**Crossing Modalities to Support Word-Learning: Incidental Orthographic
Facilitation in Oral Vocabulary Acquisition**

by

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Abstract

Children's vocabulary continues to grow quickly during the elementary school years, yet we do not fully understand the role of learning to read on oral vocabulary acquisition. The current study examined whether children's incidental encounters with orthographic representations of words could facilitate their acquisition of oral vocabulary. A paired-associate oral word learning paradigm was used to teach grade 3 French children nonword spoken labels to novel picture referents. Children participated in one of three conditions: (1) incidental exposure to consistent orthography; (2) incidental exposure to inconsistent orthography; and (3) absence of orthography. As expected, children in orthography present conditions learned words faster than children who were not exposed to orthography. However, the advantage was no longer present one day later. Children's spelling of words a day later indicated that orthographic representations had been implicitly acquired from exposure, and were more precise for children who were exposed to feedback-consistent orthography.

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Crossing Modalities to Support Word-Learning: Incidental Orthographic

Facilitation in Oral Vocabulary Acquisition

Importance of Vocabulary Teaching for Children

Vocabulary development is central to language learning: the acquisition, storage, and retrieval of words from memory allow humans to communicate effectively using language. Vocabulary acquisition is a valuable, lifelong process. Children's vocabulary grows quickly, and has been strongly linked to reading comprehension and academic achievement outcomes (West, Stanovich, & Mitchell, 1993; Lervag & Aukrust, 2010).

Of interest to the current study is the lack of research addressing how learning to read might support young elementary school children's acquisition of oral vocabulary. Following a summary of existing recommendations for vocabulary instruction, Ehri and Rosenthal (2007) conclude that orthography's potential contribution to word learning has been overlooked due to a fundamental mismatch that exists between the priorities of vocabulary researchers (who focus on meanings) and reading researchers (who focus on spelling). While this oversight may have resulted from perceptions that reading facilitates the acquisition of spellings independently of vocabulary (discussed later), the amount of reading adults and older elementary-school children report is positively and robustly linked to their vocabulary knowledge (Sénéchal, 2006; West et al., 1993). If this is true, why could orthography not also scaffold oral vocabulary learning for children who are learning to read? Preliminary studies with English children suggest that orthography may facilitate the acquisition of spoken words and their meanings – even when it is not explicitly presented. The current study extends existing research by

addressing the incidental orthographic facilitation effect demonstrated with English speaking children in another opaque language, with French grade 3 students. As described in greater detail later on, opaque orthographies employ a multiplicity of ways for representing speech sounds in print, as well as contain words with irregular spellings (such as *yacht*) that must be acquired by sight (Nation, 2009).

Vocabulary Knowledge

Vocabulary essentially refers to a person's accumulated store of word knowledge within a language. Words are, universally, the smallest meaningful units that can be moved around in an utterance (Clark, 1993). Unlike icons or indices, words act as intentional and arbitrary symbols for referents (objects, feelings, mental states, actions, or other symbols) that are not physically similar to the word, and are not necessarily present at the time the word is used. In fact, words can make reference to things that have never been experienced before, or that do not exist (e.g., unicorns, Santa).

Word knowledge is multidimensional, and can vary in both quantity (breadth; number of words known) and quality (degree and depth of word knowledge). The depth of a person's word knowledge is dependent upon their knowledge of a word's multiple facets, or dimensions. These multidimensional sources of information can include knowledge of a word's phonology (pronunciation), orthography (spelling), semantics (meaning), syntax (e.g., grammatical class and function), and morphology (e.g., information regarding parts of a word that contain meaning, such as roots, affixes, or compounds), among others (Hu, 2003). These dimensions are customarily acquired in parts over time, either through explicit instruction or incidental encounters. The current

study will examine how incidental exposure to a word's orthography might facilitate the acquisition of oral vocabulary in French children.

Accumulated word knowledge is stored in a person's lexicon, which serves as their mental dictionary and vocabulary store (Clark, 1993). For present purposes, it is assumed that separate entries for each word contain integrated information about their forms and meanings, providing symbolic referential mental representations for words. This is consistent with Perfetti and Hart's (2002) description of lexical representations as being constructed of tripartite phonological, orthographic, and semantic constituents. These constituents are also stored in the lexicon(s) of bilinguals, though the nature of the bilingual lexicon as a single language-general or as separate language-specific networks is not addressed in the present study. There is also evidence of organization and interconnections existing among lexical entries in both monolingual and bilingual memory, which have been metaphorically described as multi-layered networks (Dorte, Haastrup, & Henriksen, 2008). Access to stored word knowledge by ear and by eye allows individuals to understand and convey information in speech and writing. The acquisition of the necessary representational knowledge that allow for these successful communicative processes to occur will now be discussed.

