, either within- language (experiment 2, for the error analysis) or across- languages (experiment 1, for the reaction times analysis). Participants who were learning French as a L2 for around two- to three years seemed to be sensitive to the phonological representations of the pseudowords, and this activation interfered with the lexical decision process by activating L2 lexical phonology. In experiment 1, in a French (L2) lexical decision task, participants took more time (and seemed to make more errors) to correctly reject pseudohomophones that sounded like French (L2) words when pronounced using English (L1) correspondences. This effect supports the idea of an automatic phonological activation in L2, especially when considering that no phonological ouput is required in the lexical decision task. It also seems to support the idea of a language- nonselective phonological activation: this pseudohomophone interference may be accounted for by a connection at the level of sublexical phonology across languages. When reading the pseudohomophone, L1 sublexical phonology could have connected to L2 sublexical phonology, which in turn could have activated L2 lexical phonological representations. In experiment 2, participants made more errors in a French (L2) task for pseudowords that sounded like French words by using French print- to- sound correspondences. Again, this effect was interpreted as revealing that children activated L2 sublexical phonology, which in turn connected to lexical phonology and activated the basewords from which the pseudohomophones had been created. As for experiment 1, once these L2 lexical phonological representations are activated, they compete with L2 lexical orthographic representations of the baseword, which triggers either more errors or longer reaction times. This explanation could be modelled within the BIA+ model of bilingual word recognition, which includes both lexical and sublexical levels of phonological representations as well as an interface between L1 and L2. Our results also indicated that children had acquired sufficient knowledge of French correspondences. Indeed, in order for pseudohomophones to create interference, it must be assumed that children applied correct grapheme- to-phoneme corresponces when reading these words.

The fact that the pseudohomophone interference effect only affected the pattern of errors in experiment 2 testing within- language L2 homophony raised some doubts about the automaticity of the mechanism under study. Though the post hoc analysis taking into account orthographic similarity of the pseudohomophones to the baseword revealed that the effect was apparently not due to a misconception of the L2 word spellings, this effect on errors, but not on reaction time data –as found in experiment 1- needs some discussion. Based on consideration of both within- and cross- language homophony experiments, one tentative interpretation is that cross- language influences from L1 may have been so strong –especially from L1- to- L2- that any influence from competing L2 correspondences was obscured. That the L1 set of correspondences is stronger than those from the L2 in such a population of young L2 learners does not seem surprising and future studies should manipulate factors such as L2 proficiency and recent language exposure in order to better comprehend this mechanism. With regard to this, the BIA+ model suggests that phonological activation – and semantic activation- in

L2 should be delayed in comparison with L1 activation. Although the current experiments did not allow this prediction to be tested, this stronger influence from L1 as compared to L2 on L2 sublexical phonology tends to support this view. The extent to which this differential effect across the two experiments reveals a temporal delay of L2 lexical phonology activation, or an imprecise knowledge of L2 correspondences requires futher investigation and better controls of print- to- sound knowledge in L2 learners (e.g., the use of a homophony judgement task for instance, Commissaire et al., 2011). With respect to theoretical approaches on sublexical orthography- to- phonology conversion, this study also points to the need to disentangle whether this conversion system is rule- based (as in DRC model, Coltheart et al., 2001) or whether it works as a connectionist- type system where correspondences only differ by different connection strengths –or different resting level activations- depending on the number of words that share the same correspondence (e.g., friends) or do not (e.g., enemies). In previous research, observations of the co- activation of multiple associations have been interpreted as ruling out the hypothesis of a rule- based mechanism (van Wijnendaele & Brysbaert, 2002). Nevertheless, masked phonological priming is shown here to be a better measure of these phonological effects in that this procedure obviously taps automatic mechanisms, and that our study could not disentangle these two hypotheses. This issue is particularly relevant in the case of L2 learners who first acquire L1 before learning a L2, and who therefore already have a set of conversion rules in their visual word recognition system. It is highly likely that all L2 grapheme- to- phoneme correspondences that are shared by the existing L1 are easily incorporated to the sublexical network, as well as correspondences that are specific to the L2. In the language pair studied, many consonants are shared across languages (e.g., letters such as "b" or "d") and this L1 knowledge should be transferred to L2 at the beginning of acquisition. Correspondences that are specific to English (e.g., "th" → /δ/ in *though*) should also be gradually learned, albeit slower in case of within- language inconsistency in L2 ("th" also maps onto /θ/ in *think*). Finally, L2 grapheme- to- phoneme correspondences that are contradictory with L1's (e.g., "a" maps onto /a:/ in French while onto /a:/ but also /eI/ in English) should take the longest to be integrated and could suffer from competing correspondences. The ease of acquisition of these different types of correspondences could obviously depend on the features of each of the languages. For instance, English is considered as a very opaque language both from spelling- to- sound and sound- to- spelling (Ziegler et al., 1996), and we could imagine that acquiring correspondences in English as a L2 should represent a considerable challenge, especially for learners for whom native language is much more transparent (e.g., Spanish). Note that cross- linguistic differences in terms of preferred grain- size of phonological recoding could also play a role in the ease of L2 phonological acquisition, especially in the case of L2 late learners who have already developed a highly automatic decoding strategy in their L1.

So, it seems then that after only a few years of L2 learning in a school context, multiple grapheme- to- phoneme correspondences in both languages may be co-activated and interfere with lexical decisions, a finding in line with data from highly proficient bilinguals. It also shows that phonological activation during visual word recognition is automatic, especially under conditions where the proportion of pseudohomophones is low (a third of pseudoword items, and a sixth of all items). This has important theoretical implications in favour of a strong involvement of phonology during visual word recognition, even in a L2 which is not acquired through extensive oral exposure as can be L1 acquisition. This last remark is especially interesting considering participants were English native speakers for whom it has been assumed by some researchers that phonological activation is reduced relative to speakers of more transparent languages (i.e., *the orthographic depth hypothesis*, Frost, Katz & Bentin, 1987). To this respect, Goswami et al. (2001) showed that automatic phonological activation, as reflected by a pseudohomophone interference effect in the lexical decision task, was observed for German native children -aged 7 to 9 years old- but not in English native children. However, the extent to which speakers of an opaque language such as English may develop new strategies when learning a foreign language whose print- to-sound matching is more transparent needs further investigation.

Study 7. Cross-language phonological consistency

When learning a L2, individuals must acquire a new set of print- to- sound correspondences, among which some already exist in their L1 and may be considered as consistent across languages[29]. In the case of French learners of English as a L2, most English consonants (except for h, j or r) and some vowels (a → /a:/ as in *have* or i → /i;/ as in *fill*) have consistent mappings across languages. Yet, L2 learners also need to develop correspondences for L2 language- specific graphemes for which no correspondence have yet been established in L1 (e.g., oa → /o:/ as in *boat*, or th → /θ/ or /δ/ as in *think* and *though*) as well as to develop correspondences that are inconsistent with the L1 (a → /o:/ or /eI/ as in *ball* and *take*). The case of French and English languages is very pertinent in this respect. While French is considered to be inconsistent in the sound- to- print direction (spelling direction or feedback consistency), it is quite consistent in the print- to- sound direction (reading direction or feedforward consistency). For instance, while the grapheme "eau" is always pronounced as /o:/, there are multiple graphemic representations of the phoneme /o:/ such as "o", "au", "eau", "op", "ot", for which frequency of occurrence depends on some variables such as position in the word and consonantal context (Pacton, Perruchet, Fayol & Cleeremans, 2001; see Treiman & Kessler, 2006 for similar issues in the English language). In comparison, English has been considered as an outlier orthography (Share, 2008) in that both reading and spelling directions may be considered inconsistent with regard to the

[29] Although L2 learners may assimilate L2 phonemes to existing L1's, there are still phonetic differences across languages that prevent these phonemes from ever being entirely identical.

relationship between orthography and phonology. Therefore, in the case of French learners of English as a L2, these individuals are faced with graphemes with multiple phonemic representations in L2, with some of them being consistent with L1 (e.g., "a" maps onto /a:/ in both French and English) while others are inconsistent (e.g., "a" has the additional mapping onto /eI/ in English only). The goal of the present study was therefore to assess to what extent this cross- language consistency effect could be observed in three groups of L2 learners of varying proficiency.

In monolinguals, the consistency effect in visual word recognition refers to the observation that words which could be pronounced in multiple ways (e.g., *pint* is sounded out as /p aI n t/ but it could be pronounced as /pint/) take longer to be processed than words for which one unique pronunciation may be found [30] (e.g., *heap* where "eap" is always pronounced as /i:p/). This feedforward consistency effect may be interpreted as reflecting the competition that arises in the inconsistent condition between multiple sublexical orthographic- to- phonology associations. A feedback consistency effect has also been shown in the sound- to- spelling direction. Stone, Vanhoy and Van Orden (1997) first demonstrated that words for which the rime could be spelled in different ways (the rime /i:p/ in the word *deep* may be spelled as "eep" but also "eap" such as in *cheap*) took longer to process than words for which the rime has one unique body mapping (the rime /ob/ in the word *probe* can only be spelled as "obe" in the English language). This feedback consistency effect which implies high levels of interactivity in the word recognition system is still a matter of debate (see Lacruz &

[30] Note that the degree of consistency also depends on the grain size under consideration. The word *heap* may be considered as consistent as regard to body- rime mapping but inconsistent at the grapheme- phoneme mapping given "ea" may be pronounced as /i:/ or /e/.

Folk, 2004 and Ziegler, Montant & Jacobs, 1997 for additional evidence for the existence of this effect; but Ziegler, Petrova & Ferrand, 2008 for contradictory findings). Though most researchers who use the term "consistency" have focused on the level of word body (nucleus + coda such as "obe" in *probe*, Glushko, 1979; Stone et al., 1997; Ziegler et al., 1997, 2008), similar findings have been shown at the graphemic level, using the term, "regularity" (Coltheart et al., 2000; Lange, 2002; Rey & Schiller, 2005; see Martensen, Maris & Dijkstra 2000 for an investigation of the influence of language characteristics on the grain size of the relevant unit for observing a consistency effect). Though this particular point will not be addressed in the present study, it should also be noted that the precise definition of consistency/regularity differs somewhat according to the researcher. Some researchers consider this effect as an all- or- none phenomenon within a conversion rule system: a word is consistent/regular when it contains the most frequent body/grapheme corresponding to the rime/phoneme but inconsistent/irregular when containing another correspondence. For instance, this is the view taken within the Dual Route model of reading by Coltheart et al. (2001). The authors assume that only the print- to- sound correspondence corresponding to the rule is activated. When an inconsistent word is presented, the lexical and nonlexical routes to reading provide different information to the system, which in turn takes time to resolve the problem. Conversely, other researchers consider instead that the *strength* of the association is relevant when examining consistency effects, strength which is dependent on the statistical properties of the language (Jared, 1997). Within this framework, a consistency ratio may be computed taking into account the number of a word's friends (i.e., words that share the same orthography- to- phonology correspondence) and enemies (i.e., words that have a different correspondence). Consistency is therefore not considered as a dichotomous variable but rather, varies along a continuum (see for instance Ziegler et al., 1996, 1997 for feedforward and feedback consistency probabilities of word bodies in monosyllabic French and English words).

The present study aimed to further test for phonological activation during L2 visual word recognition in three groups of varying proficiency levels and to assess cross- language influences on sublexical grapheme- to- phoneme activations. Previous research in highly proficient bilinguals has reported lexical phonological connections across languages (using cognates and interlingual homophones, Dijkstra et al., 1999) as well as co- activation of sublexical phonology (using masked priming studies, Brysbart et al., 1999, Van Wijnendaele & Brysbaert, 2002). Although phonological activation has been predicted to be delayed in L2 as compared to L1 due to lower accessibility, this is still under debate (Dijkstra & van Heuven, 2002; Duyck, 2005, but see Duyck et al., 2004 for symmetrical phonological effects in L1 and L2). With regard to consistency effects across languages, only two studies have reported a cross- language consistency effect. Note that both studies used the naming task and focused on the word body level. Jared and Kroll (2001) showed that L2 words that had a high number of L1 enemies (words for which the word body has a different pronunciation) were named more slowly than L2 words without L1 enemies, and this effect was significant only after participants had been exposed to the L1 (see also Smits, Sandra, Martensen & Dijkstra, 2009).

In contrast, the present study focused on the grapheme level in a letter detection paradigm. Several reasons can be addressed. First, we uncovered in Study 5 that graphemes were functional units of visual word recognition in L2, as early as after a few months of L2 learning. Though English graphemes were supposed to be first analysed as orthographic functional units, we cannot leave out that some of these graphemes had consistent phonological mappings across languages while others had not. This could have impacted our findings and this issue had to be addressed. Second, relying on large grain- size units such as rimes has been shown to be mostly prevailed in readers of deep orthographies such as English (Goswami et al., 2003; Treiman et al., 1995; Ziegler et al., 2001). French readers whose orthography is quite regular in the spelling- to- sound direction should rely on smaller grain- suze units such as graphemes, and to a much lesser extent on rimes or word analogies. So, participants were told to decide whether a target letter was present or absent from a following word which was presented very briefly (34 ms). For the letter- present trials, two conditions were created according to cross- language consistency. The consistent condition was composed of words for which the target letter had a consistent orthography- to- phonology correspondence across languages (e.g., *have* for which target letter “A” is pronounced /a:/ in this word as in most French words); whereas, the inconsistent condition was composed of words for which the target letter had an inconsistent correspondence across languages (e.g., *call* for which the “a” → /o:/ correspondence is not legal in French). To further test orthographic- to- phonology sublexical interactions, the letter- absent trials were also manipulated. In some of these trials, a “trap” condition was created where participants were expected to respond more slowly -and make more errors. In this “trap” condition, words did not contain the target letter that had previously been presented. Nevertheless, they did contain the phonemic correspondence of the target letter, according to the French (L1) rules. For instance, when the target letter “I” was presented to the participants, words such as *feel* figured as traps. Indeed, the grapheme “i” is mostly pronounced as /i:/ in French (this is also the case in English but more diverse pronunciations occur in this language, “i” → /i:/, /3/ or /aI/) and this phoneme /i:/ is present in the trap word *feel*. This "trap" condition was contrasted with a standard letter-absent condition, where neither the letter nor any possible phonemic correspondence of this letter occurred in the word.

In sum, this study was motivated by several goals. Firstly, if phonological representations are automatically activated during visual word recognition, even in L2, a consistency effect should be observed in the present letter detection task, which does not require any decoding to provide the correct response (contrary to the naming task for which there are clear demands on phonological output and articulatory processes). This would also confirm previous findings of a pseudohomophone interference effect across languages, in a context that should maximize assessment of *automatic* processes (brief presentation of the target word; effect expected on "yes" responses[31]). Secondly, the influence of cross- language sublexical phonology interactions was assessed by examining the consistency effect in letter- present trials: words that had a target letter for which the grapheme- to- phoneme correspondence was consistent across languages were expected to be processed faster than words for which this correspondence was inconsistent across languages. This effect was hypothesized to reflect the influence of L1 sublexical phonology, and particularly the fact that the consistent print- to- sound correspondence had a stronger connection –or corresponded to the L1 rule- as compared to the inconsistent condition. Given French readers are supposed to mainly rely on small grain- size units, we expected that they would also do so in English as a L2, even if the English orthography should encourage to use a more diverse set of spelling- to- sound

[31] The fact that the pseudohomophone interference effect must be assessed using reaction time/error data for the "no" responses may cast some doubts about the automatic nature of the effects, due to the stronger relevance of strategic factors that is commonly attributed to this type of response (see MROM-p model of Jacobs et al., 1998).

units in reading (Goswami et al., 2003). Thirdly, a trap condition was created for the letter- absent trials: words that contained the L1 letter sound of the target letter were expected to be processed longer and trigger more errors than words that did not contain the L1 letter sound of the target letter –note that none of these words contained the target letter itself. This trap effect was supposed to reflect sublexical phonological interactions across languages and a high degree of interactivity within the visual word recognition system between orthographic and phonological representations. Indeed, an effect could reflect bottom-up orthographic- to- phonological activation (from the target letter to the corresponding phoneme) followed by phonological- to- orthographic feedback activation (which should trigger errors when making judgements about the absence of the target letter).

Method

Participants

A total of 50 individuals participated in the study, among which 23 University students (mean age: 21;2), only 8 Grade 8 children (mean age: 14;4) and 27 Grade 6 children (mean age: 11;8). The children groups were recruited in a school in Paris (Collège La Grange aux Belles) and in the area of Rouen (Collège Gounod, Canteleu). All children participants were learning English as a L2 since Grade 6 Secondary school. As for other studies, none of them had lived in a bilingual environment which involved the English language.

Materials

A total one hundred and twenty words were used in the task, among which sixty letter-present trials and sixty letter- absent trials (see Appendix p 362). Examples of all categories used may be found in Table 20. A total of sixty letter- present word trials were constructed, among which fourty were considered as experimental trials. The variable under interest was that of cross- language consistency between grapheme- to-phoneme correspondences. Half of the words contained a grapheme whose phonemic correspondence is shared across languages while the other half was composed of a grapheme whose phonemic correspondence in L2 differed for what whould be predicted by L1 grapheme- to- phoneme conversion rules. Two graphemes that have multiple print-to- sound correspondences in English were used: the graphemes “a” and “i”. For the twenty experimental trials using the grapheme “a”, half were considered to have a cross- language consistent mapping between grapheme and the corresponding phoneme (mean frequency: 303, SD: 235), that is “a” → /a:/ (e.g., *fast*) while the other half had inconsistent mappings (mean frequency: 342, SD: 279), either “a” → /eI/ (e.g., *game*) or “a” → /o:/ (e.g., *call*). Another twenty experimental trials were constructed for the grapheme “i” that was composed of ten consistent trials (mean frequency: 299, SD: 239), “i” → /i/ (e.g., *kill*) and ten inconsistent trials (mean frequency: 396, SD: 538), either “i” → /aI/ (e.g., *hire*) or “i” → /3:/ (e.g., *bird*). All the word stimuli were monosyllabic four to five letter monosyllabic words (mean length: 4.05 letters). The target grapheme was always on position 2 in the word -also in the two five letter long words. Words across both graphemes used (A and I) and consistency status (consistent vs. inconsistent) were matched across frequency, which was estimated using the Children Printed Word Database developed for British monolingual children (CPWD, Masterson, Stuart, Dixon & Lovejoy, 2003). An analysis of variance confirmed that word frequency did not vary according grapheme used or the consistency status (all *F*s < 1, n.s), nor interact with each other (*F* < 1, n.s.). In addition to these experimental trials, twenty fillers were used, using either the target letters "O" or "E". For each of these letters, ten words were used whose print- to- sound mapping were quite consistent across languages: "o" → /o:/ (e.g., *born*) or /Q/ (e.g., *gone*) and "e" → /E/ (e.g., *next*). Mean length for these words was 4.15 letters and mean frequency was at 363, SD: 408. Due to stimuli constraints, one item was bisyllabic (0.05% of filler words).

For the sixty letter- absent trials, again fourty words were considered as experimental trials. Among these words, half were considered as a trap: participants had to search a letter which was absent but whose corresponding phoneme in L1 was present in the word (e.g., detect the letter "I" in the word *deep*). The other half did not contain either the target letter to be found or its corresponding phoneme (e.g., detect the letter "I" in the word *park*). Among those trials, twenty words were associated with the target letter "I": ten items were a trap (mean frequency: 338, SD: 303) given they contained graphemes such as "ea" or "ee" and corresponding phoneme /i:/ (e.g., *deep*) and ten items were common letter- absent trials (mean frequency: 344, SD: 371) in that they contained whatever grapheme/phoneme that was neither "i" nor /i:/. Ten words were associated with target letter O, among which five "trap" words (mean frequency: 216, SD: 141) that contained the phoneme /o/ (e.g., *ball*) and five "common" words (mean frequency: 227, SD: 269, *send*); and other ten items with letter "E" among which half "trap" words (mean frequency: 194, SD: 159) containing phoneme /3/ (e.g., *burn*) and other half common words (mean frequency: 152, SD: 123, *yard*). Again, all the word stimuli were monosyllabic four to five letter monosyllabic words (mean length:

4.13 letters). An analysis of variance revealed that word frequency did not vary according target letter used, $F(2,34) = 1.43$, $p = .25$, n.s., nor the trap status, $F < 1$, n.s, nor did these variables interact with each other, $F < 1$, n.s. In addition to these experimental trials, twenty monosyllabic filler words were used, using target letter "A". Mean length for these words was 4.10 letters (mean frequency was at 280, SD: 325).