Vocabulary Acquisition: Spoken Words and Meanings

Vocabulary acquisition involves remembering the pronunciations of words and their meanings (Rosenthal & Ehri, 2008). In order to acquire a phonological representation, hearing individuals must first perceive a stream of incoming auditory information, distinguish word units in speech utterances within their language, and attend

to the sound sequence that makes up a spoken word. Once detected and perceived, the sequence of sound units must be maintained long enough in working memory to store a record of the coded auditory input in long-term memory. Several factors can influence the efficiency of the passage into long-term storage, including the length of the pronunciation (e.g., longer strands increase memory demands; Morra & Camba, 2009), the familiarity of the auditory construction (e.g., unfamiliar speech sounds increase memory demands; Morra & Camba, 2009), the effectiveness of strategies used to maintain the pronunciation in memory (e.g., repeating, chunking, visualizing, or using previously stored knowledge to create analogies), and the amount of exposure (e.g., Gu & Johnson, 1996). Following the storage of a phonological representation, recognition of a familiar spoken word will occur when an incoming pronunciation elicits an automatic search of phonological traces in lexical memory and identifies a corresponding stored phonological form, which subsequently activates the mental representation for the word and all of its constituents (Jahandarie, 1999).

In young children, phonological awareness, motor developments, and cognitive abilities may provide constraints on children's attempts at coding, rehearsing, or retrieving pronunciations from memory. Detection of speech sounds begins early-on as human infants become familiar with the sounds of the language that surround them. By the end of their first year, infants become attuned to perceiving speech sounds in their native language (Werker & Desjardins, 2001).

Recently, only children's ability to acquire a word's *phonological* form has been addressed. As symbols, however, words are by nature associated with *referents*, to which

they are arbitrarily and *intentionally* mapped according to systematic convention. That it is possible for infants as young as 7.5 months old to discriminate, remember, and recognize familiar sound sequences for words presented in isolation or in speech streams does not assume that they are able to meaningfully comprehend their symbolic function or have acquired a referential mapping (Jusczyk & Aslin, 1995). Comprehension, as a mental event, must be inferred from overt behaviour and the context in which it occurs (Fernald, Pinto, Swingley, Weinberg, & McRoberts, 2001, p.49), and most children are generally only beginning to speak by the end of their first year of life. Children's vocabulary acquisition during their first year of life appears to be a laborious process, while their second year is marked by a dramatic increase in the rate of acquisition that appears around 18 months of age, frequently referred to as the "vocabulary burst" or "naming explosion" (e.g., Gopnik & Meltzoff, 1987; Ganger & Brent, 2004). Reports of the quantity of productive words acquired by 18 months ranges widely, from between 50 and 100 words (Werker & Desjardins, 2001) to between 50 and 200 words (Clark, 1993, p.22), while by 24 months they range from 300 words (Hirsh-Pasek, Golinkoff, & Hollich, 2000) to as many as 600 words (Clark). By the time children begin school, they have acquired approximately 10,000 to 15,000 words in their vocabulary (Fromkin, 2000, p.459).

Vocabulary growth has been estimated to continue at an average rate of 2.2 words per day through age 8, though large and ever-widening differences have been found to exist in vocabulary size by the end of grade 2 due to differing rates of acquisition (Biemiller & Slonin, 2001). It is thus of great importance to understand the means and

mechanisms by which children acquire mappings between spoken forms and referents in order for effective vocabulary teaching methods to be developed and bridge the vocabulary gap as early as possible.

Of particular interest to the current study is the acquisition of mappings between spoken labels and pictures of object referents when they are presented contiguously. The facility with which word forms and meanings are mapped has been shown to vary according to the concreteness of the referent, regardless of the language in which it is being learned: it is easier to map associations between words and more concrete (e.g., a noun like *bird*) rather than more abstract (e.g., a state like *sorry*) concepts (Nelson & Schreiber, 1992). Speech directed towards children in naturalistic contexts is often embedded in social and contextual cues, and related to objects, events, and actions in their immediate surroundings, which may support the acquisition of mappings between spoken labels and referents (Akhtar & Tomasello, 2000). Ontological categories, based on experience, have been postulated as providing a framework for children to facilitate their learning of mappings between speech and meaning (Clark, 1993). Such categories may include objects, actions, events, relations, states, and properties, and are – likely intentionally – frequently used themes in preschool, early elementary school, and second-language classrooms. Word learning principles may additionally provide cognitive cues by outlining assumptions that may be used to guide the mapping of spoken labels to object wholes rather than parts or attributes (whole-object assumption), and to objects that lack an existing label rather than those that have previously been labelled (mutual exclusivity), among others (Hirsh-Pasek et al., 2000).

Together, social, perceptual, linguistic, and cognitive cues offer many sources of support for mapping spoken labels onto novel referents, and acquiring phonological and semantic representations for words. Rather than viewing these sources of information as stemming from separate views, they are acknowledged here as a manifold of cues that collectively contribute to the acquisition and internalization of associations between spoken labels and their referents. Whether alternatively referred to as links, correspondences, or expectations, it cannot be denied that the process of associative learning is involved in establishing the link between spoken labels and novel objects (Smith, 2000).

With young children, fast mapping has been proposed as potential sources for explaining children's rapid vocabulary acquisition in the early years (Carey & Bartlett, 1978). When young children are able to use "semantic, syntactic, and/or social cues" to help them identify the meaning of a new word, they are *fast mapping* the association between the word and their partial understanding of its meaning. For example, in situations where only one object in a set is unfamiliar (e.g., dog, tree, *garlic press*), children have shown evidence of fast-mapping a novel label onto the unfamiliar target when it is provided in the form of a request from the experimenter (e.g., "Can you show me the *dax*?") (e.g., Golinkoff, Mervis & Hirsh-Pasek, 1994). This quick learning of associations has been exploited in false belief methodologies, where children are introduced to several unfamiliar items that are referred to by novel names, and then asked to retrieve "only the *dax*" following a series of object-location manipulations (e.g., Carpenter, Call, & Tomasello, 2002). In both instances, syntactic cues provided by the

experimenter may also lead the child to acquiring an understanding that a dax is an object (a noun) as opposed to an action or property (which may be elicited by “I daxed you” or “this thing is daxy”) (Flavell, Miller & Miller, p.305, 2002). Exhibiting similar outcomes, a *quick incidental learning* paradigm employed in some studies has provided evidence that introducing new words during a movie by means of voice-over narration can also be effective in children’s fast acquisition of receptive vocabulary (Rice, 1990).

Regardless of the context, these “quick learning” procedures may lead to the construction of an association between a word and a referential meaning that is only *partially* clear. Indeed, very young children may acquire an understanding, and later approximation, of a word’s pronunciation, that may initially be constrained to use in situations where the referent is physically or temporally contiguous (Clark, 1993). This “goes with” relationship based on associations later develops into a “stands for” symbolic referential relationship. The precision of a word’s referential meaning may therefore go through a transition period in order to place *constraints* on its meaning, as children may initially overextend its usage to refer to something more general (e.g., using *dog* to refer to all four-legged animals) or underextend its usage to something exclusive (e.g., using *cat* to refer only to the family pet). Additional exposure to learned words and acquisition of more new words in speech will lead to the recasting of meanings for known words, the development of specificity distinctions within categorical classes, the acquisition of words with overlapping meanings, and the emergence of a hierarchical structure in memory based on this taxonomy (Clark, 1993). Supplementing oral

vocabulary growth, literacy acquisition provides readers with an additional source of word knowledge: orthography.

Words in Print: Prerequisites to Acquiring Orthographic Representations

The process(es) by which *orthographic representations* are acquired in lexical memory remains a source of debate, as is their exact structure within the lexicon and their association to other forms in memory. Mounting research nonetheless points towards the existence of orthographic representations in lexical memory for literate individuals that are discernable from phonological representations (discussed further in the following section). Word-specific orthographic representations are believed to contain information about a word's spelling, symbolically coded as an alphabetic image in memory.

Arguably a less natural form than its spoken counterpart, the processing of a word in print depends upon the reader's knowledge of and ability to use a language's writing system (e.g., Liberman, 1992). Of interest to the current study is the lack of congruence between orthographic and phonological forms in opaque orthographies, which may interfere with children's ability to exploit mappings between written and spoken words.