In the whole experiment, participants therefore saw an equal number of target letters across present/absent conditions (for target letters "A" and "I", respectively fourty trials each; for target letters "E" and "O", respectively twenty trials each), minimizing any strategic influence. The target letters were either used in experimental or filler items. Furthermore, target letters were presented an equal number of times across consistency conditions for letter- present trials and trap condition for letter- absent trials.

Table 20. Characteristics of the items

	Letter- present trials			**Letter- absent trials**		
		Consistent	Inconsistent		Trap	Standard
Experimental trials						
	A (20)	fast	call - game	O (10)	ball	send
	I (20)	kill	hire - bird	I (20)	deep	park
				E (10)	burn	yard
Fillers						
	O (10)	gone		A (20)		trip
	E (10)	next				

Procedure

A target detection task was performed following Rey et al. (2000)'s procedure. The target letter was first presented for 700 ms in upper-case in the middle of the screen followed by a fixation point during 1 000 ms. The target word then appeared in lower-case for 33 ms. It was replaced by a blank screen presented for 70 ms followed by 50 ms mask consisting of hashes. Participants had to press “yes” if they detected the target letter in the word with their dominant hand or “no” if they did not detect it with the nondominant hand. The experiment was followed by a 10 trial training phase. The whole testing procedure lasted around 15 minutes.

Results

A combined analysis on the overall reaction times –on correct responses- on the three groups of participants revealed that homogeneity of variances, as assessed by the Levene test, was satisfactory, $F(2, 57) = 2.095$, $p = .132$, though close from classical criterion of $p = .10$. Results for the overall group of participants are presented here in Table 21.

For each analysis on letter- present and letter- absent trials, an Anova was conducted on reaction times and errors on both participants (F_1) and items (F_2) analyses. For letter- present trials, consistency condition was entered as a within-subject variable on the F_1 and as a between-subject variable on the F_2. Similarly, for the letter- absent trials, trap status was entered as a within-subject variable on the F_1 and between-subject variable on the F_2. In both analyses, group was entered as a between- subject variable on the F_1 and as a within- subject variable on the F_2.

Letter- present trials

Reaction times

Reaction times that were higher than 2.5 standard deviations on the participants' means were discarded. The main effect of group was significant on both participant and item analyses, $F_1(2,57) = 26.015$, $p < .001$, partial $\eta^2 = .48$, $F_2(2,76) = 423.48$, $p < .001$. This revealed that Grade 6 children were slower than Grade 8 children, 124 ms, $p = .04$ and than adults, 324 ms, $p < .001$. Grade 8 children were also significantly slower than adults, 201 ms $p < .01$. The main effect of consistency was also significant on both analyses, $F_1(1,57) = 7.467$, $p < .01$, partial $\eta^2 = .12$, F_2 $(1,38) = 5.17$, $p = .029$. This revealed that participants were faster on the consistent condition as compared to the inconsistent condition, 19 ms. The interaction between group and consistency condition did not reach significance, $F_1(2,57) = 2.263$, $p = .113$, n.s., $F_2(2,76) = 2.41$, $p = .10$, n.s. Yet, examination of consistency effects across groups revealed that this effect was significant for Grade 8 children (61 ms, $F(1,9) = 9.142$, $p = .014$, partial $\eta^2 = .50$) and for the adults (18 ms, $F(1,22) = 4.767$, $p = .04$, partial $\eta^2 = .18$) but not for Grade 6 children (4 ms, $F < 1$, n.s.).

Errors

There was a main effect of group by- items only, $F_1(2,57) = 2.466$, $p = .094$, $F_2(2,76) = 4.14$, $p < .05$. This reflected that Grade 6 children made more errors than the adults, 4.2 %, p < .05. Neither effect of consistency nor interaction between consistency and group reached significance, all Fs < 1, n.s.

Table 21. Mean reaction times in ms (and standard deviations) and percentages of errors for adults, Grade 8 children and Grade 6 children in letter- present trials (consistent vs. inconsistent conditions) and letter- absent trials (trap vs. standard conditions).

	Letter-present		Letter-absent	
	Consistent	Inconsistent	Trap	Standard
Adults				
	547 (122)	565 (140)	638 (146)	634 (152)
	5.9 (7.7)	6.8 (7.9)	6.3 (8.1)	5 (6.2)
Grade 8 children				
	726 (167)	787 (168)	865 (187)	818 (158)
	8.5 (4.7)	7 (8.6)	13 (6.7)	9.5 (14)
Grade 6 children				
	878 (170)	882 (196)	1019 (265)	1018 (245)
	11.8 (9.5)	9.1 (8.8)	11.1 (12.8)	10.6 (11.2)

Letter- absent trials

Group was entered as a between- subject variable on the F_1 and as a within-subject variable on the F_2. In addition, trap status was entered as a within- subject variable on the F_1 and between-subject variable on the F_2.

Reaction times

Reaction times that were higher than 2.5 standard deviations on the participants' means were discarded. The main effect of group was significant, $F_1(2,57) = 21.85$, $p < .001$, partial $\eta^2 = .43$, $F_2(2,76) = 240.22$, $p < .001$. This reflected faster reaction times for adults as compared to Grade 8 children (206 ms, $p = .01$) who in turn were faster than Grade 6 children (177 ms, $p = .02$). The effect of trap status did not reach significance, $F_1(1,57) = 2.862$, $p = .096$, $F_2(1,38) = 1.46$, $p = .23$, n.s., and neither did the interaction between group and trap status, $F_1(2,57) = 1.525$, $p = .23$, n.s., $F_2(2,76) = 1.58$, $p = .21$, n.s.

Errors

The effect of group reached significance by- items only, $F_1(2,57) = 2.282$, $p = .11$, n.s., $F_2(2,76) = 6.96$, $p < .001$. The effect of trap status did not reach significance, $F_1(1,57) = 2.196$, $p = .14$, n.s., $F_2(1,38) = 1.33$, $p = .26$, n.s., and neither did the interaction between group and trap status, all Fs < 1, n.s.

In sum, a cross- language consistency effect was evidenced for the letter- present trials. This effect reflected that letters that corresponded to the L1 grapheme- to- phoneme correspondence in the L2 target word were detected faster than when these same letters corresponded to a L2- specific correspondence. For instance, detecting the letter “A” in the English target word *black* where “a” → /a/ as in French was easier than detecting “A’ in the target word *take* where “a” → /eI/, which is an English specific grapheme- to- phoneme correspondence. This effect did not interact with group. Yet, given that homogeneity of variances across groups was only at $p = .13$ (standard criterion at $p = .10$) and that interaction probabilities were at $p = .13$ and $p = .10$ for participant and item analyses respectively, the effect was also examined for each group separately. This analysis revealed that though the consistency effect was significant for both Grade 8 and adult groups, it did not reach significance for Grade 6 children. Surprisingly, there was no trap status effect for the letter- absent trials. Though trap condition such as detecting the letter “I” in the target word *deep* was expected to trigger more false alarms and/or longer reaction times as compared to a standard condition of an absent target letter, this effect did not seem to emerge neither in reaction time nor error data.

Discussion

The present study aimed to test for cross- language feedforward graphemic consistency effects during a letter detection task in L2. In the case of letter- present trials, consistency was manipulated so that half of experimental words (one third of letter- present trials) contained a target letter for which its phonemic correspondence was consistent with L1 (“a” → /a/ or “i” → /i/) and the other half had a target letter for which the phonemic correspondence was inconsistent with L1 (“a” → /eI/ or /o:/ or “i” → /aI/ or /3/). With regard to letter- absent trials, a “trap” condition was included in half experimental items so that the L1 phonemic correspondence of the target letter was present in the word, while the letter itself was absent (“I” in the word *deep* which contains the phoneme /i:/). The other half of the items did not contain either the target letter or the phonemic correspondence (“I” in *black*).

The first finding to be discussed here concerns the cross- language consistency effect which was shown in the reaction time data indicating that participants were faster for the consistent as compared to the inconsistent condition. Closer examination of the pattern revealed that this effect was significant for the two older groups only, the Grade 8 children and the adults who had at least two and seven years of English learning, respectively. The 4 ms difference observed in the Grade 6 children group who had only started English a few months ago was not significant. This first result therefore reveals that, in the higher proficiency groups, phonological activation arose automatically during the letter detection task, although the target word was presented very briefly (34 ms[32]), an observation which is in line with previous studies using this same paradigm (see more phonological effects in the letter detection task, Gross, Treiman & Inman, 2000; Lange, 2002; Rey et al., 2000). As in the previous Study 6, these data also indicate that phonology may be activated in L2 in this population of L2 school learners from Grade 8 at Secondary School, and that participants had good knowledge of L2 grapheme- to- phoneme correspondences. Indeed, the presence of a consistency effect suggests that participants knew how to decode these English words. Consistency effects were however not significant in the Grade 6 group and this is also in keeping with findings by Commissaire et al. (2011) who reported chance level in L2 decoding skills in a similar group of participants. These data however cannot resolve whether or not the absence of effect for this group was due to poorly specified grapheme- to- phoneme correspondence knowledge or to a different phonological activation mechanism.

The consistency effect found for the letter- present trials may be interpreted as reflecting the influence of L1 sublexical phonology. All three correspondences used in the stimuli for both target letters “A” and “I” (“a” → /a/, /eI/ and /o/, and “i” → /i/, /aI/ and /3/) were legal and occurred in the English (L2) language (see Berndt, Reggia & Mitchum, 1987 for conditional probabilities of grapheme- to- phoneme correspondences in English) while only one of these correspondences occurred in French (L1, “a” → /a/ and “i” → /i/). The observation that detecting a letter when it corresponded to a cross-language consistent correspondence (“A” in *have*) was faster than when corresponding to an inconsistent one (“A” in *take*) may indicate that the strength of the consistent

[32] The fact that a blank screen of 70 ms was presented right after the target word however probably lengthened the presentation due to retinal persistence.

connection may have been stronger than for the inconsistent one. This finding may be easily understood within the monolingual BIAM (Diependaele et al., 2011) and bilingual BIA and BIA+ models (Dijkstra & van Heuven, 2002). Given that lexical access is supposedly language- nonselective and that stronger exposure may be expected to the consistent grapheme- to- phoneme correspondence than to the inconsistent correspondence –due to longer L1 exposure-, it is reasonable to assume that connections that are shared across languages such as in the consistent condition were activated faster than those that are specific to the L2, such as in the inconsistent condition. Nevertheless, several limitations must be taken into account in order to pursue this investigation and alternative accounts of this effect need to be addressed. Rather than providing support for cross- language influences, it is possible that the target letter, which was presented before the word, has been decoded in L1 and that the consistency effect found in the present study only reflects a phonemic similarity effect between the target letter and the word. Rey et al. (2000) showed in a similar paradigm that detecting a target letter was faster when phonemic similarity was allowed between the target letter and the word (e.g., detecting the target letter "O" whose letter name is /o:/ in the word *slope* where "o" → /o/) than when phonemic similarity was not possible (e.g., as in *prove* where "o" → /u/). If the target letter was decoded in L1 in the present study, then it is reasonable to assume that the consistency effect reflects the congruence between the target letter –and name- and the word pronunciation. In that case, this effect would only show that phonological activation was automatic and that participants could correctly decode the items but no clear- cut interpretation in terms of cross- language influences may be developed. However, the trap condition contained words which contained the letter name of the target letter in L1 (detecting "I" in *deep* where "ee" sounds like /i:/, letter name of the letter “I” in French). The fact that no effect of trap condition was found for the letter- absent trials seems to suggest that target letters were decoded in L2. In order to test for this alternative hypothesis in terms of target letter decoding, modulations of the paradigm may be legitimate such as cross- modal presentation of sound and target words (i.e., presenting the target letter orally followed by consistent vs. inconsistent written words) or manipulation of recent exposure to the L2 (i.e., in order to stimulate decoding in one language or in the other).

The notion of letter name may also have had an impact on the stimuli used in the *inconsistent* condition. For half of these items, the phonemic correspondence of the grapheme actually coincided with the letter name of the target letter in English (i.e., the “a” → /eI/ and “i” → /aI/ correspondences for target letters “A” and “I” as in the words *take* and *fire*). The other half items had a phonemic transcription which did not correspond to the letter name of the target letter (“a” → /o/ and “i” → /3/ as in *call* and *bird*). Letter name has been shown to exert a strong influence on monolingual literacy (Rey et al., 2000; Treiman, Sotak & Bowman, 2001) and this acquisition would merit investigation in L2. Examination of the reaction time data taking into account three consistency conditions (consistent; inconsistent but letter name; inconsistent) actually showed that the consistency effect was significant between consistent and inconsistent conditions only (p = .01) and that the letter name items were somewhat in the middle. Given that the consistent and letter name conditions (“A” → /a/ and /eI/ and “I” → /i/ and /aI/) contained print- to- sound correspondences that were also more frequent than the inconsistent condition (“A” → /o/ and “I” → /3/, see Berndt et al., 1987), it is not legitimate to draw any conclusions here about whether this post hoc result reveals the influence of letter name per se, or different connection strengths among the grapheme-to- phoneme correspondences representing language statistics (i.e., frequency of occurrence).

The lack of control of within- language rime consistency could constitute another limitation of the present study. Among the words used, some contained consistent mappings at the body/rime level in English (“ake” in the word take is always pronounced /eIk/ in monosyllabic words) while others had inconsistent mappings (e.g., the word *have* contains the body “ave” which can be mapped onto the rime /a:v/ as in *have*, but also onto /eIv/ as in *brave*). Among inconsistent words, two factors could have affected our results: the number of words that share or do not share this particular rime (i.e., friends and enemies) but also the summed frequency of the word(s) that share that rime. For instance, while the body/rime mapping “ave” → /a:v/ appears in only that one monosyllabic word, i.e., *have*, the frequency of that word is very high and the two factors could therefore lead to contradictory predictions. So, given the materials used in the present study was selected according to several criteria already, i.e., word frequency, length, type of grapheme- to- phoneme correspondence, position of the target letter, we could not manipulate body/rime consistency within English. However, given the strength of cross- language over within- language (L2) phonological influences (see Study 6), and the fact that body/rime consistency could play a minor role in French readers as compared to English readers, we assume that this factor did not interfere too much with the cross- language graphemic consistency effect uncovered in the present experiment.

The second aspect of the present study concerned the trap condition that was created in the letter- absent trials. Judging that the target letter was absent in a word would be expected to take longer or to entail more errors when these words contained the L1 phonemic transcription of the target letter to be detected (detecting “I” in the trap word *deep*) than when it would not (detecting “I” in the word *ball*). Surprisingly, no effect was found either for the reaction time or error data. Several explanations may be suggested in order to explain this null effect. Firstly, one could argue that phonology does not influence “no” responses and that responses were simply made on the basis of orthographic cues. It would be possible that participants based their response only on low- level orthographic cues and that words were not accessed phonologically. However, this first account seems unlikely for several reasons. It cannot be assumed that words were accessed phonologically when the target letter was detected within the word (yes responses), but not when the target letter was absent (no responses). If strategies in terms of reduced phonological activation were to be detected in the present study, these should have influenced all responses (McQuade, 1991). In addition, phonological activation for letter- absent trials has been reported by previous studies (Lange, 2002; Ziegler & Jacobs, 1995; Ziegler, Van Orden & Jacobs, 1997). For instance, Lange (2002) found that participants made more errors when detecting the target letter “J” in the pseudoword *geudi* where the grapheme “g” produces homophony with the real word *jeudi* (*Friday*). Note that she also found an effect in the pseudoword *bongour* where the grapheme “g” does not produce homophony with a real word if contextual rules are taken into account (“g” → /j/ when preceding the graphemes “e” and “i” but → /G/ when preceding the graphemes “a”, “o” and “u”) but does if context is not considered (“g” may also be pronounced /J/ and this word may therefore sound like *bonjour*, *hello*), suggesting that sublexical phonology may be understood in terms of co- activation of multiple grapheme- to- phoneme correspondences rather than as a rule- like phenomenon. Ziegler and colleagues reported more errors in a letter search task when participants were asked to detect the letter “I” in *gane* due to homophony with the lexical form *gain* than in a control pseudoword such as *garn*. Though these studies were in L1, they show that grapheme- to- phoneme correspondences may modulate letter detection latencies in the letter detection task, even in the case of the target letter being absent of the word. Secondly, the relative involvement of phonology versus orthography in detecting the target letter may have depended on participants’ speed of response. It could be hypothesized that the longer the response times, the stronger the influence of phonology and therefore the stronger the trap condition effect. A post- hoc analysis entering participants’ speed as a continuous predictor did not reveal any more information on the data so this variable of participants’ speed did not seem to explain the pattern. Thirdly, not all grapheme- to- phoneme correspondences under investigation may have been known by the participants and this may have affected the pattern of results. For the letter- absent trials, three target letters were used: I, E and O. In the case of the letter “I”, the trap condition was mostly constructed using items that contained complex graphemes such as “ee” or “ea” that sounded like /i:/ such as *deep*. For the letter E, items contained the grapheme “i” that sound like /3/ in words such as *bird*. Finally, for the letter “O”, items such as *call* were presented for which the grapheme “a” is sounded as /o:/. Given that these connections were specific to the L2, either containing new graphemes (“ee” and “ea”) or inconsistent connections with the L1 (“a” → /o:/ and “i” → /3/), it may be the case that our participants did not process these correspondences equally, and may have processed them differently across groups. Given these possible explanations, it seems that several factors may have entered the equation (speed of responses, letter and print- to- sound correspondences under interest, level of proficiency in each group) leading to multiple interacting effects. A final more theoretical explanation for this lack of effect is that sublexical orthography- to- phonology activation may not be interactive enough to trigger a bidirectional effect from grapheme- to- phoneme and phoneme- to- grapheme. As already mentioned, some authors argue *against* the existence of a feedback consistency effect (i.e., longer latencies for words such as *cheep* as compared to *probe* because the former rime /ip/ may be transcribed using two spellings, either “eep” or “eap” while the latter rime /ob/ only has one spelling counterpart, “obe”) in monolingual word recognition (Ziegler et al., 2008). Though our manipulation differs from what can be called feedback consistency, it also entails some bidirectional activations at the sublexical orthographic- to- phonology level. Future studies are therefore needed to understand whether this absence of effect may be explained by some methodological issues (characteristics of participants, choice of materials) or because of theoretical limitations.

To conclude, the present study revealed a cross- language consistency effect: detecting letters whose grapheme- to- phoneme correspondence was identical in both languages was faster than detecting the same letter in a word where the correspondence was different across languages. Again, this experiment revealed an automatic phonological activation during L2 visual word recognition, in a task where no phonological output was required and whose response could be based on pure visuo-orthographic processing. The consistency effect was interpreted as revealing cross-language influences at the sublexical phonological level. It also showed that multiple factors may be taken into account when assessing phonological effects in visual word recognition, such as decoding and knowledge of print- to- sound correspondences.

Part 3.

General Discussion

The goal of the present doctoral dissertation was to investigate word recognition mechanisms during second language (L2) acquisition. As hazardous as this may seem, this choice was to provide a broad perspective on various issues that seemed operative in the framework of L2 word recognition: the tuning of lexical orthographic representations, cross- language lexical interactions, sublexical orthographic coding (orthographic typicality and grapheme parsing) and orthographic- to- phonology connections. Before examining each of these issues in turn, a few general observations will be made about the population under interest and the context of L2 acquisition.

Most studies on L2 word recognition using on- line methodologies have made the choice to focus on adult bilinguals, usually of high proficiency in the nondominant language. These have proved to be an interesting population for examining a wide range of theoretical issues ranging from lexical organisation and access during visual and auditory word recognition (i.e., the debate on language- selective vs. nonselective lexical access, see Dijkstra & Grainger, 2002) but also phonological processing in the oral language (Broersma & Cutler, 2011 on phonemic confusion; Dupoux, Peperkamp & Sebastian- Galles, 2010 on stress deafness) or attentional and executive functions (Hernandez, Costa, Fuentes, Vivas & Sebastian- Galles, 2010 on executive control; Green, 2011 about language control). Though commonalities may be demonstrated in bilinguals who have a similar proficiency level, context of acquisition (i.e., family multilingual background, linguistic minority, school immersion programs or standard school acquisition), age of L2 acquisition as well as degree of exposure to the L2 are determinant factors too. Word recognition mechanisms in populations who learn a L2 at school have received little attention though this is one of the most customary contexts of L2 acquisition. This gap in the literature is especially significant for *children* or *adolescent* L2 learners at school (see Brenders et al., 2011 for a recent study). Those "L2 school learners" as they are referred to in the present work can be characterized as benefitting from little overall exposure to the L2 (around three to four hours per week during Secondary school), no previous oral language knowledge before exposure to the written format, robust experience with L1 oral and written language leading to possible cross- language influences. Though only L2 school learners were assessed in the present work, implying no comparison with other populations, several groups varying in proficiency/exposure were examined. Several issues were studied in this work, either focused on lexical or sublexical –orthographic and phonological- processes: some of these issues have already been examined in other populations (i.e., the language-nonselective lexical access debate or cross- language phonological influences) while others, were quite exploratory (i.e., the tuning of L2 representations, orthographic typicality and graphemic processing in L2).

1. On lexical representations: cross- language interactions and lexical tuning

One major focus of the present work was about testing language- nonselective lexical access in L2 school learners, a hypothesis that has achieved a wide consensus in relation to highly proficient bilinguals these last decades. Several lines of evidence including examination of cognate and interlingual homographs processing or cross-language orthographic and phonological connections have revealed in highly proficient bilinguals that lexical representations are co- activated in the initial phases of lexical access in visual word recognition, whatever the language they belong to (Bijeljac- Babic et al., 1997; De Groot & Nas, 1991; Dijkstra et al, 1998, 1999, 2002, 2010, 2011; Font, 2001; Font & Lavaur, 2004 ; Gollan et al, 1997; Grainger & Dijkstra, 1992; Jared & Szucs, 2002; Kim & Davis, 2003; Lemhöfer & Dijkstra, 2004; Lemhöfer et al., 2004; Midgley et al., 2008, 2010; Schwartz et al., 2007; van Hell & Dijkstra, 2002; Van Heuven et al., 1998). This lexical organization principle has also been revealed to be valid in visual sentence recognition (Duyck et al., 2007), speech production (Costa et al., 2000, 2005; Kroll, Bobb, Misra & Gruo, 2008), and speech comprehension (Marian & Spivey, 2003). This issue has also been tested, though far less, in special populations such as children (Brenders et al., 2011) and older participants (Siyambadapitiya, Chenery & Copland, 2009 using cognates), and in individuals with disorders such as acquired aphasia (Goral et al., 2006) and deafness (co- activation of orthographic form of words and corresponding sign translation, Morford et al., 2001). However, this huge literature has concerned highly proficient bilinguals who are supposed to master the nondominant language very efficiently and who are exposed to and/or use this language on a daily basis. Given the relative paucity of empirical data on L2 learners of low proficiency and little L2 exposure, the aim was to test the language- nonselective lexical access hypothesis in L2 school learners of varying proficiency.

Table 22. Summary of the findings from Chapter 1.

Study 1. Within- language priming.			
Adults	RT	**Orthographic typicality**	English non- specific words faster than English specific words (24 ms)
		Priming	(Identity and Form p. combined) faster than Unrelated p. (34 ms, $p < .001$). Identity faster than Form p. (31 ms, $p < .01$)
	Errors	-	

Grade 8 children	RT	**Orthographic typicality**	n.s.
		Priming	(Identity and Form p. combined) faster than Unrelated p. (21 ms, $p < .05$). Identity faster than Form p. (32 ms, $p < .01$)
	Errors	-	
Adults & Grade 8 children (exploratory)	RT		Simple grapheme condition: Identity faster than Form p. (36 ms, $p < .01$) Identity faster than Unrelated p. (40 ms, $p < .01$) No difference between Form and Unrelated p. (4 ms, n.s.) Complex grapheme condition: No difference between Identity and Form p. (17 ms, n.s.) Identity faster than Unrelated p. (41 ms, $p < .05$) No difference between Form and Unrelated p. (24 ms, n.s.)
		Study 2. Cognate experiment	
Grade 8 children	RT	**Frequency**	High Frequency faster than Low Frequency (41 ms)
		Status	Cognates slower than (English specific and non- specific controls) (58 ms, $p < .05$) English non- specific words faster than specific words (41 ms, $p < .01$)
	Errors	**Interaction**	Frequency effect for English non- specific condition only (12%, $p < .01$)
		Study 3. Cross- language priming.	
Part 1. L2- to- L1 priming			
Adults	RT	**Session**	Second session faster than first session (63 ms)
		Relationship	Related p. slower than Unrelated p. (15 ms)
		Prime language	French p. faster than English p. (20 ms)
	Errors	**Session**	First session less accurate than second session (4.2%)
		Relationship	Related p. less accurate than Unrelated p. (3%)
Grade 8 children	RT	**Session**	Second session faster than first session (65 ms)
		Relationship	Related p. faster than Unrelated p. (20 ms)

	Errors	**Session**	First session less accurate than second session (5.1%)
Grade 6 children	RT	**Session**	Second session faster than first session (67 ms)
	Errors	**Session**	First session less accurate than second session (6%)
		Session * Relationship	Inhibition in first session (3.5%, n.s.) Facilitation in second session (- 3.9%, n.s.)
Part 1. L2- to- L1 priming. Follow- up study 1			
Adults	RT	**Prime language**	French p. slower than English p. (20 ms)
		Prime frequency	Faster for High Frequency p. than Low Frequency p. (24 ms)
		Relationship	Related slower than Unrelated p. (ms)
		Prime language * Prime frequency * Relationship	For English primes: Inhibition p. effect for High Frequency p. (31 ms, $p = .06$) Null effect for Low Frequency p. (- 2 ms, n.s.) For French primes: Null effect for High Frequency p. (- 6 ms, n.s.) Nnsignificant inhibition for Low Frequency p. (26 ms, n.s.)
Grade 8 & Grade 6 children combined	RT	**Prime frequency**	Faster for High Frequency p. than Low Frequency p. (53 ms)
		Prime frequency * Relationship	Null effect for High Frequency p. (- 2 ms, n.s.) Facilitation effect for Low Frequency p. (-30 ms, $p < .05$)
Part 1. L2- to- L1 priming. Follow- up study 2			
Adults	RT	**Session**	Second session faster than first session (56 ms)
		Prime language	French p. faster than English p. (12 ms)
		Prime language * Relationship	Significant inhibition for English p. (19 ms, $p < .05$) Null effect for French p. (- 6 ms, n.s.)
	Errors	**Session**	Second session more accurate than first session (5.2%)
		Prime language	French p. more accurate than English p. (2.2%)
Part 2. L1- to- L2 priming.			
Adults & Grade 8 children	RT	**Group**	Adults faster than Grade 8 children (95 ms)
		Session	Second session faster than first session

		(62 ms)
	Session * Relationship	Null effect for the first session (6 ms, n.s.) Facilitation effect for the second session (-16 ms, $p < .05$)
	Prime Frequency * relationship	Null effect for High Frequency p. (5 ms, n.s.) Facilitation effect for Low Frequency p. (-17 ms, $p < .01$)
	Group	Adults more accurate than Grade 8 children (2.9 %)
Errors	**Session**	Second session more accurate than first session (.06%)
	Prime frequency	High Frequency p. more accurate than Low Frequency p. (2.3 %)

The cognate experiment from Study 2 aimed to test for language- nonselectivity in a group of French-speaking Grade 8 participants who have been learning English as a L2 for two years. Cognate words were presented along with monolingual English (L2) control words in an English lexical decision task. According to previous studies, a cognate effect would indicate that membership of two languages - target and nontarget language of the task- induced different processing times as compared to pure monolingual words, an interpretation that would support the co- activation of both L1 and L2. Though cognate effects have been shown to be facilitatory in this same task in highly proficient bilinguals (see Dijkstra & van Heuven, 2002 for a review) and, more recently, in child L2 learners (Brenders et al., 2011), the effect was inhibitory in the present experiment. Though the direction of this effect clearly contrasts with that of Brenders et al. (2011), this finding may be interpreted as reflecting the influence of nontarget language (L1) on English (L2) lexical processing and reveals some interaction between the two languages, though possibly at a post- lexical level. Note that conditions of our experiment slightly differed from that of Brenders and colleagues (2011). In contrast with standard studies on cognate processing, monolingual control words in our experiment were manipulated according to orthographic typicality and proportion of cognates within the "yes" responses was lower (i.e., a quarter of items in our experiment as compared with half of them in Brenders et al.). In terms of the BIA model of bilingual word recognition, this effect may be accounted for by the feedback activation from language nodes to word nodes. Given the language ambiguity of cognate words, these activate L1 language node more strongly than L2's, even in a L2 lexical decision task. This L1 language node in turn activates back L1 words, but also inhibits L2 words and the corresponding L2 language node. This mechanism could therefore explain the inhibition found for cognate words as compared with monolingual L2 words.

The second study on cross- language lexical interactions described in Study 3 explored the neighbourhood frequency priming effect from L2- to- L1[33] (experiment 1 and follow- up study 2) and from L1- to- L2 (experiment 2). The rationale behind these experiments was that a cross- language *inhibition* priming effect would reveal the presence of lexical competition across languages, and therefore co- activation of lexical representations whatever the language (Bijeljac- Babic et al., 1997; Dijkstra et al., 2010). Overall, a cross- language inhibition priming effect per se proved difficult to observe, but the interactions that were observed between priming effect and prime frequency point to the existence of links across the two languages. In the adult groups, an inhibition priming effect was found from L2- to- L1 in two different groups of participants that proved independent of task instructions (experiments 1 and follow- up study 2). Surprisingly, an interaction between session and relationship emerged only

[33] The within- condition L1- to- L1 was also investigated within the same experiment. For sake of clarity, this issue will not be addressed in the General Discussion.

from L1- to- L2: this reflected a facilitation effect in the second session but a null effect in the first session. This absence of an inhibition priming effect from L1- to- L2 was unexpected given that a stronger influence from the dominant to the nondominant language was expected within the framework of BIA. This could have been explained by target frequency. Given that English target words had to be known by the children, these words were chosen so that they were highly frequent. This high frequency seems to have implied short reaction times –shorter indeed than for the L1 lexical decision task from experiment 1-, and therefore too little time for the influence of inhibition to arise. In the children groups, no inhibition effect was observed for neither L2- to- L1 or L1- to- L2. However, clear interactions between priming effect and prime frequency were observed in both follow-up analyses of experiment 1, from L2- to- L1, and in experiment 2, from L1- to- L2. Though simple effects did not reveal an inhibition effect *per se*, the interaction revealed the influence of the prime from one language onto the processing of the target word from the other language, which therefore supports the language- nonselective lexical access hypothesis. Several variables whose impact has proved important in previous studies also seemed relevant in the present experiments. Inhibition priming was seen to be stronger for the first session of presentation (as for Dijkstra et al., 2011 in a comparable study with Dutch- English highly proficient adult bilinguals; Grainger & Jacobs, 1999) as well as when preceded by high frequency prime words (see post hoc analysis of experiment 1 and children results from experiment 2, Nakayama et al., 2008; Segui & Grainger, 1990).

Two more findings were congruent with the literature. First, the absence of an instruction effect (mention vs. no mention of the relevance of the nontarget language) in the L2- to- L1 priming experiment 1 confirmed that co- activation of the two languages is automatic and was not enhanced even when the conditions were not as purely monolingual. This suggests that the identification system is not directly modulated by nonlinguistic factors, as postulated in the BIA+ model (Dijkstra & van Heuven, 2002; see also Green, 1998). Second, a language switching cost was found in experiment 1 and follow- up study 2 in adult participants: target processing was longer in the different- language prime condition as compared to the same- language prime condition. This result confirms previous literature on the topic (Beauvillain & Grainger, 1987; Chauncey, Grainger & Holcomb, 2008; Orfanidou & Sumner, 2005; Von Studnitz & Green, 1997). It also adds to the evidence for language- nonselectivity in the higher proficient group by showing the influence of lexical properties of the prime on the processing of target words.

In all, testing for language- nonselective lexical access in low- proficiency L2 learners has proved to be a difficult task, both when assessing cognate processing and cross- language orthographic neighbourhood effects. Language- nonselectivity, as measured by cross- language lexical competition, was quite clearly observed in the adult group, though significantly from L2- to- L1 only. This result itself certainly contrasts with the previous findings of Bijeljac- Babic and colleagues (1997). In the children, evidence for cross- language interactions were found: a cognate inhibition emerged in Study 2 and the influence of prime characteristics on the processing of target words from another language was reported in Study 3, both from L2- to- L1 (follow- up study 1) and from L1- to- L2. Though this debate has mostly prevailed in the bilingual literature, a few comments can be made here about its origin and the extent to which interlingual connections are representative of L2 processing. Language- nonselectivity, by definition, concerns those words that are orthographically –or phonologically-similar across languages. This includes cognate and interlingual homographs, which may be identical (*silence*) or orthographically similar (*tomato* – *tomate*) and orthographic or phonological neighbours (*rire – fire* and *rire – deer*). One first comment is that mostly monosyllabic and short words are concerned by this co- activation given that the longer the word length, the fewer the neighbour words. One recent study by Vitetitch (2012) has highlighted this shortcoming in this debate. The author conducted a corpus analysis of phonological neighbourhood within and across the English and Spanish languages. Their observations appear to undermine the impact of language-nonselectivity: indeed, both of these languages had very few phonological neighbours in the other language and the proportion of neighbours was much higher within the language. These observations on cross- language *phonological* neighbourhood are quite consistent with the findings from Lemhöfer and colleagues (2008). In order to overcome the limitations implied by factorial designs (i.e., matching the stimuli on all relevant dimensions which are supposed to be held constant, loss of information inherent to the need for using dichotomous variables while these are inherently continuous) and to conduct studies on more representative items, they chose to conduct a multiple regression analysis on reaction times observed for a large sample of English (L2) items (1 025 monosyllabic words) for three groups of bilinguals whose L1 was either French, German or Dutch. Interestingly, most factors that significantly explained the data were within- language variables: word frequency, morphological family size, number of higher frequency within- language neighbours and semantic variables. In contrast, only one between- language variable was reported to explain significant variance in the reaction times, namely cognate status. There was however no evidence for the influence of cross- language neighbourhood: either number of cross- language neighbours (or summed frequency) or the influence of the number of higher frequency neighbours. Note though that the frequency of the most frequent cross- language neighbour did not seem to be taken into account in the analysis. Thus, cross- language interactions at the level of lexical representations may be reported when the study design encourages its emergence and this seems to be apparent whatever the language pairings (see Voga & Grainger, 2007 for cross- script cognate effect; Dimitropoulou, Duñabeitia & Carreiras, 2011 for cross- script phonological priming effect) but the use of a large sample of more representative items would tend to cover up its influence. This finding sheds some light on the need for current theoretical models of bilingual word recognition to focus on *within- language* variables as well as between- language variables.

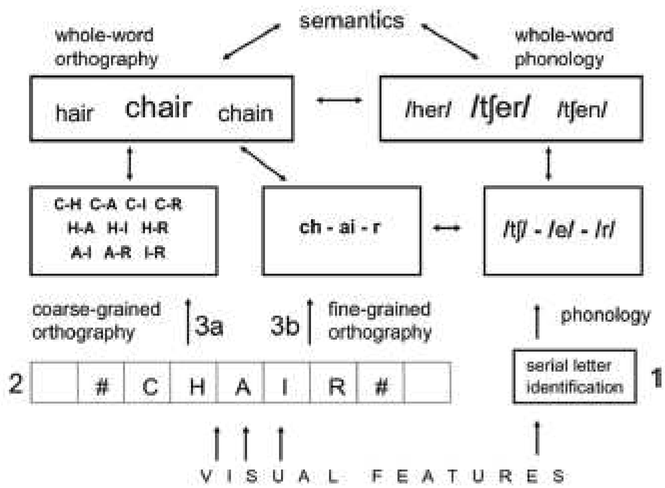
Given the importance of within- language variables in examining L2 word recognition, one previously unaddressed issue that concerned the "tuning" or precision of L2 orthographic representations was explored. Until the recent studies from 2010 by Grainger and colleagues about developmental aspects of word recognition (Dufau et al., 2010; Glotin et al., 2010; Grainger & Ziegler, 2011; Grainger et al., 2012), most work on the topic had been conducted by Castles and her team. Castles and colleagues, inspired by the search- model of lexical access by Forster (1987), developed a theoretical framework in order to investigate word recognition development in monolingual children, namely the *lexical tuning hypothesis* (Castles et al., 1999; 2007; Davis et al., 2005). This hypothesis postulates that orthographic representations should be more and more fine-tuned - or precise - as vocabulary grows. At the beginning of reading acquisition, only a few words would be in the developing lexicon and the orthographic representations would have no need to be finely tuned given there would be few candidates that compete during lexical access. This lack of precision would concern both letter identity and letter position in the word. Progressively, as vocabulary grows and new written lexical forms are learned (substitution neighbours such as *fight* – *light* - *might* – *night* – *right* – *sight*, or transposition neighbours such as *trial* - *trail*), orthographic representations would become more fine- tuned in order to maximize lexical access efficiency. According to this view, these developmental changes in word recognition would therefore be dependent on vocabulary growth. In monolinguals, letter identity tuning was investigated by means of orthographic neighbourhood size effects (Castles et al., 1999; see also Duñabeitia et al., 2008 and Laxon et al., 1988, 2002) while letter position coding was investigated with transposed- letter priming effects (Castles et al., 2007; see also Grainger et al., 2012 and Perea & Estevez, 2008).

In Study 1, this lexical tuning issue was tested in L2 school learners of varying L2 exposure/years of learning and vocabulary (i.e., adults and Grade 8 children) by comparing identity and form priming effects in a masked primed lexical decision task. The rationale was that any priming difference between these two orthographically related conditions (identity and form conditions) would reflect the existence of a fine-tuned coding, sensitive to the one- letter difference between the two priming conditions. Conversely, no priming difference would be in favour a broad-tuning mechanism of word recognition. The findings showed that the tuning of L2 lexical representations could be considered as highly precise as early as after two years of English learning, from Secondary Grade 8. In addition, this fine- tuned mechanism was present for English words of varying orthographic typicality, for both English specific words that contain orthographic sequences that are not legal in French (L1) and English non-specific words for which orthographic sequences are legal in both languages. An exploratory analysis revealed that precision was possibly lower when the letter change between the form prime and the target was embedded in a complex English specific grapheme such as –oa (e.g. *bowt – BOAT)*. For these target words, no significant difference emerged between identity (*boat – BOAT*) and form priming conditions (*bowt-BOAT*), revealing possible broadly- tuned coding of complex graphemes that are legal in the L2 only. Both of these sublexical findings are more specifically discussed within the next section on sublexical orthographic coding.

Recently, a novel theoretical view, which also refers to the precision of orthographic representations, has been proposed in monolingual research to account for developmental changes in word recognition[34]. Grainger & Ziegler (2011) suggested that there may be two orthographic routes depending on the precision of the sublexical orthographic coding.

[34] We chose not to present here any *developmental* theories of reading acquisition that also give some clues about developmental changes in word recognition (for most recent discussion, see Ehri, 2005). On the whole, developmental theories assume that reading acquisition procedes from the initial involvement of a sublexical grapheme- to-phoneme conversion route to reading which processes graphemes sequentially, followed by the progressive establishment of a lexical orthographic route to reading, also called "sight word reading" by Ehri (2005), which processes letters in a parallel fashion, similarly to the expert reader (see Sprenger- Charolles et al., 1998, 2003 for precise investigation of these mechanisms in a French population and Share (1995, 2008) about the development of orthographic representations in children).

Figure 6. Representation of the routes from visual input to semantics. Pathway 1 represents the orthography- to- phonology route to meaning. Pathway 2 represents the emergence of a parallel letter identification process, similar to the one developed by the IA model (McClelland & Rumelhart, 1981). This parallel and abstract letter identity coding is then computed into two co activated pathways. Pathway 3a corresponds to a coarse- grained sublexical orthographic route while Pathway 3b corresponds to a fine-grained sublexical orthographic route. From Grainger & Ziegler (2011).



As represented in Figure 6, several pathways to reading are supposed to emerge during reading acquisition. Pathway 1 represents an orthography- to- phonology route where the letters are *serially* identified (in the direction of the language) on the basis of visual features and then converted into the corresponding phonemes which contact the phonological lexicon. Developmentally, this is the first mechanism to reading that emerges (Ehri, 2005; Sprenger- Charolles et al., 1998, 2003). Pathway 2 then represents the development of a *parallel* letter identification process which codes for abstract letter identity simultaneously for each position in a word. This pathway is then divided into two co- activated orthographic routes. On the one hand, a coarse- grained orthographic route (pathway 3a) converts letters into open- bigrams composed of contiguous and noncontiguous letters. This open- bigram coding was developed by Grainger & van Heuven (2003, see also Whitney, 2001 for a close theoretical proposition) in order to account for transposed- letter priming effects. Both contiguous and noncontiguous bigrams are supposed to be coded while keeping the relative order or letters. As an example, the word *chair* may be coded with ten bigrams: contiguous bigrams CH HA AI IR and non-contiguous bigrams CA CI CR HI HR AR (note that simulations of orthographic effects using this code may modulate the different bigram weights according to the number of intervening letters in the noncontiguous bigrams, Dufau et al., 2010). This type of flexible code is supposed to best constrain word identity by enabling a fast activation of the semantic code of the word[35]. On the other hand, a fine-grained route to reading (pathway 3b) which would code letters into graphemes is necessary to make the link between orthographic and phonological codes of the visual input. This type of sublexical orthographic representation as represented by graphemes or morphological units (the "chunking" constraint) would therefore quickly map into a phonological, and eventually, morphological representation. So, while both pathways 3a and 3b directly contact the orthographic lexicon, only pathway 3b makes a connection to phonology by converting graphemes into phonemes.

This new theoretical proposition therefore takes into account the possible diverse nature of the sublexical orthographic code in terms of level of precision. Though this model distinguishes two types of letter *position* coding, not letter *identity* coding, and does not specify the developmental mechanism that enables the emergence of these two

[35] Note that orthographic learning using this coarse- grained orthographic code was successfully simulated by two methods, Self Organising Maps (or SOMs, Dufau et al, 2010) and Adaptive Resonance Theory algorithms (ART, Glotin et al., 2010) and therefore proves to be a realistic coding for development of the lexicon.

sublexical orthographic routes, the premises of this new proposal for orthographic coding should be further investigated and the findings be applied to the L2 word recognition field. Given the high flexibility of open- bigram coding, this type of coding may not be too influenced by the language, either L1 or L2 (considering both languages share the same alphabet). Most possible bigrams that occur in L2 could occur in L1 given both contiguous and noncontiguous bigrams are coded. Conversely, the fine-grained orthographic route is supposed to “chunk” letters into relevant units such as graphemes and morphemes, in order to facilitate phonological and morphological processing of the written word. This specific sublexical orthographic route would possibly need some transformation when dealing with a L2, whose graphemes, and especially complex graphemes, differ from the L1’s.

The role of vocabulary as the variable modulating word recognition mechanisms also merits comment. According to the lexical tuning hypothesis developed by Castles et al. (1999, 2007), the more words individuals have in their lexicon, the more the need for discrimination and therefore the more precise the level of lexical representation tuning. In the case of our population of L2 school learners, vocabulary was shown to be restricted to highly frequent English words (though vocabulary scores were larger for the adults as compared to the children) and exposure to the written language is low given the learning context of the L2 (three to four hours of English classes per week during the school year). Given the restricted vocabulary in L2 of these participants, it seems unlikely that participants had to develop fine- grained L2 orthographic representations due to discrimination needs in the L2 lexicon. It is suggested instead that it is not vocabulary in the language *per se* that constrains word recognition mechanisms, but some more general reading- related skill. As recently demonstrated by

Andrews and colleagues, written language proficiency in adult participants, as measured by reading, spelling and vocabulary, determines the degree of precision of orthographic representations, this is the so- called *lexical quality* hypothesis (Perfetti, 1992; see Burgund, Schlaggar & Petersen, 2006 for disentangling the contributions of general maturation from that of reading skill in the development of perceptual expertise for reading). Not only higher written language proficiency is related to higher level of lexical competition but also to stronger nonword facilitation priming (Andrews & Hersch, 2008; Andrews & Lo, 2012). In our study, although participants had a small L2 vocabulary, they had extensive exposure to their L1, and had already developed literacy skills in that language. It is therefore not surprising that lexical tuning overall seemed finely- grained as soon as after two years of exposure. The increasing field on individual differences in orthographic coding (Andrews & Hersch, 2010; Andrews & Lo, 2012) points to the need for examining individual differences in both L1 and L2 reading-related skills by examining larger samples of participants and the contribution of these skills to the level of tuning of L2 lexical representations.

2. On sublexical orthographic coding

Studies 4 and 5 aimed to further examine the orthographic pathway, more precisely at the sublexical level. When learning a L2, individuals are confronted with orthographic sequences that are very specific to the L2, from the L2 learners' point of view, which they need to acquire and associate to the corresponding phonemes. They also encounter orthographic patterns that are legal in the L1 and may occur in several L1 words. Orthographic typicality has been reported to have an early influence on monolingual lexical access, prior to any lexicality or frequency effect (Hauk et al., 2006). In bilinguals, orthographic typicality has been shown to affect language decisions (Vaid & Frenck- Mestre, 2003) as well as the degree of language switching cost (Grainger & Beauvillain, 1987; Orfanidou & Sumner, 2005; see though Thomas & Allport, 2000). Yet, the interpretation of these effects usually lies at a lexical or post-lexical level. Judging the language membership of words is faster for those words that contain language orthographic markers (i.e., *right* in English; *vieille* in French) as compared to those that are more non- specific, and this may be interpreted as reflecting the feedback from language nodes to lexical nodes. Words with orthographic markers would more strongly activate the corresponding language node, which would in turn inhibit the other language node and corresponding lexical representations. Again, the decrease of language switching cost when orthographic markers are present may be interpreted as a reduced lexical competition from the nontarget language (see though Green, 1998 and Thomas & Allport, 2000 for other interpretation of language switch cost in terms of task switching and more general cognitive control). In the present work, an investigation was conducted of the extent to which orthographic typicality has an influence during the earlier phases of lexical access (i.e., at the sublexical level). Previous results from Chapter 1 first revealed that the tuning of lexical representations, as measured by the difference between identity and form priming effects, was similar for specific and non- specific English (L2) words in both adult and Grade 8 participant groups. This same experiment revealed, for the adult group only, an advantage for English non- specific target words (*house*) as compared to English specific words (*right*). This latter English non- specific advantage was also reported in Study 2, in a group of Grade 8 learners. The goal of Study 4 was to replicate this orthographic typicality effect and to examine to what extent sublexical and/or lexical variables accounted for it. In the lexical decision task from Study 4, the English non- specific advantage in was also observed in the reaction time data, though the effect was numerically much larger for the adults than for the Grade 8 children[36]. In addition, this advantage was also shown in the Grade 6 children group, who had only a few months of L2 learning. Although this advantage for English non- specific over English specific words –or disadvantage for English specific words- was first assumed to reflect a sublexical effect (due to the presence of uncommon orthographic sequences in English specific words), this sublexical hypothesis was not supported by the exploratory regression analyses. First, a sublexical variable supposed to measure the "atypicality" of a word, namely bigram frequency in L1 – mean or minimal bigram frequency- did not explain significant variance in either English specific or non- specific word latencies. Second, a cross- language lexical variable did explain significant variance in English non- specific word latencies, namely the cumulative frequency of cross- language neighbours. So, the precise locus of this effect remains quite unclear and more studies are needed. Probably a larger set of items should be used in order to exert better control over all within- and cross- language parameters that may influence visual word recognition. The regression methodology used by Lemhöfer et al. (2008) associated with larger samples of participants could also help in disentangling lexical from sublexical effects. In addition, the relative difficulty of separating the contributions of orthographic and phonological variables, and of assessing early sublexical effects indicates that the lexical decision task may not be the best methodological tool for

[36] Note that target words from Studies 1 and 2 were similar in terms of length (4 or 5 letter long) and written frequency.

examining this issue. Given these observations, the decision was to consider orthographic sublexical effects at a more precise level, by using a task that has been shown to tap into initial phases of lexical access.

Table 23. Summary of the findings from Chapter 2.

Study 4. Typicality experiment.				
Adults & Grade 8 combined	RT	**Words**		
			Group	Adults faster than Grade 8 children (72 ms)
			Orthographic typicality	English non- specific words faster than English specific words (21 ms)
		Pseudowords	-	
	Errors	**Words**		
			Group	Adults more accurate than Grade 8 children
		Pseudowords		
			Group	Adults more accurate than Grade 8 children
			Orthographic typicality	English non- specific more accurate than English specific pseudowords (3.9%)
Adults & Grade 8 children combined (exploratory)	RT	**English non- specific words**		Effect of group, $F = 22.392, p < .001$ Effect of target Frequency, $F = 4.979, p < .05$ Effect of cumulative frequency neighbourhood, $F = 5.155, p < .05$
		English specific words		Effect of group, $F = 20.252, p < .001$ Effect of target Frequency, $F = 7.33, p < .01$
Grade 6 children	RT	**Words**		
			Orthographic typicality	English non- specific words faster than English specific words (111 ms)
		Pseudowords	-	
	Errors	**Words**	-	
		Pseudowords		
			Orthographic typicality	English non- specific more accurate than English specific pseudowords (5.3%)

Grade 6 children (exploratory)	RT	**English non- specific words** **English specific words**	No correlations; No significant predictor
		Study 5. Grapheme experiment.	
Adults	RT	**Graphemic condition**	Simple graph. faster than complex graph. (specific and non- specific) (18 ms, $p < .05$) No difference between specific and non- specific complex graph. (15 ms, n.s.)
	Errors	-	
Grade 8 children	RT	-	
	Errors	-	
Grade 6 children	RT	**Graphemic condition**	Simple graph. faster than complex graph. (specific and non- specific) (40 ms, $p < .05$) Non- specific complex graph. faster than specific complex graph. (45 ms, $p < .05$)
	Errors	-	

Study 5 specifically focused on the grapheme level during visual word recognition. Graphemes have been shown to be relevant units at the sublexical orthographic level per se (Rey et al., 2000) but also at the sublexical orthographic- to-phonology interface in adult participants (Rey & Schiller, 2005; Rey et al., 1998 in English and French) and more recently in children (Marinus & de Jong, 2011). The aim was to investigate the extent to which graphemes were used as functional units in L2 word recognition in three groups of participants, and whether the language specificity of graphemes had an influence. The rationale was that graphemes may be considered as functional units during lexical access if dealing with complex graphemes (or multi-letter graphemes) triggered a processing cost as compared to simple graphemes. No difference between simple and complex grapheme processing would constitute evidence against graphemic coding. Next, the language specificity effect was assessed by comparing words whose complex grapheme was shared across languages or non- specific (*hour*) as compared to those that were specific to the L2 (*boat*). The idea was that any difference between these two conditions would reflect a cross- language influence at this graphemic level. A general graphemic complexity effect emerged – a difference between simple and complex graphemes- in both Grade 6 children and adults, although this effect surprisingly did not emerge in the Grade 8 children. While detecting the target letter took longer in English specific complex graphemes as compared to English non-specific complex graphemes for the Grade 6 children, this was not the case for the adults who performed similarly for specific and non- specific complex grapheme condition. These findings were interpreted as reflecting that the grapheme was a functional unit in L2 visual word recognition as early as after a few months of English learning, possibly revealing that word recognition mechanisms developed in L1 rapidly transferred to L2 (see Marinus & De Jong about graphemic effects in monolingual children aged ten years old). The finding of a language specificity effect in the beginner group may only reveal that these specific graphemes have induced an additional cost in processing as compared to non- specific complex graphemes. Considering that there may be a graphemic level between the letter and word levels, this additional cost could reflect the slower activation for L2 specific graphemes, due to reduced exposure to these graphemes as compared to non- specific graphemes, which also occurred in L1. The fact that adults seemed to similarly process English specific and non- specific complex graphemes could indicate that these participants had successfully integrated both types of L2 graphemes.

In this connection, it is worth mentioning again the exploratory analyses from Study 1. These analyses revealed that the tuning of lexical representations, as measured by the difference between identity and form priming conditions, was lower when the letter change between prime and target was embedded in a complex grapheme as compared to when it corresponded to a simple grapheme. For instance, while the difference between identity and form priming conditions was significant for the simple grapheme condition (*boat*- *BOAT* as compared to *doat*- *BOAT*), this difference did not reach significance for the complex grapheme condition (i.e., *boat*- *BOAT* as compared with *bowt*- *BOAT*). Though other variables such as letter position in the word may have influenced this finding [37] (Guerrera & Forster, 2007), this exploratory analysis points to the need for deepening research on the graphemic level, in both bilingual and monolingual populations. Particularly, comparing complex graphemes made of vowels such as "oo", "ea", "ou", "ee" with those containing consonants such as "th" or 'sh' could also be of interest given the recent findings on processing differences between vowels and consonants (Duñabeitia & Carreiras, 2011; Lupker, Perea & Davis, 2007; Perea & Acha, 2009). Investigating the influence of L1 specific graphemes on L2 visual word recognition could also prove to be a relevant issue for understanding orthographic grapheme coding as well as its phonological coding counterpart. For instance, many complex graphemes are also specific to the French language: "an", "on", "in", "ain" and the extent to which French learners of English *wrongly* "transfer" this coding mechanism to English could be examined (see for instance Cutler, Mehler, Norris &

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[37] An attempt was made to match both simple and complex grapheme conditions in terms of letter change position when creating the stimuli. Yet, the simple condition was often possible only for external (initial) positions, while the complex condition could mostly be created in a middle position (position 3).

Segui, 1989 on the incorrect syllabic segmentation in speech comprehension in L2 learners and bilinguals). In sum, more studies are needed about orthographic sublexical mechanisms to understand how children and adults L2 learners acquire the orthographic specificities of a language. The present studies also emphasize the gap that seems to exist in the monolingual literature, both in terms of empirical data on grapheme processing and of precise theoretical hypotheses concerning the grapheme level, its connection to both orthographic and phonological pathways and its development (see though recent proposals by Grainger & Ziegler, 2011).

3. On the orthography- to- phonology interface

Table 24. Summary of the findings from Chapter 3.

Study 6. Pseudohomophone Interference effect			
Experiment 1. Within- language homophony			
Grade 8 children (English as L1)	RT	-	
	Errors	**Pseudoword status**	Graphemic controls more accurate than pseudohomophones (5%)
Experiment 2. Cross- language homophony			
Grade 8 children (English as L1)	RT	**Pseudoword status**	Graphemic controls faster than pseudohomophones (93 ms)
	Errors	**Pseudoword status** -	Graphemic controls more accurate than pseudohomophones (7.8%) Check (questionnaire)
Study 7. Cross- language orthographic- to- phonology inconsistency			
Adults, Grade 8 and Grade 6 combined	RT	**Letter present trials** **Group**	Adults faster than Grade 8 children (201 ms, $p < .01$) Adults faster than Grade 6 children (324 ms, $p < .001$) Grade 8 children faster than Grade 6 children (124 ms, $p < .05$)

	Consistency	Consistent faster than inconsistent (19 ms) N.B. Adults consistency effect: 18 ms, $p < .05$ Grade 8 children consistency effect,: 61 ms, $p < .05$ Grade 6 children consistency effect: 4 ms, n.s.
	Letter absent trials **Group**	Adults faster than Grade 8 children (206 ms, $p < .01$) Adults faster than Grade 6 children (383 ms, $p < .001$) Grade 8 faster than Grade 6 children (177 ms, $p < .05$)
Errors	**Letter present trials** **Group**	Adults more accurate than Grade 6 children (4.2%, $p < .05$) No difference between adults and Grade 8 children (1.4%, n.s.) No difference between Grade 8 and Grade 6 children (2.7%, n.s.)

Studies 6 and 7 from Chapter 3 aimed to investigate phonological activation during L2 visual word recognition. Specifically, several issues were raised: 1) whether phonological information was activated in a L2 lexical decision task in L2 school learners who had only a few years of L2 learning; and 2) whether cross- language influences could be observed at the sublexical level. Given that this project was partly designed in Scotland, Study 6 was conducted with English speakers who learn French as a L2. In this study, pseudohomophones were introduced into a lexical decision task in French. These pseudohomophones sounded like real L2 words when pronounced with French spelling- to- sound correspondences (*cheau* from the baseword *chaud*, warm; experiment 1) or with English correspondences (*veat* from the baseword *vite*, *fast*; experiment 2). In both experiments, a pseudohomophone interference effect was observed: participants made more errors (and took longer in experiment 2) to correctly reject pseudohomophones as compared to graphemic controls. This was interpreted as reflecting: 1) automatic phonological activation during L2 visual word recognition; 2) good knowledge of the L2 print- to- sound correspondences; and 3) co- activation of these correspondences whatever the language. In terms of the BIA and BIA+ models

(Dijkstra et al., 1998; 2002), this effect indicates that the orthographic representation of the pseudohomophone – activated by its phonological representation - competed with the orthographic representation of the real word, slowing down responses. In the case of cross- language influences, this demonstrated that sublexical phonology in L1 could also activate lexical phonological and orthographic representations in L2, as had been previously reported in highly proficient bilinguals (Brysbaert et al., 1999; Nas, 1983). Study 7 further investigated cross- language influences at the sublexical orthographic- to- phonological level. As in the other studies in this thesis, participants were French speakers who learned English as a L2. Three groups of L2 learners, namely adults, Grade 8 and Grade 6 children had to perform a letter detection task in L2. For the letter- present trials, cross- language print- to- sound consistency was manipulated so that for some items, the target letter to be detected had a common orthography- to- phonology correspondence across languages (i.e., detect "A" in *have*) while other items contained a target letter whose correspondence in English was different from the one in French (i.e., detect "A" in *take*). For the letter- absent trials, a "trap" condition was created: some items were presented that, though they did not contain the target letter, they did contain the letter name according to the nontarget language French. For instance, words such as *feel* were presented when the target letter to detect was "I". Though the letter name of "I" in English (i.e., /aI/) does not correspond to the phonological representation of *feel* (i.e., /fi:l/), the letter sound of "I" in French did. For the letter- present trials, although a consistency effect was observed in the combined analysis of the three groups, examination of the separate groups revealed that it was significant for the Grade 8 children and for the adults only. In these groups, participants took longer to detect a letter when its print- to- sound correspondence was different across languages than when it was identical – or similar given phonetic variations across English and French. Suprisingly, no effect emerged for the letter- absent trials. This study demonstrated that phonological information was activated within the L2, even in a letter detection task that does not require phonological output to correctly respond to the task. It also showed the influence of the consistency of the sublexical orthographic- to- phonology connection across languages. Yet, the influence of letter names remains unclear in that it is impossible to be sure how participants actually named the target letter (i.e., target letter "A" decoded as /eI/ in English or /a/ in French). The fact that the L1 letter name of the target letter did not influence letter detection processing for the letter- absent trials (no difference when detecting the letter "I" whose letter sound in L1 is /i/ in *deep* or in *fake*) seems to suggest that target letters were decoded in English and that the effect found for letter- present trials indeed resulted from the influence of cross- language consistency.

In sum, phonological activation in L2 was reported in tasks such as the lexical decision and the letter detection tasks, which, contrary to the naming task, do not require phonological information to be processed. This activation was reported as early as after two or three years of L2 learning, both in English and French speakers who learn respectively French and English. This activation seemed though greatly reduced (nonsignificant consistency effect, Study 7) in the Grade 6 children who had only a few months of L2 exposure. As with highly proficient bilinguals, language- nonselectivity in phonological coding was reported in young learners of a L2: the cross- language pseudohomophone interference effect in English learners of French as a L2 (Study 6, experiment 2) revealed that L1 sublexical phonology interacted with lexical phonological and orthographic representations in L2; the cross- language consistency effect observed in French learners of a English (Study 7) in turn revealed the co-activation of orthography- to- phonology correspondences from both languages and the influence of the strong L1 connection. These findings may be explained within the BIA+ framework given that they indicate language- nonselectivity at multiple levels (lexical and sublexical orthographic and phonological levels). One issue made by these models could however not be answered, that is the *temporal delay hypothesis*, which postulates that phonological and semantic information is activated slower in L2 as compared to within L1 –and as compared to orthographic activation. Though phonological activation was assumed to be quite fast in the letter detection task for instance (the target word was presented for 34 ms only), no direct comparison of the L1 and L2 phonological temporal course was made and this issue remains thus unanswered in these groups of L2 school learners. The impact of the specific language under interest could not be tested either, though the French- English language pairing could have constituted a good test of linguistic influences. Indeed, given the English language is very inconsistent in its print- to- sound mapping (and sound- to- print), while French is not so much in this direction (Seymour, Aro & Erskine, 2003; Ziegler et al., 1996, 1997), these two languages could possibly differ in terms of the relative weigth of orthographic/ phonological routes to reading (i.e., the o*rthographic depth hypothesis*, Frost et al., 1987). Similar experiments in the two countries could therefore have possibly shed some light on the specificities of each language in terms of the degree of phonological activation. The question of whether participants use their L1 reading strategies when reading in L2, or adapt their word recognition mechanism to the L2 is also of interest though it goes beyond the scope of this work. Interestingly, some authors have revealed that the L1 phonological representations could affect the precision of L2 lexical representations. Ota, Hartsuiker & Haywood (2009) tested Japanese and Arabic speakers who learned English as a L2 in a semantic similarity judgement task. They introduced homophones and near- homophones in the pairs for which participants were supposed to answer "no relation". For instance, pairs of items such as *boy – sun* were presented where *sun* is homophone of *son*, an associate of *boy*. The near- homophones were constructued using a phonemic contrast which did not exist in L1: the contrast "r-l" for Japanese speakers and the contrast "p-b" for Arabic speakers. They were presented pairs of items such as *key- rock* where *rock* was a near- homophone of *lock*; and item pairs such as *sea – peach* where *peach* was a near- homophone of *beach*. They showed that all speakers made more errors to homophones as compared to graphemic controls. In addition, each group of speakers made specific errors for items that contained the specific contrast that did not exist in their L1 (the "r-l" contrast for Japanese speakers; the "p-b" contrast for Arabic speakers). This study adds interesting evidence for the role of L1 phonological representations in the development of L2 representations (see Cutler et al., 1989 about the role of L1 speech segmentation strategies on the strategies used in L2). As discussed in Study 7, further studies could possibly investigate the processing of orthographic sequences in L2, which are L1-specific graphemes (e.g., "an", "ain", "oin"). In addition, it has been shown in late L2 learners, and to a lesser extent in early bilinguals, some difficulties in acquiring precise phonological representations in the nondominant language (see Flege, 1993 on L2 phonological representations in the oral language in early and late L2 learners), and that the level of auditory discrimination of novel sounds may affect literacy acquisition (Wang & Geva, 2003). So, future studies should add the testing of reading- related skills in L2 learners, and particularly word and pseudoword reading tasks in order to assess how these participants decode L2 words at each level of L2 acquisition. In the longer term, a link between studies on phonological activation during L1 visual word recognition and the field of speech perception and production should also enable new relevant findings to be uncovered.

4. Theoretical implications and conclusions

Before we turn to our own work, we should acknowledge again the great contributions the two bilingual models of visual word recognition (BIA, Dijkstra et al., 1998; and BIA+, Dijkstra & van Heuven, 2002) have added to the psycholinguistic field by providing a theoretical framework to many empirical findings that have been uncovered these last decades. Most findings in the present study were consistent with these two models, although they also point to the need for deepening understanding of some aspects of L2 word recognition, particularly the role of sublexical orthographic and phonological representations. Chapter 1 on lexical orthographic coding in L2 confirmed overall previous findings from highly proficient bilinguals on cross-language lexical competition, session effects, language switch costs and prime frequency effects. Proficiency effects could potentially be explained by the modulation of resting levels of L2 words, as reflecting word frequency. Though inhibition priming effects were not observed for children, there were some hints of a prime frequency * priming interaction suggesting this mechanism may also be observed in these participants. Suprisingly, the hypothesis that cross- language inhibition effects would be more prominent from L1- to- L2, than from L2- to- L1, seemed not to be supported by the data. This goes against BIA and BIA+ model predictions in that L1 lexical representations are supposed to be more subjectively frequent than L2 representations, and should therefore exert more inhibition to the L2. The finding of a language switch effect using the masked priming paradigm (Study 3, experiment 1) could also help disentangle the different interpretations that have been proposed to account for this effect. While the initial BIA model accounted for this effect via the influence of language nodes on lexical representations, the later BIA+ suggested that this effect lay outside the lexicon, and resulted from task schema influence. Together with Chauncey et al (2008), the present findings would seem to support the initial BIA model, rather than the BIA+ model, although there is a need to remain cautious here given that this was not the focus of this experiment. Study 3 also confirmed both BIA and BIA+ models showing that non-linguistic variables do not directly affect the word identification system per se, and therefore contrasted with Grosjean (2007)'s language mode hypothesis.

The first "lexical" chapter also raised the question of the precision of orthographic representations, an issue which resonates with current interests in monolingual research (see the two sublexical orthographic routes proposed by Grainger & Ziegler, 2011). It seems however too hasty to try incorporate this concept in the BIA+ model, especially given that the orthographic sublexical level that is postulated mainly includes letters, which are shared across French and English. Possibly, the development of new units at the orthographic sublexical level would help in understanding how some L2 words could have less "precise" representations –in terms of less precise orthographic components. This first chapter also showed one diverging result with the current literature, that is, a cognate *inhibition* effect, a finding which could nevertheless be explained within the BIA model in terms of language nodes' asymmetric influences on word representations from each language. This strengthens the need for more research in L2 school learners in order to comprehend better how language membership interacts with word recognition and to what extent strategies and decision biases may modulate the word recognition system.

Chapter 2 on sublexical orthographic representations introduced new issues that had not been much investigated in the context of L2 acquisition and therefore opened new theoretical questions about how letter frequency and graphemic language specificity are coded within the system. If lexical access is language- nonselective at the sublexical level too, it could be hypothesized that letters and graphemes –considering that a functional graphemic level is added in the orthographic pathway to reading- that occurred in L1 benefit from a higher resting level than those that are language specific. At the orthographic level, language non- specific graphemes would therefore be more quickly activated than language specific graphemes, at least in initial phases of L2 learning. As for the letter level postulated in BIA (and initial monolingual IA mode, McClelland & Rumelhart, 1981), no lateral inhibition would be assumed among these units. The extent to which these graphemic units would influence lexical access and ease of identification, and be connected to their phonological counterparts constitutes future advances that cannot be answered by the present data.

Finally, chapter 3 on sublexical orthography- to- phonology connections revealed similar findings in L2 school learners as had been previously reported in highly proficient bilinguals. As postulated by the BIA+ model which integrates phonological activation, grapheme- to- phoneme correspondences were found to be co- activated across languages. This was found in a lexical decision task (Study 6), and in a letter detection task (Study 7), both tasks in which phonological processes are harder to detect as compared to the naming task, and in individuals who had only two to three years of L2 exposure. These cross- language influences were even shown to be stronger than within- language influences (within the L2) in this group of L2 learners, possibly revealing faster L1 sublexical phonological activation as compared to L2. This last observation would tend to support the temporal delay hypothesis postulated by BIA+, though for sublexical phonology and not only lexical phonology, but the design of the present experiments could not admittedly test for this hypothesis. With regard to the BIA+ model, it is not clear yet in the model as to whether the grapheme-to- phoneme conversion system that links orthographic to phonological sublexical levels was considered as rule- based or as depending on different connection strengths that would be established depending on language exposure. As discussed by van Wijnendaele & Brysbaert (2002), a rule- based conversion system would be likely to consider as rules only those correspondences that are legal in L1 while leaving aside those that are not legal (i.e., what are termed here cross- language inconsistent correspondences), at least in populations who first learn their L1, and later the L2. According to the authors, the finding of a L2- to- L1 phonological priming effect is more theoretically consistent with the conception of a connectionist- type grapheme to phoneme conversion system where correspondence activation levels, i.e., connection strength, strongly depend on the number of friends and enemies (Jared, 1997). Though the present studies do not give a clear- cut answer to this debate, the findings concerning the influence of correspondence strength and the influence of the L1 point to the need to incorporate a mechanism which assumes different connection strengths between graphemes and corresponding phonemes depending on whether these correspondences are shared across languages (corresponding to a strong or weak L1 connection) versus specific, and on L2 proficiency –manipulating again resting levels.

More globally, the outcome points to the need to broaden the research in L2 visual word recognition by taking into account that language- nonselectivity at the level of lexical orthographic representations only concerns a limited number of words (Lemhöfer et al., 2008). Several issues arise for those words that are very specific to the language, in terms of sublexical processing, and further studies should be conducted to this purpose. As developed in the L2 reading acquisition field (using off- line measures of reading- related skills such as phonological processing tasks), a cross- linguistic perspective taking into account the commonalities and specificities of each language would also constitute an interesting topic to develop. This seems especially intriguing when one considers that orthographic neighbourhood effects have been shown to be modulated according to the language under investigation (Andrews, 1997; van Heuven et al., 1998) and phonological effects to depend on language transparency – and subsequent preferred grain size of units (Frost, Katz & Bentin, 1987; Goswami et al., 2001, 2003; Ziegler & Goswami, 2006). My own personal interest in language learning makes me consider that future studies should also focus on how learners acquire a L2 whose script partially differs from that of the L1 (see recent study from van Heuven, Conklin, Coderre, Guo & Dijkstra, 2011 for an innovative comparison of three groups of trilinguals of varying languages/scripts). Using this type of language pairing, different orthographic symbols may tap into a unique phonemic correspondence (alphabetic "m" and Greek "μ") and conversely a similar symbol may correspond to different phonological translations (alphabetic "p" and similar Greek "ρ" which map onto /p/ and /r/ respectively). The case of alphabetic learners of Greek as a L2 could make a useful test of cross- language influences at the sublexical orthographic level and whether abstract letter identities may be represented across different scripts.

At the methodological level, this doctoral work revealed the inherent limitations of behavioural methods alone. Multiple simultaneous activations (orthographic, phonological, semantic) during the lexical decision task and the varying temporal course of the effects make it hard to control for all variables that may influence word recognition. This is particularly true when examining visual word recognition in a L2, with participants who had a very restricted vocabulary. One limitation of the study comes from the lack of a systematic control of familiarity and subjective frequency of the stimuli for each grade group. Though the L2 frequency measures used (from the CPWD database) for most experiments revealed to be satisfactory (Study 2), it would have been more powerful to regularly check subjective frequencies. Large- scale studies taking into account individual differences in reading- related skills (e.g., phonological and orthographic processing skills; spelling skills), in metalinguistic tasks (e.g., phonological awareness) or even in auditory perception (e.g., phonemic discrimination) when examining these issues should help in establishing more detailed profiles of the different groups of participants. The bilingual field also benefits from the use of eletrophysiological data which can prove to reveal subtle processing differences that may not be observable in behavioural results (Abutalebi & Green, 2007 on language control; Midgley et al., 2008 on orthographic coding; see review from van Heuven & Dijkstra, 2010). This would probably be especially useful when examining sublexical processes in L2, such as letter and grapheme processing, and for a greater understanding of proficiency effects (Midgley, Holcomb & Grainger, 2009). In addition, findings from artificial grammar learning studies also constitute an appealing way to comprehend the mechanisms in play during the learning of a new lexicon. Findings about the fast emergence of lexical competition across a newly acquired lexicon and the existing one – after a single exposure - constitutes strong support for psycholinguistic models on visual word recognition which assume lateral inhibition at the lexical level as a fundamental structural mechanism (Bowers, Davis & Hanley, 2005; Gaskell & Dumay, 2003).

To conclude, the present doctoral work aimed to assess several issues in L2 school learners, a population that has received little attention in the field. Among these issues, some have already been discussed in relation to highly proficient bilinguals; the goal was therefore to extend the results and examine the extent to which similar mechanisms could be found in the population of school L2 learners. Nevertheless, other issues raised here have not yet been addressed in the literature and future studies will therefore be needed so that the findings can be incorporate into a bilingual word recognition model. The approach adopted was to investigate several theoretical issues that corresponded to the challenges L2 learners must face. It is acknowledged that this approach may seem unusual within the frame of a doctoral work, for which it might instead be expected to raise one central concern and deepen it the most. Yet, our feeling is that raising multiple issues that challenge L2 acquisition was the most appealing project which enabled to survey a consequent part of the bilingual literature and to bring an overall view of the interdependent concerns that affect L2 acquisition. We believe that doctoral work is one piece of broader research projects that have now been initiated and that hopefully we will have the opportunity to further address this issues in future studies.

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Appendices

Proficiency tests.

Instructions were given orally. French native speakers were asked to translate from French to English. The corresponding translations were presented to English speakers (Study 6) who were asked to translate into French. Correct translations were accepted even when misspelled. In some cases, several translations could be accepted when considered as synonyms. The intermediate list was presented to participants only when they reached a high score on the beginner list (higher than 90% correct).

Beginner list		Intermediate list	
Aimer	Fort	Suivre	L'écran
Voir	Jouer	Tuer	La marée
Dire	Lire	Le trou	La sagesse
Aller	Le ciel	Empêcher	La manche
La tête	La fenêtre	Gagner	Échouer
La nuit	L'ami	Partager	Plaisanter
La maison	L'église	La maladie	Le cerf
Jeune	L'espoir	Le toit	La larme
Travailler	Attendre	La colline	L'aiguille
Vraiment	Propre	La prison	L'outil
Le soir	Dormir	L'amitié	La casserole
La fille	La sœur	Traverser	Ranger
Donner	Rencontrer	Rêver	La bougie
Petit	L'hiver	Le menton	La chèvre
L'année	Acheter	Le tapis	L'ongle
L'argent	Oublier	Le dessin	L'éventail
Le pays	L'oreille	Fumer	La craie
Parfois	Le sable	La chasse	Chuchoter
Tard	La tante	Le plafond	Le barrage
La lumière	Le doigt	Sauter	Le papillon
La voiture	Écouter	Crier	Se raser
Devenir	Envoyer	Le poing	Le phare
Parler	Vendre	Le rideau	Renverser
Noir	Chanter	Le ruisseau	La mouette
Croire	Nager	L'ennui	Le naufrage

Chapter 1. Study 1. Within- language (L2) Priming

Target words

Target	Length	Target Freq.	Ortho. Typic.	Big. Freq. L1	Low Big. Freq. L1	Big. Freq. L2	**Identity Prime**	**Form Prime**	Cross Ln. Shared N. Freq.	**Unrelated Prime**	Unrelated Prime Freq.
BOTH	4	149	Specific	442	10	3472,31	**both**	**doth**	_	**farm'**	141
BREAK	5	81	Specific	1009	6	1286,47	**break**	**breek***	_	**doyne**	0
CLOCK	5	68	Specific	485,5	23	989,07	**clock**	**cluck**	_	**heart'**	78
COAT	4	176	Specific	756,67	31	5597,24	**coat**	**coot***	_	**fice**	0
COOK	4	300	Specific	736,67	2	2500,62	**cook**	**coak***	_	**hear'**	327
DEAD	4	100	Specific	258,33	4	2059,16	**dead**	**deid***	_	**pank**	0
DOWN	4	2799	Specific	100,33	2	1851,48	**down**	**pown**	_	**like'**	3578
FEEL	4	303	Specific	98	6	2485,53	**feel**	**beel**	_	**woog**	0
FIGHT	5	114	Specific	332,25	2	2489,34	**fight**	**fijht***	_	**beach'**	141
FOOD	4	925	Specific	143,67	1	2304,39	**food**	**lood**	_	**grea**	0
GOOD	4	1493	Specific	73	1	2439,28	**good**	**goad***	_	**want'**	1493
GREY	4	143	Specific	1211	14	1979,94	**grey**	**groy***	_	**bust**	0
HIGH	4	260	Specific	363,33	2	437,38	**high**	**pigh**	_	**call'**	254
KIND	4	192	Specific	784	31	1880,07	**kind**	**kird**	_	**woan**	0
KNOW	4	1230	Specific	200,67	1	1529,12	**know**	**pnow***	_	**well'**	1052
LOOK	4	2469	Specific	82,33	2	2786,86	**look**	**dook**	_	**hife**	0

Target	Length	Target Freq.	Ortho. Typic.	Big. Freq. L1	Low Big. Freq. L1	Big. Freq. L2	**Identity Prime**	**Form Prime**	Cross Ln. Shared N. Freq.	**Unrelated Prime**	Unrelated Prime Freq.
MEET	4	162	Specific	86	0	2255,69	**meet**	**neet**	_	**sing'**	147
MILK	4	289	Specific	785	0	1474,51	**milk**	**mink**	_	**stam**	0
MOON	4	373	Specific	207	0	3092,77	**moon**	**mown***	_	**ball'**	346
NEAR	4	311	Specific	185	36	2247,34	**near**	**vear**	_	**birt**	0
PINK	4	133	Specific	851,67	3	1047,85	**pink**	**vink**	_	**free'**	130
QUEEN	5	552	Specific	417,5	6	1052,47	**queen**	**quein***	_	**bownd**	0
SLOW	4	227	Specific	392	1	714,71	**slow**	**slew***	_	**bike'**	211
TALK	4	211	Specific	591	0	1226,38	**talk**	**dalk**	_	**powt**	0
TEETH	5	335	Specific	361,75	6	825,77	**teeth**	**deeth**	_	**black'**	360
THINK	5	1390	Specific	677,25	3	5784,17	**think**	**shink**	_	**sload**	0
THREE	5	706	Specific	806,75	1	3304,64	**three**	**ghree***	_	**small'**	717
WAKE	4	68	Specific	11,67	4	2351,81	**wake**	**wate**	_	**yest**	0
WARM	4	373	Specific	858	0	1411,64	**warm**	**walm**	_	**hill'**	365
WASH	4	176	Specific	334,67	3	1470,17	**wash**	**fash**	_	**milt**	0
WEAR	4	214	Specific	160,33	2	3771,88	**wear**	**weer***	_	**dugh**	0
WIFE	4	168	Specific	177	8	4049,02	**wife**	**sife**	_	**does'**	222
WISH	4	465	Specific	1085,67	3	3853,6	**wish**	**wigh***	_	**stur**	0
WORD	4	81	Specific	666,33	1	2279,05	**word**	**wond**	_	**push'**	78

WRONG	5	173	Specific	1857,5	0	1976,78	**wrong**	**prong***	–	**slumb**	0
Target	Length	Target Freq.	Ortho. Typic.	Big. Freq. L1	Low Big. Freq. L1	Big. Freq. L2	**Identity Prime**	**Form Prime**	Cross Ln. Shared N. Freq.	**Unrelated Prime**	Unrelated Prime Freq.
YEAR	4	246	Specific	160,33	2	1964,93	**year**	**yeer***	–	**wait’**	262
COME	4	2374	Non-specific	1269	328	3923,41	**come**	**bome**	5,66	**dird**	0
DRIVE	5	116	Non-specific	713,75	84	907,56	**drive**	**druve**	0,07	**chest’**	78
FIRE	4	357	Non-specific	1049,33	284	3351,24	**fire**	**fore**	0,2	**saik**	0
FIVE	4	173	Non-specific	387,33	196	3000,02	**five**	**fove**	0,61	**hold**	176
FLAT	4	154	Non-specific	796,33	74	5187,87	**flat**	**foat**	–	**doke**	0
GAME	4	160	Non-specific	466	312	3154,25	**game**	**gume**	–	**ears’**	149
GIVE	4	368	Non-specific	315,67	69	2764,27	**give**	**gile**	–	**dast**	0
HAIR	4	243	Non-specific	1846,67	280	3550,47	**hair**	**hoir**	–	**nice’**	292
HORSE	5	441	Non-specific	802,25	142	2377,81	**horse**	**hirse**	1,69	**plint**	0
HIDE	4	173	Non-specific	304,67	59	971,67	**hide**	**hile**	–	**care’**	173
HOME	4	1352	Non-specific	594,67	142	3786,59	**home**	**hone**	0,34	**frin**	0
HOPE	4	216	Non-specific	211,33	127	665,19	**hope**	**nope**	5,2	**past’**	241
NOISE	5	322	Non-	1341,75	227	1688,72	**noise**	**roise**	1,99	**ranck**	0

specific

Target	Length	Target Freq.	Ortho. Typic.	Big. Freq. L1	Low Big. Freq. L1	Big. Freq. L2	**Identity Prime**	**Form Prime**	Cross Ln. Shared N. Freq.	**Unrelated Prime**	Unrelated Prime Freq.
HOUR	4	57	Non-specific	1490,33	142	1874,08	**hour**	**hoar**	–	**ruve**	0
HOUSE	5	1880	Non-specific	1504	142	3676,95	**house**	**hoise**	–	**their'**	1944
LATE	4	187	Non-specific	1136	341	1113,43	**late**	**lute**	–	**aunt'**	195
LIFE	4	203	Non-specific	259,67	29	1848,16	**life**	**dife**	–	**gouf**	0
LOUD	4	127	Non-specific	1334,33	29	1594,86	**loud**	**roud**	0,68	**half'**	114
LOVE	4	230	Non-specific	162	88	3179,25	**love**	**rove**	0,07	**dact**	0
MORE	4	1030	Non-specific	1272,33	578	5522,53	**more**	**yore**	1,15	**find'**	1036
MOUSE	5	782	Non-specific	1613	578	3652,99	**mouse**	**molse**	0,88	**stank**	0
MOVE	4	200	Non-specific	287,33	88	3677,7	**move**	**wove**	0,07	**sand'**	178
NAME	4	306	Non-specific	423,67	185	3073,75	**name**	**nyme**	–	**rind**	0
NINE	4	143	Non-specific	1040,33	51	1452,22	**nine**	**nipe**	0,27	**glad'**	84
HARD	4	471	Non-specific	990	127	3042,4	**hard**	**hald**	–	**tine**	0
NOSE	4	297	Non-specific	586,67	227	1170,08	**nose**	**nuse**	–	**bird'**	287

PROUD	5	65	Non-specific	1843,5	29	1332,1	**proud**	**droud**	_	**spell'**	76
RAIN	4	373	Non-specific	1969,33	309	1824,96	**rain**	**rawn**	_	**blue'**	414
SAFE	4	241	Non-specific	222,67	29	1829,36	**safe**	**lafe**	0	**pond'**	268
SAME	4	319	Non-specific	542	328	4386,14	**same**	**sume**	1,89	**burl**	0
SAVE	4	89	Non-specific	398,33	196	5276,45	**save**	**sive**	7,03	**moil**	0
SOME	4	3435	Non-specific	748	328	4333,79	**some**	**jome**	4,66	**this'**	3805
SPEND	5	54	Non-specific	1916,75	82	881,28	**spend**	**spind**	_	**float'**	62
TIME	4	1750	Non-specific	367,33	179	3582	**time**	**tame**	5,66	**jime**	0
TRUE	4	73	Non-specific	654,67	403	374,19	**true**	**troe**	0,27	**pler**	0
VOICE	5	262	Non-specific	651,5	261	2090,89	**voice**	**roice**	0,81	**drant**	0

*** : complex grapheme condition**
' : prime *word*

Target Pseudowords

Target	Length	Ortho. Typic.	Identity Prime	**Form Prime**	Form Prime Freq.	**Unrelated Prime**	Unrelated Prime Freq.
WRASH	5	Specific	wrash	**wrish**	_	**about'**	1977
YERM	4	Specific	yerm	**yeam**	_	**baby'**	790
LOOR	4	Specific	loor	**door'**	857	**been'**	892
PUCK	4	Specific	puck	**luck'**	122	**blow'**	141
DAKE	4	Specific	dake	**pake**	_	**city'**	308
POLD	4	Specific	pold	**cold'**	446	**dark'**	489
COWT	4	Specific	cowt	**cost'**	22	**desk'**	22
BALK	4	Specific	balk	**bank'**	114	**draw'**	95
SMEW	4	Specific	smew	**smow**	_	**duck'**	441
SPOW	4	Specific	spow	**stow**	_	**each'**	546
LASH	4	Specific	lash	**vash**	_	**help'**	1720
DOAT	4	Specific	doat	**boat'**	563	**feet'**	552
KNID	4	Specific	knid	**knad**	_	**poor'**	333
SHROE	5	Specific	shroe	**throe**	_	**right'**	852
BAGH	4	Specific	bagh	**bath'**	257	**full'**	300
REAVE	5	Specific	reave	**leave'**	170	**ghost'**	157
KLAY	4	Specific	klay	**play'**	1095	**here'**	1625
ARTH	4	Specific	arth	**alth**	_	**kick'**	19
DRAY	4	Specific	dray	**droy**	_	**lots'**	800
BREWK	5	Specific	brewk	**drewn**	_	**lunch'**	130
GLOOR	5	Specific	gloor	**floor'**	314	**might'**	327
CLAWK	5	Specific	clawk	**clalk**	_	**mouth'**	146
WORL	4	Specific	worl	**work'**	814	**need'**	800
TWEE	4	Specific	twee	**tree'**	995	**next'**	828
COWK	4	Specific	cowk	**dowk**	_	**plug'**	127
FALK	4	Specific	falk	**halk**	_	**pool'**	111
EAGHT	5	Specific	eaght	**eight'**	130	**fresh'**	105
DACK	4	Specific	dack	**back'**	2299	**from'**	2299
HEER	4	Specific	heer	**leer**	_	**shop'**	311

Target	Length	Ortho. Typic.	Identity Prime	**Form Prime**	Form Prime Freq.	**Unrelated Prime**	Unrelated Prime Freq.
LOTH	4	Specific	loth	**roth**	_	**show’**	330
DINK	4	Specific	dink	**fink**	_	**stay’**	338
BOAR	4	Specific	boar	**bear’**	1214	**take’**	1093
REID	4	Specific	reid	**read’**	349	**wall’**	349
SEWN	4	Specific	sewn	**seen’**	325	**wolf’**	300
DIGHT	5	Specific	dight	**light’**	306	**world’**	343
TIGH	4	Specific	tigh	**tish**	_	**your’**	1923
NOICE	5	Non- specific	noice	**noile**	_	**about’**	1977
MOTE	4	Non- specific	mote	**mone**	_	**baby’**	790
MURT	4	Non- specific	murt	**must’**	879	**been’**	892
FARL	4	Non- specific	farl	**fall’**	143	**blow’**	141
BOME	4	Non- specific	bome	**bope**	_	**city’**	308
FEST	4	Non- specific	fest	**best’**	481	**dark’**	489
DAIL	4	Non- specific	dail	**jail’**	27	**desk’**	22
BEUL	4	Non- specific	beul	**bell’**	162	**draw’**	95
HANE	4	Non- specific	hane	**hape**	_	**duck’**	441
PIDE	4	Non- specific	pide	**pife**	_	**each’**	546
GADE	4	Non- specific	gade	**gave’**	782	**feet’**	552
FLAD	4	Non- specific	flad	**blad**	_	**help’**	1720
DAFE	4	Non- specific	dafe	**hafe**	_	**poor’**	333
HOUNE	5	Non- specific	houne	**roune**	_	**right’**	852
MIDE	4	Non- specific	mide	**side’**	284	**full’**	300
DRENS	5	Non- specific	drens	**dress’**	154	**ghost’**	157
ONER	4	Non- specific	oner	**over’**	1479	**here’**	1625
LAIN	4	Non- specific	lain	**jain**	_	**kick’**	19
FISE	4	Non- specific	fise	**lise**	_	**lots’**	800
NORSE	5	Non- specific	norse	**dorse**	_	**lunch’**	130
VOMES	5	Non- specific	vomes	**comes’**	330	**might’**	327
STINE	5	Non- specific	stine	**stime**	_	**mouth’**	146
HIRL	4	Non- specific	hirl	**girl’**	527	**need’**	800
CUME	4	Non- specific	cume	**came’**	2007	**next’**	828

Target	Length	Ortho. Typic.	Identity Prime	**Form Prime**	Form Prime Freq.	**Unrelated Prime**	Unrelated Prime Freq.
JAME	4	Non- specific	jame	**jate**	_	**plug’**	127
DIME	4	Non- specific	dime	**dipe**	_	**pool’**	111
MAXE	4	Non- specific	maxe	**made’**	1777	**from’**	2299
QUIRT	5	Non- specific	quirt	**quiet’**	162	**fresh’**	105
PINE	4	Non- specific	pine	**rine**	_	**shop’**	311
MOUD	4	Non- specific	moud	**doud**	_	**show’**	330
PRUE	4	Non- specific	prue	**proe**	_	**stay’**	338
FONG	4	Non- specific	fong	**long’**	1171	**take’**	1093
PICE	4	Non- specific	pice	**mice’**	292	**wall’**	349
MAND	4	Non- specific	mand	**hand’**	295	**wolf’**	300
DRASS	5	Non- specific	drass	**grass’**	306	**world’**	343
HAIF	4	Non- specific	haif	**paif**	_	**your’**	1923

‘ : prime *word*

Chapter 1. Study 2. Cognate Experiment

Target words and pseudowords

Target Words	Length	Status	Freq. Categ.	Freq.	Big. Freq. L1	Low. Big. Freq. L1	Big. Freq. L2	Target Pseudowords	Length
BUS	3	Cognate	Medium	219	398,5	247	2755,76	TID	3
FACE	4	Cognate	Medium	262	872	568	1970,4	GEER	4
LION	4	Cognate	Medium	314	591,33	228	1422,79	BOAD	4
FRUIT	5	Cognate	Medium	133	846	434	380,11	DRICE	5
TABLE	5	Cognate	Medium	241	781,5	303	832,04	GROIL	5
TRAIN	5	Cognate	Medium	257	1799,25	723	1281,44	PLEAK	5
ORANGE	6	Cognate	Medium	146	1216	269	722,6	FEARCH	6
ANIMAL	6	Cognate	Medium	146	688,2	350	666,27	GLIDGE	6
CENTRE	6	Cognate	Medium	151	1388	339	927,61	FLIDER	6
VILLAGE	7	Cognate	Medium	325	865,17	665	706,37	MEDDING	7
AGE	3	Cognate	Low	24	255,5	46	354,19	ISK	3
DATE	4	Cognate	Low	16	1112,67	302	849,04	GAIR	4
FILM	4	Cognate	Low	32	500,67	169	1526,49	DILK	4

Target Words	**Length**	**Status**	**Freq. Categ.**	**Freq.**	**Big. Freq. L1**	**Low. Big. Freq. L1**	**Big. Freq. L2**	Target Pseudowords	Length
PIANO	5	Cognate	Low	30	917,25	416	388,01	SPOLE	5
POINT	5	Cognate	Low	19	1094,25	742	2186,6	CLEAD	5
HOTEL	5	Cognate	Low	24	853,75	437	1426,93	FRASS	5
COUSIN	6	Cognate	Low	14	2830,2	754	993,28	VOTTLE	6
GARAGE	6	Cognate	Low	32	1409,2	510	643,22	TALACE	6
EXCUSE	6	Cognate	Low	38	797,2	255	426,08	DRANER	6
SILENCE	7	Cognate	Low	27	793,17	453	734,2	LICTURE	7
EGG	3	Specific	Medium	333	32,50	1	43,18	UDD	3
BIKE	4	Specific	Medium	211	222,67	11	1975,86	VALM	4
CITY	4	Specific	Medium	308	358,67	11	2675,79	JOLL	4
EIGHT	5	Specific	Medium	130	206,75	6	2030,65	VOUGH	5
HELLO	5	Specific	Medium	252	687,75	222	520,71	SMOWD	5
WATCH	5	Specific	Medium	400	653,50	24	1819,15	CLEED	5
FLOWER	6	Specific	Medium	127	806,80	4	1716,41	FLEESE	6
YELLOW	6	Specific	Medium	316	508,20	4	576,83	PHADOW	6
FRIEND	6	Specific	Medium	219	1173,60	331	1074,33	GOLOUR	6
GOODBYE	7	Specific	Medium	103	146,67	0	132,07	DURTAIN	7

Target Words	Length	Status	Freq. Categ.	Freq.	Big. Freq. L1	Low. Big. Freq. L1	Big. Freq. L2	Target Pseudowords	Length
SHY	3	Specific	Low	16	94,50	80	2458,06	BEW	3
WORD	4	Specific	Low	81	814,33	2	2279,05	DIGH	4
SICK	4	Specific	Low	84	444,33	65	1099,7	LEET	4
CLOCK	5	Specific	Low	68	427,75	42	989,07	PRILE	5
SHINY	5	Specific	Low	92	412,75	21	3278,38	STEAN	5
SKIRT	5	Specific	Low	11	186,50	20	379,09	JONEY	5
ANSWER	6	Specific	Low	62	935,40	1	1702,56	TOREST	6
CHEESE	6	Specific	Low	89	831,60	19	738,08	SQUING	6
TWELVE	6	Specific	Low	38	110,80	0	207,45	SPLONG	6
WELCOME	7	Specific	Low	76	465,50	13	354,05	SHICKLY	7
SAD	3	Non- specific	Medium	238	918,50	478	4145,3	MAB	3
LOVE	4	Non- specific	Medium	230	472,67	70	3179,25	FISS	4
NAME	4	Non- specific	Medium	306	675,67	430	3073,75	CEAR	4
SEVEN	5	Non- specific	Medium	141	950,00	451	1764,79	PLOWN	5
CHAIR	5	Non- specific	Medium	208	1126,75	712	1615,6	DEACH	5
APPLE	5	Non- specific	Medium	219	894,25	701	582,88	DUICE	5
LISTEN	6	Non- specific	Medium	114	1417,80	770	1596,62	BURING	6

Target Words	**Length**	**Status**	**Freq. Categ.**	**Freq.**	**Big. Freq. L1**	**Low. Big. Freq. L1**	**Big. Freq. L2**	Target Pseudowords	Length
SUMMER	6	Non- specific	Medium	197	1275,60	383	1882,64	JICKLE	6
SISTER	6	Non- specific	Medium	227	1576,60	622	2522,93	DATTLE	6
TEACHER	7	Non- specific	Medium	249	1012,83	61	1756,47	SURTHER	7
PEN	3	Non- specific	Low	32	1494,00	1162	702,88	LAT	3
HOUR	4	Non- specific	Low	57	2182,67	437	1874,08	TUGE	4
BORN	4	Non- specific	Low	65	1163,67	350	2332,06	DATH	4
BEGIN	5	Non- specific	Low	65	600,00	204	1009,52	CHONG	5
FALSE	5	Non- specific	Low	38	1038,25	90	1383,39	STIMB	5
CLOUD	5	Non- specific	Low	35	625,50	155	1397,01	DAUGH	5
AUGUST	6	Non- specific	Low	19	600,60	235	374,41	SMOUND	6
TRAVEL	6	Non- specific	Low	70	1337,20	315	568,73	FASTLE	6
ELEVEN	6	Non- specific	Low	49	663,40	23	523,02	LIRATE	6
FOREVER	7	Non- specific	Low	22	1220,33	190	1414,58	MEATHER	7
BOY	3	Filler	High	844				NAR	3
GIRL	4	Filler	High	527				DOAT	4
ROOM	4	Filler	High	625				GAST	4

Target Words	**Length**	**Status**	**Freq. Categ.**	**Freq.**	**Big. Freq. L1**	**Low. Big. Freq. L1**	**Big. Freq. L2**	Target Pseudowords	Length
SNOW	4	Filler	High	514				DAST	4
QUEEN	5	Filler	High	552				LIRST	5
THREE	5	Filler	High	706				DREAT	5
SMALL	5	Filler	High	717				NOUSE	5
NIGHT	5	Filler	High	725				DEVER	5
WINDOW	6	Filler	High	560				BAFORE	6
MORNING	7	Filler	High	552				SLOTHER	7
BIG	3	Filler	High	2666				LAT	3
GOOD	4	Filler	High	1493				FOME	4
LIKE	4	Filler	High	3578				VIND	4
THINK	5	Filler	High	1390				LOUND	5
HOUSE	5	Filler	High	1880				SLERE	5
WATER	5	Filler	High	1525				WHOUT	5
SCHOOL	6	Filler	High	1393				SPROOL	6
PEOPLE	6	Filler	High	1926				MEOPLE	6
LITTLE	6	Filler	High	3164				VITTLE	6
CHILDREN	8	Filler	High	2291				SPILDREN	8

Chapter 1. Study 3. Cross- language priming

Experiments 1a and 1b: L2 to L1 priming

Target words

			French primes					English primes						
			Related primes			Unrelated primes		Related primes				Unrelated primes		
Target	Length	Freq.	**Prime**	Freq.	Position	Prime	Freq.	**Prime**	Freq.	Fam.	position	Prime	Freq.	Fam.
PROUE	5	5,34	**proie**	29,59	4	cadre	30,27	**proud**	65	3,4	5	speak	41	5,67
PLANER	6	3,99	**placer**	22,37	4	intime	26,08	**player**	3	4,73	4	monday	65	5,53
MORSE	5	0,88	**morte**	84,39	4	salon	84,12	**worse**	65	4	1	under	517	4,2
FORGER	6	1,62	**former**	15,95	4	maquis	16,01	**forget**	100	5,13	5	school	1393	5,73
LOUE	4	1,69	**joue**	86,82	1	gare	84,19	**love**	230	5,93	3	tall	181	4,07
TARTE	5	10,54	**tante**	110,95	3	pluie	111,76	**taste**	65	3,27	3	often	189	5,4
RUSE	4	13,72	**rose**	98,24	2	pain	99,32	**rule**	24	3,67	3	same	319	5
DUNE	4	3,45	**lune**	63,24	1	port	64,86	**june**	32	4,07	1	open	241	5,8
BAIL	4	2,57	**bain**	43,11	4	mode	46,96	**ball**	346	4,67	3	door	857	5,27

HORDE	5	3,78	**corde**	32,03	1	messe	32,7	**horse**	441	4,07	4	child	35	5,4
RAME	4	7,02	**dame**	110,07	1	prix	107,5	**game**	160	5,33	1	food	925	5,53
FARD	4	4,73	**tard**	362,64	1	dieu	368,51	**farm**	141	3,53	4	true	73	5,6
COLON	5	0,88	**coton**	24,66	3	nuage	26,49	**color***	70	5,4	5	white	441	4,67
BOUE	4	52,3	**bout**	381,36	4	gens	409,39	**blue**	414	5,53	2	meet	162	5,2
HOUX	4	1,28	**doux**	67,91	1	midi	68,18	**hour**	57	5,27	4	talk	211	5,73
AIRE	4	4,46	**dire**	856,76	1	tête	861,49	**fire**	357	4,6	1	town	681	4
COÛT	4	1,22	**goût**	124,8	1	mari	118,38	**cost**	22	3,8	3	real	178	5
SOUTE	5	0,95	**toute**	802,3	1	avant	737,7	**south**	76	4,29	5	green	538	5,29
CUITE	5	8,65	**suite**	270,88	1	train	271,28	**quite**	279	5,17	1	snake	208	4,87
NAGE	4	8,58	**page**	55,88	1	aube	55,81	**name**	306	5,87	3	bird	287	4,4
GANT	4	7,97	**tant**	436,42	1	loin	452,36	**want**	1493	5,67	1	cold	446	5,47
LEST	4	0,68	**lent**	23,31	3	pipe	26,42	**best**	481	5,8	1	girl	527	6
LACER	5	0,68	**laver**	30,68	3	orage	30,61	**later**	235	5,27	3	today	349	5,93
BOUSE	**5**	**3,72**	**boule**	38,92	4	enfer	**38,78**	**house**	**1880**	**5,8**	**1**	**first**	**817**	**5,67**
TAXE	4	1,42	**taxi**	41,22	4	poil	42,91	**take**	1093	5,67	3	come	2374	5,47
CIME	4	4,46	**aime**	257,57	1	face	262,16	**time**	1750	5,73	1	near	311	3,8

ALTO	4	0,95	**auto**	30,34	2	mars	31,42	**also**	387	4,6	3	grey	143	3,87
SOLE	4	1,89	**sale**	76,95	2	trou	76,08	**some**	3435	4,8	3	read	349	5,27
BAL	3	18,31	**mal**	545,82	1	cet	491,5	**bad**	508	5,64	3	try	343	5
BOL	3	20,07	**bon**	594,99	3	eau	417,84	**boy**	844	6	3	see	2575	5,8
GEL	3	6,22	**tel**	133,31	1	six	156,22	**get**	2077	4,64	3	job	292	5,73
NET	3	38,1	**nez**	177,64	3	mur	172,57	**new**	1155	5,79	3	can	4679	5,73
SOU	3	12,57	**fou**	111,08	1	été	121,55	**you**	10715	6	1	dad	2726	5,47
PIN	3	9,53	**fin**	338,65	1	sûr	343,51	**pig**	151	3,67	3	one	3069	5,67
CAP	3	15,68	**cas**	217,36	3	dos	213	**cat**	1187	5,47	3	pen	32	4,67
COQ	3	15,68	**cou**	112,7	3	fer	106,28	**cow**	333	4	3	ear	103	3,27

*** colour**

Target pseudowords

		Related primes				Unrelated primes		
Target	Length	Prime	Freq.	Position	Language	Prime	Freq.	Language
ILI	**3**	**ill**	**92**	**3**	**Anglais**	**day**	1777	**Anglais**
MAF	**3**	**man**	**1439**	**3**	**Anglais**	**for**	**5777**	**Anglais**

BUR	**3**	**buy**	**219**	**3**	**Anglais**	**yes**	**1101**	**Anglais**
DIB	**3**	**did**	**1458**	**3**	**Anglais**	**why**	**636**	**Anglais**
HERT	**4**	**here**	**1625**	**4**	**Anglais**	**only**	**657**	**Anglais**
FROS	**4**	**from**	**2299**	**4**	**Anglais**	**wife**	**168**	**Anglais**
LIDE	**4**	**like**	**3578**	**3**	**Anglais**	**year**	**246**	**Anglais**
RINE	**4**	**nine**	**143**	**1**	**Anglais**	**feel**	**303**	**Anglais**
VALT	**4**	**salt**	**327**	**3**	**Anglais**	**free**	**130**	**Anglais**
PIVE	**4**	**live**	**746**	**3**	**Anglais**	**know**	**1230**	**Anglais**
TORE	**4**	**more**	**1030**	**1**	**Anglais**	**bank**	114	**Anglais**
MONG	**4**	**song**	**124**	**1**	**Anglais**	**five**	173	**Anglais**
LIFU	**4**	**life**	**203**	**4**	**Anglais**	**very**	**1553**	**Anglais**
MAVE	**4**	**make**	**1577**	**3**	**Anglais**	**look**	**2469**	**Anglais**
VOME	**4**	**home**	**1352**	**1**	**Anglais**	**fear**	51	**Anglais**
MOUGE	**5**	**mouse**	**782**	**4**	**Anglais**	**level**	**16**	**Anglais**
VORD	**4**	**word**	**81**	**1**	**Anglais**	**many**	**649**	**Anglais**
PRIGE	**5**	**price**	**5**	**4**	**Anglais**	**dozen**	**3**	**Anglais**
RUVER	**5**	**river**	**435**	**2**	**Anglais**	**month**	**32**	**Anglais**

MONEL	5	money	365	5	Anglais	crazy	43	Anglais
PAPEN	5	paper	365	5	Anglais	floor	314	Anglais
FATIER	6	father	333	4	Anglais	sunday	73	Anglais
ICO	3	ici	483,65	3	Français	eux	504,26	Français
NAC	3	sac	125	1	Français	jeu	130,68	Français
RUG	3	rue	453,65	3	Français	toi	450,34	Français
DUX	3	dix	209,86	2	Français	âge	205,27	Français
VURT	4	vert	91,01	2	Français	côte	90,74	Français
GROF	4	gros	246,96	1	Français	pays	241,55	Français
VIGE	4	vide	187,9	3	Français	peau	174,26	Français
RURE	4	rire	256,76	2	Français	pied	248,18	Français
SIPT	4	sept	75,61	2	Français	faim	74,93	Français
LIRO	4	lire	112,43	3	Français	joie	134,12	Français
TOLT	4	tort	51,55	2	Français	juin	51,28	Français
RONL	4	rond	52,5	4	Français	ceci	53,78	Français
BIEU	4	lieu	213,38	3	Français	vent	207,64	Français
FAVE	4	cave	44,75	1	Français	soin	45,41	Français

NOLE	**4**	**note**	**39,32**	**2**	**Français**	**choc**	**38,65**	**Français**
REUGE	**5**	**rouge**	**258,04**	**2**	**Français**	**façon**	**259,26**	**Français**
FONG	**4**	**fond**	**381,56**	**4**	**Français**	**ciel**	**301,76**	**Français**
PIACE	**5**	**pièce**	**193,78**	**3**	**Français**	**ombre**	**190,88**	**Français**
LAVRE	**5**	**livre**	**161,15**	**2**	**Français**	**odeur**	**159,86**	**Français**
MIYEN	**5**	**moyen**	**76,96**	**2**	**Français**	**repas**	**76,62**	**Français**
POLER	**5**	**poser**	**73,85**	**3**	**Français**	**basse**	**74,66**	**Français**
CUCHER	**6**	**cacher**	**48,45**	**2**	**Français**	**plaine**	**41,28**	**Français**

Experiments 2: L1-to- L2 priming

Target words

				Related primes		Unrelated primes	
Target	Freq.	Fam.	Prime Freq. Condition	Prime	Freq.	Prime	Freq.
BLUE	414	5.53	HF	boue	52,3	pont	64,86
FAST	660	4.27	HF	faut	653,92	coup	641,55
FIRE	357	4.6	HF	rire	256,76	pays	241,55
FOOD	925	5.53	HF	fond	381,56	dieu	368,51
GAME	160	5.33	HF	dame	110,07	huit	102,5
GIVE	368	5.33	HF	vive	49,45	banc	48,31
HOT	479	5.67	HF	mot	260,47	mer	246,55
HOUR	57	5.27	HF	pour	6214,19	elle	6991,49
JUNE	32	4.07	HF	lune	63,24	abri	51,08
LIFE	203	5.87	HF	lire	112,53	robe	111,96
NEVER	828	5.87	HF	lever	75,67	somme	74,19
NEW	1155	5.79	HF	nez	177,64	mur	172,57
NINE	143	5	HF	mine	52,44	truc	51,15
PEN	32	4.67	HF	peu	1586,96	vie	835,47
SAD	238	4.67	HF	sac	125,47	jeu	130,68
TIME	1750	5.73	HF	aime	257,57	sens	300,41
BAD	508	5.64	LF	bal	18,31	pré	19,8
BALL	346	4.67	LF	bail	2,57	cône	2,57
COST	22	3.8	LF	coût	1,22	judo	1,22
COW	333	4	LF	coq	15,68	nid	14,59
FIVE	173	5.53	LF	fixe	40,61	vain	40,14

GET	2077	4.64	LF	gel	6,22	zoo	6,08
HORSE	441	4 .07	LF	horde	3,78	enjeu	3,99
HOUSE	1880	5.8	LF	bouse	3,72	vibre	3,78
LATER	235	5.27	LF	lacer	0,68	nocif	0,74
LOVE	230	5.93	LF	lave	10,82	dent	11,15
NAME	306	5.8	LF	nage	8,58	rite	8,45
PIG	151	3.67	LF	pic	10,34	axe	10
RAIN	373	4.53	LF	bain	43,11	joli	44,53
TAKE	1093	5.67	LF	taxe	1,42	luge	1,42
WANT	1493	5.67	LF	gant	7,97	trac	8,24
WORSE	65	4	LF	corse	4	cycle	4,05

Target pseudowords

Target	Prime Freq. Condition	Prime	Freq.	Position	Prime	Freq.
TROW	**HF**	trou	76,08	4	sept	75,61
JEX	**HF**	jeu	130,68	3	âme	129,53
VUY	**HF**	vue	199,93	3	feu	215,47
NOAR	**HF**	noir	277,43	3	oeil	278,51
CEEL	**HF**	ciel	301,76	2	mois	304,96
MAW	**HF**	mal	545,82	3	bon	594,99
NEAGE	**HF**	neige	76,42	3	repas	76,62
JOIL	**HF**	joie	134,12	4	mari	118,38
SOE	**HF**	sol	148,31	3	ami	149,6
GROY	**HF**	gros	247,06	4	pied	248,18
LIX	**HF**	dix	209,86	1	dos	213,99
COWP	**HF**	coup	641,55	3	nuit	674,55
DEAX	**HF**	deux	1557,91	3	rien	1543,72
QUAW	**HF**	quai	55,14	4	lait	62,23

POWT	**HF**	port	64,86	3	midi	68,18
MUBE	**HF**	aube	55,81	1	doux	67,91
GRUDE	**LF**	prude	0,95	1	navet	0,88
DARM	**LF**	daim	5,14	3	pneu	4,93
MULL	**LF**	mule	4,26	4	aire	4,46
ESSOW	**LF**	essor	3,78	5	préau	3,51
CIDOE	**LF**	cidre	3,99	4	épine	3,92
ROY	**LF**	roc	7,5	3	fée	6,62
VELL	**LF**	velu	2,43	4	ardu	2,43
HASSAL	**LF**	vassal	1,49	1	rapace	1,96
RUGAR	**LF**	rugir	0,88	4	sosie	0,88
BAWLET	**LF**	ballet	6,01	3	armure	5,47
BILT	**LF**	bile	5,74	4	cube	5,81
SAWN	**LF**	sain	8,58	3	bouc	8,92
CHAW	**LF**	char	7,91	4	raie	7,84
CLOY	**LF**	clou	10,2	4	voeu	10,61
TAR	**LF**	tir	16,01	2	riz	17,7
PUN	**LF**	pin	9,53	2	ail	7,97

Chapter 2. Study 4. Typicality experiment.

Target words and pseudowords

Target word	Length	Ortho. Typ.	Freq.	Cross- Ln N size	Higher Freq. Neighbour	Big. Freq. L1	Low. Big. Freq. L1	Big. Freq. L2	Target pseudoword	Ortho. Typ.	Big. Freq. L1	Low. Big. Freq. L1	Big. Freq. L2
ABOUT	5	Non-specific	1977	2	2,84	651,25	237	2604,03	**AGOUT**	Non-specific	549,50	99,00	1541,19
ALONE	5	Non-specific	97	1	0,74	707,25	596	1132,13	**ALODE**	Non-specific	524,00	175,00	730,01
APPLE	5	Non-specific	219	1	8,04	894,25	701	582,88	**ARPLE**	Non-specific	706,75	48,00	571,61
CARRY	5	Non-specific	130	2	35,07	1718,75	51	1114,60	**BIVER**	Non-specific	1188,75	474,00	2840,87
CLOUD	5	Non-specific	35	4	17,3	625,5	155	1397,01	**BOVE**	Non-specific	746,00	70,00	2946,93
FALSE	5	Non-specific	38	2	60,88	1038,25	90	1383,39	**BRIP**	Non-specific	1090,00	247,00	118,17
FAST	4	Non-specific	660	2	1811,83	1188,67	878	3291,77	**CARDY**	Non-specific	1673,75	12,00	879,91
FIVE	4	Non-specific	173	6	49,45	643,67	474	3000,02	**CLOID**	Non-specific	495,00	294,00	751,13
GAME	4	Non-specific	160	5	110,07	818	700	3154,25	**DAIR**	Non-specific	533,00	302,00	1796,23
GIVE	4	Non-specific	368	6	49,45	500,33	200	2764,27	**DAST**	Non-specific	996,67	302,00	3110,94

Target word	Length	Ortho. Typ.	Freq.	Cross- Ln N size	Higher Freq. Neighbour	Big. Freq. L1	Low. Big. Freq. L1	Big. Freq. L2	**Target pseudoword**	Ortho. Typ.	Big. Freq. L1	Low. Big. Freq. L1	Big. Freq. L2
HAIR	4	Non-specific	243	5	8,85	663	331	3550,47	**DIFE**	Non-specific	806,33	274,00	801,01
HORSE	5	Non-specific	441	5	22,23	957,25	425	2377,81	**FELSE**	Non-specific	566,75	90,00	1239,15
HOUSE	5	Non-specific	1880	4	8,85	1744,5	437	3676,95	**FIDE**	Non-specific	426,00	232,00	1290,32
JUICE	5	Non-specific	35	1	13,79	499	306	1854,27	**FOSE**	Non-specific	768,00	560,00	1429,49
LATE	4	Non-specific	187	9	40,4	1313,67	905	1113,43	**HIRSE**	Non-specific	618,50	231,00	1914,01
LATER	5	Non-specific	235	7	30,68	1687,75	905	3310,65	**JAIN**	Non-specific	829,67	351,00	1689,00
LIFE	4	Non-specific	203	4	112,43	481	274	1848,16	**JATE**	Non-specific	1129,00	351,00	611,51
LOSE	4	Non-specific	38	5	98,24	611	521	1884,49	**JUILE**	Non-specific	743,75	306,00	1387,09
LOVE	4	Non-specific	230	5	77,8	472,67	70	3179,25	**LABER**	Non-specific	1181,25	274,00	2204,92
MOUSE	5	Non-specific	782	6	4,67	2009	754	3652,99	**MIVE**	Non-specific	709,00	474,00	2811,81
NAME	4	Non-specific	306	6	110,07	675,67	430	3073,75	**MOUST**	Non-specific	1911,50	754,00	3134,03
NEVER	5	Non-specific	828	2	75,67	1069,5	190	3139,18	**NAVER**	Non-specific	1175,25	430,00	2645,11
NINE	4	Non-specific	143	3	52,44	474	212	1452,22	**NISE**	Non-specific	846,33	212,00	751,41

Target word	Length	Ortho. Typ.	Freq.	Cross- Ln N size	Higher Freq. Neighbour	Big. Freq. L1	Low. Big. Freq. L1	Big. Freq. L2	**Target pseudoword**	Ortho. Typ.	Big. Freq. L1	Low. Big. Freq. L1	Big. Freq. L2
NOISE	5	Non-specific	322	6	149,66	910	491	1688,72	**NUME**	Non-specific	420,00	177,00	2329,04
NOSE	4	Non-specific	297	7	98,24	601	491	1170,08	**NUNE**	Non-specific	238,00	177,00	690,43
PRICE	5	Non-specific	5	4	80	1443	337	2122,09	**PIME**	Non-specific	660,00	473,00	2987,59
RAIN	4	Non-specific	373	7	788,72	1412,33	966	1824,96	**POUSE**	Non-specific	2053,25	754,00	3577,30
RIVER	5	Non-specific	435	6	96,28	1144,25	465	3050,27	**PRILE**	Non-specific	1688,00	806,00	1654,91
TIME	4	Non-specific	1750	6	257,57	519,67	386	3582,00	**ROISE**	Non-specific	996,50	742,00	1811,38
TRIP	4	Non-specific	116	3	790	1467	247	257,72	**VAME**	Non-specific	732,67	601,00	2986,16
AUNT	4	specific	195	_	_	813	193	898,02	**ARNT**	specific	913,33	54	947,98
BEACH	5	specific	141	_	_	562,25	61	2903,28	**BADY**	specific	665,33	5	1210,26
BIRTH	5	specific	5	_	_	585,25	169	1218,65	**CREAD**	specific	559,25	31	1217,01
BODY	4	specific	146	_	_	557,33	5	873,43	**DEACH**	specific	636	61	2560,52
BOOK	4	specific	541	_	_	488,67	11	2554,54	**DIRTH**	specific	860,75	169	1189,17
BREAD	5	specific	224	_	_	539,25	31	1289,31	**DOOK**	specific	253,33	11	2808,81
COAT	4	specific	176	_	_	2193,33	63	5597,24	**DRAZY**	specific	751,75	4	516,25

Target word	Length	Ortho. Typ.	Freq.	Cross- Ln N size	Higher Freq. Neighbour	Big. Freq. L1	Low. Big. Freq. L1	Big. Freq. L2	**Target pseudoword**	Ortho. Typ.	Big. Freq. L1	Low. Big. Freq. L1	Big. Freq. L2
COOK	4	specific	300	_	_	2017	11	2500,62	**EADY**	specific	161,67	2	884,24
CRAZY	5	specific	43	_	_	977,75	4	464,97	**GOWER**	specific	832,25	2	2350,02
EASY	4	specific	184	_	_	390,33	2	1211,05	**HICK**	specific	310,33	54	995,19
FIRST	5	specific	817	_	_	620,75	425	1853,00	**LOAT**	specific	391,67	63	5883,48
GIFT	4	specific	41	_	_	168,67	32	861,91	**MIFT**	specific	377,33	32	909,45
GOOD	4	specific	1493	_	_	268	114	2439,28	**MIRST**	specific	669,75	425	1640,08
MILK	4	specific	289	_	_	518,67	27	1474,51	**MOOK**	specific	540	11	3285,31
MOON	4	specific	373	_	_	795	114	3092,77	**MOOP**	specific	677	114	2953,67
NIGHT	5	specific	725	_	_	258,25	18	2120,11	**NOOD**	specific	260	114	2044,98
SICK	4	specific	84	_	_	444,33	65	1099,70	**PIGHT**	specific	407	18	2081,46
SLOW	4	specific	227	_	_	213,33	15	714,71	**RILK**	specific	398,33	27	1313,36
SNAKE	5	specific	208	_	_	118,5	21	147,78	**SLEAK**	specific	139,5	22	837,39
SPEAK	5	specific	41	_	_	152,75	22	973,45	**SPAKE**	specific	187,25	21	466,56
TEACH	5	specific	30	_	_	616	61	2595,18	**SPOW**	specific	227,67	15	719,35
THANK	5	specific	408	_	_	824,25	4	3472,52	**THARK**	specific	277,75	4	3571,72

Target word	Length	Ortho. Typ.	Freq.	Cross- Ln N size	Higher Freq. Neighbour	Big. Freq. L1	Low. Big. Freq. L1	Big. Freq. L2	**Target pseudoword**	Ortho. Typ.	Big. Freq. L1	Low. Big. Freq. L1	Big. Freq. L2
THINK	5	specific	1390	_	_	456	4	5784,17	**THONK**	specific	377,75	4	3940,22
TOWER	5	specific	97	_	_	926,5	2	2327,55	**VEACH**	specific	633,5	61	2463,79
WALK	4	specific	335	_	_	693,33	27	1288,42	**WELK**	specific	210,33	13	3136,58
WATCH	5	specific	300	_	_	653,5	24	1819,15	**WHARE**	specific	798,75	9	3591,10
WHERE	5	specific	1425	_	_	573,25	9	6192,91	**WHIPE**	specific	302,25	9	3254,00
WHITE	5	specific	441	_	_	570,75	9	3971,21	**WIGE**	specific	368,67	12	3639,37
WIFE	4	specific	168	_	_	228,33	12	4049,02	**WOTCH**	specific	448,25	2	2620,30
YEAR	4	specific	246	_	_	265,33	8	1964,93	**YEAL**	specific	229,67	8	1703,71

Chapter 2. Study 5. Grapheme Experiment

Target letter	Condition	Letter-present Target	Freq.	Length	Position	Letter- absent Target	Freq.
A	1	HARD	471	4	2	COLD	446
A	1	BALL	346	4	2	BUSY	238
A	1	MAKE	1577	4	2	BOOK	541
E	1	BEST	481	4	2	BIRD	287
E	1	NECK	87	4	2	PINK	133
O	1	WORK	814	4	2	KING	698
O	1	LOVE	230	4	2	BATH	257
O	1	WORD	81	4	2	CARE	173
A	1	FLAT	154	4	3	SING	157
A	1	WHAT	3967	4	3	COME	2374
A	1	THAN	484	4	3	MILK	289
O	1	SPOT	97	4	3	FIVE	173
O	1	STOP	892	4	3	NEED	800
O	1	SHOT	73	4	3	RING	95
O	1	WORSE	45	5	2	TRUCK	59
O	1	HORSE	441	5	2	THING	457
A	1	PLANE	54	5	3	SINCE	65
A	1	WHALE	95	5	3	SHORT	84
A	1	BLACK	360	5	3	FLOOR	314
E	1	DRESS	154	5	3	BUILD	124
E	1	SPELL	76	5	3	SCARF	68
O	1	THOSE	257	5	3	LIGHT	306
O	1	SMOKE	81	5	3	BREAK	81
O	1	CLOCK	68	5	3	SPEND	54
A	2	HAIR	148	4	2	SOCK	57

Target letter	Condition	Letter-present Target	Freq.	Length	Position	Letter- absent Target	Freq.
A	2	WAIT	94	4	2	STEP	70
O	2	YOUR	923	4	2	BEAR	1214
O	2	HOUR	144	4	2	TALK	211
O	2	LOUD	127	4	2	DIRT	76
A	2	LAUGH	170	5	2	FRESH	105
A	2	PAINT	260	5	2	DRINK	189
O	2	SOUTH	76	5	2	SWEET	114
O	2	MOUTH	146	5	2	GUESS	127
O	2	NOISE	322	5	2	SMELL	127
A	2	CHAIR	208	5	3	KNOCK	127
O	2	CLOUD	35	5	3	CHEST	78
A	3	SAYS	281	4	2	GOLD	214
A	3	EARS	149	4	2	HURT	160
A	3	EACH	546	4	2	GIRL	527
E	3	READ	349	4	2	POOR	333
E	3	FEAR	51	4	2	PUSH	78
O	3	DOES	222	4	2	LATE	187
O	3	TOWN	681	4	2	LAST	617
O	3	ROAD	398	4	2	NEAR	311
A	3	BOAT	563	4	3	SHOW	330
A	3	PLAY	1095	4	3	TIME	1750
A	3	YEAR	246	4	3	FULL	300
O	3	SHOE	105	4	3	MEAN	149
O	3	KNOW	1230	4	3	TAKE	1093
O	3	SLOW	227	4	3	CALL	254
O	3	BOARD	57	5	2	CHEEP	95
O	3	TOAST	51	5	2	STAND	143

Target letter	Condition	Letter-present Target	Freq.	Length	Position	Letter- absent Target	Freq.
A	3	TEACH	30	5	3	DRIVE	166
A	3	HEART	78	5	3	THROW	81
A	3	BEACH	141	5	3	LUNCH	130
E	3	BREAD	224	5	3	STONE	149
E	3	DREAM	76	5	3	BLOOD	70
O	3	BROWN	389	5	3	START	222
O	3	FLOAT	62	5	3	SNAIL	59
O	3	CROWD	81	5	3	WASTE	103

Note. Condition 1: simple grapheme condition. Condition 2: complex non- specific grapheme condition. Condition 3: complex specific grapheme condition.

Chapter 3. Study 6. Pseudohomophone interference effect

Experiment 1. Pseudoword targets

Baseword	Number of syllables	Number of phonemes	Freq.	**Length**	**PSH Target**	**O. Sim. to baseword**	**O. Control Target**	**O. Sim. to baseword**	**Baseword**	**Freq.**	Filler Target
LIT	1	2	340,6	3	**LEA**	0,38	**LOA**	0,38	BORD	197,36	GORD
VITE	1	3	351,89	4	**VEAT**	0,41	**VOAT**	0,38	BEAU	297,17	REAU
VIDE	1	3	187,9	4	**VEED**	0,48	**VOED**	0,48	OEIL	278,51	REIL
LIRE	1	3	112,43	4	**LEAR**	0,41	**LOAR**	0,38	HAUT	253,24	CAUT
VILLE	1	3	311,69	5	**VEEL**	0,43	**VOEL**	0,43	FACE	262,16	DACE
FRERE	1	4	142,36	5	**FRARE**	0,51	**FRORE**	0,66	VITE	351,89	PITE
OREILLE	2	4	103,45	7	**OREIGH**	0,69	**OREITH**	0,67	VOIX	612,7	GOIX
SEMAINE	2	5	111,89	7	**SEMANE**	0,79	**SEMINE**	0,59	ORDRE	179,26	ARDRE
VERT	1	3	91,01	4	**VARE**		**VORE**		ROUTE	251,35	LOUTE
MIDI	2	4	68,18	4	**MEADY**		**MOADY**		PEINE	390,2	TEINE
ROUGE	1	3	258,04	5	**ROOGE**		**ROIGE**		MONDE	732,43	NONDE

Baseword	Number of Syllables	Number of Phonemes	Freq.	Length	PSH Target	O. Sim. to baseword	O. Control Target	O. Sim. to baseword	Baseword	Freq.	Filler Target
NEZ	1	2	177,64	3	**NEY**		**NEX**		TANTE	110,95	BANTE
DROLE	1	4	99,93	5	**DROAL**		**DROIL**		BELLE	246,35	RELLE
TROP	1	3	790	4	**TROW**		**TROG**		SAVOIR	290,95	FAVOIR
QUI*	1	2	7923,25	3	**KEA**		**KOA**		MENTON	58,65	NENTON
DOUCHE	1	3	20,68	6	**DUSH**		**DUTH**		CHEVAL	110,27	PHEVAL
DOS	1	2	213,99	3	**DOW**		**DOY**		VENTRE	136,62	MENTRE
FAUX	1	2	77,76	4	**FAW**		**FAZ**		BOUCHE	272,1	NOUCHE
GRIS	1	3	114,05	4	**GREA**		**GRUN**		METTRE	230,2	SETTRE
FLEUR	1	4	42,97	5	**FLUR**		**FLER**		JAMAIS	1122,97	JAMOIS

* this item was removed from the analyses.

Experiment 2. Pseudoword targets

Baseword	Number of Syllables	Number of Phonemes	Freq.	Length	PSH Target	O. Sim. to baseword	O. Control Target	O. Sim. to baseword	Baseword	Freq.	Filler Target
VENT	1	2	207,64	4	**VANT**	0,72	**VUNT**	0,72	BORD	197,36	**GORD**
GROS	1	3	246,96	4	**GROT**	0,66	**GRON**	0,66	BEAU	297,17	**REAU**
PIED	1	3	248,18	4	**PIET**	0,66	**PIEF**	0,66	ŒIL	278,51	**REIL**
RIRE	1	3	256,76	4	**RIRRE**	0,93	**RIRSE**	0,83	HAUT	253,24	**CAUT**
FORT	1	3	265,61	4	**FAURT**	0,69	**FEURT**	0,69	FACE	262,16	**DACE**
GENS	1	2	409,39	4	**JENS**	0,57	**HENS**	0,57	VITE	351,89	**PITE**
NUIT	1	2	676,55	4	**NUID**	0,66	**NUIF**	0,66	VOIX	612,7	**GOIX**
SOEUR	1	3	116,55	5	**SEURE**	0,60	**SOURE**	0,62	ORDRE	179,26	**ARDRE**
BLANC	1	3	211,76	5	**BLANT**	0,70	**BLANE**	0,70	ROUTE	251,35	**LOUTE**
ROUGE	1	3	258,04	5	**ROUJE**	0,78	**ROUPE**	0,78	PEINE	390,2	**TEINE**
COEUR	1	3	380,07	5	**QUEUR**	0,55	**GUEUR**	0,55	MONDE	732,43	**NONDE**
CHAUD	1	2	104,19	5	**CHEAU**	0,60	**CHIAU**	0,60	TANTE	110,95	**BANTE**
VENIR	2	5	196,01	5	**VEUNIR**	0,86	**VEINIR**	0,91	BELLE	246,35	**RELLE**

Baseword	Number of Syllables	Number of Phonemes	Freq.	Length	PSH Target	O. Sim. to baseword	O. Control Target	O. Sim. to baseword	Baseword	Freq.	Filler Target
QUATRE	1	4	282,64	6	**CATRE**	0,56	**NATRE**	0,56	SAVOIR	290,95	**FAVOIR**
BATEAU	2	4	61,22	6	**BATAU**	0,89	**BATEU**	0,86	MENTON	58,65	**NENTON**
ENTRER	2	4	109,26	6	**ANTRER**	0,67	**ONTRER**	0,67	CHEVAL	110,27	**PHEVAL**
MANGER	2	4	138,31	6	**MENGER**	0,82	**MINGER**	0,82	VENTRE	136,62	**MENTRE**
JARDIN	2	5	148,72	6	**JARDAIN**	0,88	**JARDOIN**	0,88	BOUCHE	272,1	**NOUCHE**
DONNER	2	4	216,55	6	**DAUNER**	0,70	**DAINER**	0,70	METTRE	230,2	**SETTRE**
ENCORE	2	4	1579,05	6	**ENQUORE**	0,79	**ENGUORE**	0,79	JAMAIS	1122,97	**JAMOIS**

Experiments 1 and 2. Word targets

Length	Target	Freq.	Number of syllabes
4	LAIT	62,23	1
4	LUNE	63,24	1
4	FAIM	74,93	1
4	SEPT	75,61	1
4	GARE	84,19	1
4	LIRE	112,43	1
4	FETE	72,23	1
4	JUIN	51,28	1
4	HAUT	253,24	1
4	NOIR	277,43	1
4	CIEL	301,76	1
4	PEUR	307,23	1
4	TARD	362,64	1
4	SEUL	521,96	1
4	SOIR	527,23	1
4	REVE	101,82	1
4	CHEZ	690,54	1
4	VOIR	716,55	1
4	JOUR	826,35	1
4	RIEN	1543,72	1
5	PLAGE	72,03	1
5	CHIEN	117,64	1
5	FROID	166,82	1
5	BELLE	246,35	1
5	VILLE	311,69	1
5	FILLE	110,95	1
5	HEURE	439,86	1
5	TROIS	660,34	1

Length	Target	Freq.	Number of syllables
5	AVION	46,82	2
5	DEBUT	128,51	2
5	ECOLE	128,51	2
5	ANNEE	128,99	2
5	FINIR	68,92	2
5	ALLER	376,08	2
5	MATIN	376,89	2
5	PETIT	768,72	2
5	PAYER	58,31	2
5	AUSSI	1359,86	2
6	PASSER	288,78	2
6	CHEVAL	110,27	2
6	VOYAGE	115,13	2
6	ECRIRE	116,15	2
6	BESOIN	251,76	2
6	DEBOUT	158,85	2
6	PENSER	161,62	2
6	GARCON	186,96	2
6	CHEMIN	197,5	2
6	ARGENT	200,54	2
6	SAVOIR	290,95	2
6	DEMAIN	155,54	2
6	PARLER	350,74	2
6	SOLEIL	328,78	2
6	ENFANT	381,96	2
6	MAISON	461,55	2
6	VISAGE	490,54	2
6	DEVANT	788,73	2

5	ARBRE	67,16	1	6	JAMAIS	1122,97	2
5	TEMPS	1289,39	1	6	DEPUIS	656,69	2

Have you ever seen this word ?

For each of these words, I want you to tell me

1. if you have ever seen this word at school (in a textbook for example).

You can answer Yes or No in the 2nd column.

2. If you know its meaning.

If you do, you can write it down in the 3rd column

WORD	Have you ever seen it ?	Do you know its meaning ?
LIT		
VITE		
FRÈRE		
VILLE		
SEMAINE		
VERT		
OREILLE		
MIDI		
ROUGE		
VIDE		
NEZ		
DRÔLE		
TROP		
QUI		
LIRE		
DOUCHE		
DOS		
FAUX		
GRIS		
FLEUR		

Chapter 3. Study 7. Cross- language phonological consistency.

Letter- present targets							Letter- absent targets						
Item status	**Letter**	**Phoneme**	**Consistency**	**Length**	**Target**	**Freq.**	**Item status**	**Letter**	**Phoneme**	**Trap**	**Length**	**Target**	**Freq.**
Expé	A	/a:/	Consistent	4	**card**	51	Expé	I	/i/	Piège	4	**feel**	303
Expé	A	/a:/	Consistent	4	**dark**	489	Expé	I	/i/	Piège	4	**free**	130
Expé	A	/a:/	Consistent	4	**farm**	141	Expé	I	/i/	Piège	4	**meet**	162
Expé	A	/a:/	Consistent	4	**fast**	660	Expé	I	/i/	Piège	4	**read**	349
Expé	A	/a:/	Consistent	4	**half**	114	Expé	I	/i/	Piège	4	**team**	103
Expé	A	/a:/	Consistent	4	**hard**	471	Expé	I	/i/	Piège	4	**tree**	995
Expé	A	/a:/	Consistent	4	**last**	617	Expé	I	/i/	Piège	4	**each**	546
Expé	A	/a:/	Consistent	4	**past**	241	Expé	I	/i/	Piège	4	**keep**	625
Expé	A	/a:/	Consistent	4	**path**	203	Expé	I	/i/	Piège	4	**mean**	149
Expé	A	/a:/	Consistent	4	**bark**	41	Expé	I	/i/	Piège	4	**deal**	19
Expé	A	/eI/	Inconsistent	4	**game**	160	Expé	I	/i/	Rien	4	**aunt**	195
Expé	A	/eI/	Inconsistent	4	**name**	306	Expé	I	/i/	Rien	4	**calm**	32
Expé	A	/eI/	Inconsistent	4	**same**	319	Expé	I	/i/	Rien	5	**glass**	211

Letter- present targets							Letter- absent targets						
Item status	**Letter**	**Phoneme**	**Consistency**	**Length**	**Target**	**Freq.**	**Item status**	**Letter**	**Phoneme**	**Trap**	**Length**	**Target**	**Freq.**
Expé	A	/eI/	Inconsistent	4	**take**	1093	Expé	I	/i/	Rien	4	**park**	446
Expé	A	/eI/	Inconsistent	4	**wake**	68	Expé	I	/i/	Rien	5	**start**	222
Expé	A	/o:/	Inconsistent	4	**call**	254	Expé	I	/i/	Rien	4	**both**	149
Expé	A	/o:/	Inconsistent	4	**salt**	327	Expé	I	/i/	Rien	4	**goes**	322
Expé	A	/o:/	Inconsistent	4	**talk**	211	Expé	I	/i/	Rien	4	**home**	1352
Expé	A	/o:/	Inconsistent	4	**walk**	335	Expé	I	/i/	Rien	4	**hope**	216
Expé	A	/o:/	Inconsistent	4	**wall**	349	Expé	I	/i/	Rien	4	**nose**	297
Expé	I	/i/	Consistent	4	**fish**	784	Expé	O	/o/	Piège	4	**ball**	346
Expé	I	/i/	Consistent	4	**gift**	41	Expé	O	/o/	Piège	4	**fall**	143
Expé	I	/i/	Consistent	4	**give**	368	Expé	O	/o/	Piège	4	**tall**	181
Expé	I	/i/	Consistent	4	**hill**	365	Expé	O	/o/	Piège	4	**warm**	373
Expé	I	/i/	Consistent	4	**kill**	97	Expé	O	/o/	Piège	5	**false**	38
Expé	I	/i/	Consistent	4	**kiss**	43	Expé	O	/o/	Rien	5	**dress**	154
Expé	I	/i/	Consistent	4	**milk**	289	Expé	O	/o/	Rien	4	**head**	703

Item status	Letter	Phoneme	Consistency	Length	Target	Freq.	Item status	Letter	Phoneme	Trap	Length	Target	Freq.
Letter- present targets							**Letter- absent targets**						
Expé	I	/i/	Consistent	4	**sick**	84	Expé	O	/o/	Rien	4	**send**	87
Expé	I	/i/	Consistent	4	**wish**	465	Expé	O	/o/	Rien	4	**mess**	141
Expé	I	/i/	Consistent	4	**miss**	449	Expé	O	/o/	Rien	4	**west**	51
Expé	I	/aI/	Inconsistent	4	**five**	173	Expé	E	/ɜ/	Piège	4	**burn**	16
Expé	I	/aI/	Inconsistent	4	**nine**	143	Expé	E	/ɜ/	Piège	4	**hurt**	160
Expé	I	/aI/	Inconsistent	4	**rice**	16	Expé	E	/ɜ/	Piège	4	**turn**	233
Expé	I	/aI/	Inconsistent	4	**wife**	168	Expé	E	/V/	Piège	4	**duck**	441
Expé	I	/aI/	Inconsistent	4	**time**	1750	Expé	E	/ɜ/	Piège	4	**luck**	122
Expé	I	/ɜ:/	Inconsistent	4	**bird**	287	Expé	E	/ɜ/	Rien	4	**bath**	257
Expé	I	/ɜ:/	Inconsistent	4	**dirt**	76	Expé	E	/ɜ/	Rien	5	**laugh**	170
Expé	I	/ɜ:/	Inconsistent	4	**girl**	527	Expé	E	/ɜ/	Rien	4	**yard**	51
Expé	I	/ɜ:/	Inconsistent	5	**first**	817	Expé	E	/ɜ/	Rien	4	**mind**	281
Expé	I	/ɜ:/	Inconsistent	5	**birth**	5	Expé	E	/ɜ/	Rien	4	**pint**	3
Filler	O	/o:/	Consistent	4	**born**	65	Filler	A	/a/	Rien	4	**joke**	141
Filler	O	/Q/	Consistent	4	**gone**	473	Filler	A	/a/	Rien	4	**more**	1030

Letter- present targets							Letter- absent targets						
Item status	**Letter**	**Phoneme**	**Consistency**	**Length**	**Target**	**Freq.**	**Item status**	**Letter**	**Phoneme**	**Trap**	**Length**	**Target**	**Freq.**
Filler	O	/Q/	Consistent	4	**lost**	316	Filler	A	/a/	Rien	4	**town**	681
Filler	O	/o:/	Consistent	4	**door**	857	Filler	A	/a/	Rien	4	**loud**	127
Filler	O	/Q/	Consistent	4	**shop**	311	Filler	A	/a/	Rien	4	**doll**	19
Filler	O	/o:/	Consistent	5	**horse**	441	Filler	A	/a/	Rien	4	**live**	746
Filler	O	/Q/	Consistent	4	**frog**	211	Filler	A	/a/	Rien	4	**pick**	114
Filler	O	/o:/	Consistent	5	**floor**	314	Filler	A	/a/	Rien	4	**pink**	133
Filler	O	/Q/	Consistent	4	**body**	146	Filler	A	/a/	Rien	4	**ring**	95
Filler	O	/o:/	Consistent	4	**fork**	5	Filler	A	/a/	Rien	4	**sing**	157
Filler	E	/E/	Consistent	4	**bell**	162	Filler	A	/a/	Rien	4	**dish**	49
Filler	E	/E/	Consistent	4	**best**	481	Filler	A	/a/	Rien	4	**fill**	70
Filler	E	/E/	Consistent	4	**desk**	22	Filler	A	/a/	Rien	4	**king**	668
Filler	E	/E/	Consistent	4	**less**	28	Filler	A	/a/	Rien	4	**lift**	76
Filler	E	/E/	Consistent	4	**next**	828	Filler	A	/a/	Rien	4	**lips**	35
Filler	E	/E/	Consistent	4	**help**	1720	Filler	A	/a/	Rien	4	**hunt**	68
Filler	E	/E/	Consistent	4	**neck**	87	Filler	A	/a/	Rien	5	**quick**	178
Filler	E	/E/	Consistent	4	**sell**	76	Filler	A	/a/	Rien	4	**cure**	11

Filler	E	/E/	Consistent	5	**smell**	127	Filler	A	/a/	Rien	4	**must**	879
Filler	E	/E/	Consistent	4	**tell**	595	Filler	A	/a/	Rien	5	**build**	124