Conventional use of alphabetic orthographies fundamentally relies upon an understanding of the correspondences between letter(s) in print and sounds in speech. Referred to as the alphabetic principle, insight into conventional letter-sound mappings provides individuals with essential knowledge of the symbolic code (the alphabet) required to process written words as compositions of symbols rather than icons or indices (Caravolas, 2006). Processing novel words in print is initially a very challenging process, and novice readers tend to make explicit their vocalized attempts at translating print into

speech (Jahandarie, 1999). These attempts require that individuals draw upon their stored knowledge of the alphabetic principle in order to sound out printed words by consecutively decoding their letters into speech sounds, while concurrently maintaining the sequence of decoded sounds in working memory. As the sequence of speech sounds is processed, an automatic search of the individual's lexicon takes place in an attempt to locate an existing phonological representation in memory that matches the target sequence. In this way, individuals are able to acquire orthographies for familiar spoken words through "self teaching" (Share, 1995), adding word-specific orthographic representations to their existing lexical knowledge. The addition of orthographic representations arguably provides an alternative and more direct route from print to the lexicon, allowing for lexical access and retrieval of word information from memory on the basis of the recognizable letter string input (Dijkstra, 2005). Indeed, sight-word reading (or reading words from memory) is believed to be a reading strategy that gains automaticity with print exposure, and lends itself functionally to proficient readers' ability to quickly and accurately comprehend a text (Ehri, 1998).

An early meta-analysis assessing the impact of vocabulary instruction on reading comprehension revealed noteworthy effect sizes (M effect size = .91), indicating that a growing vocabulary may offer the necessary foundation for acquiring further words and word meanings in memory (Stahl & Fairbanks, 1986), reflecting the traditional Matthew Effect (Stanovich, 1986). Indeed, Cunningham and Stanovich (1997) reported that children's first-grade oral vocabulary scores accounted for thirty percent of the variance in their reading comprehension scores ten years later, in eleventh grade. Having

documented oral vocabulary as being a strong indicator, teaching strategies that aid to build vocabulary early may offer the greatest defence against the widening gap in comprehension witnessed between good and poor readers. A great deal of word-reading growth has been identified as occurring in grade 2, while by grade 3 children are focusing on “reading to learn” rather than “learning to read” and are experiencing growth in reading comprehension (e.g., Aarnouste, VanLeeuwe, Voeten, & Oud, 2001). As such, providing incidental exposure to orthography during oral vocabulary learning in a period that immediately follows children’s largest period of reading growth would ensure that they can make efficient use of such supports as early as possible.

Several factors can influence the efficiency of storage and accuracy of orthographic representations in memory. Similar to the considerations for spoken forms, processing and memory constraints create length and familiarity limitations for acquiring written word forms (Gathercole & Baddeley, 1993). Familiarity and fluency in employing one’s knowledge of a language’s alphabetic code may impede pre-literate learners’ attempts at retaining accurate printed forms in memory. It should also be noted that the above-described process for acquiring orthographic forms in memory is an ideal situation that applies to only the most straightforward of circumstances: accurate decoding results in the recognition of a familiar spoken form to which the orthography clearly maps, and this can be added to lexical memory. Languages, however, vary in the clarity with which spoken words are represented orthographically. For instance, French and English both have opaque orthographies that employ a multiplicity of ways for representing speech sounds in print, and also contain their share of words with irregular

spellings, which are error-prone for decoding and must thus be acquired by sight (e.g., *ocean*, *yacht*, and *island*) (Nation, 2009). In addition, stored forms for words that contain doubled letters (e.g., *vacuum/vaccum*), vowels whose pronunciation may vary (e.g., *inconsistant/inconsistent*), or silent letters (e.g., *c* in *scissors*) all appear to contain ambiguity, even for experienced readers (Frith, 1980).

Studies investigating how we acquire orthographic forms for words that are spelled inconsistently (i.e., lack one-to-one mappings between speech and print) suggest that the form is at first underspecified in memory, but we initially establish a “frame” for building the form in memory by storing clearly specified letters or letter-units and underspecified “spacers” that allow for fairly accurate recognition, but approximate production, of inconsistent words in print (McKague, Davis, Pratt, & Johnston, 2008). For example, children trying to spell nonwords that had been presented in both spoken and written form showed an effort to preserve their memory of the orthography in a dictation task, including a silent letter “somewhere in the middle,” despite its interference with the preservation of the phonological form (Ehri, 1980). The precision and refinement of our orthographic forms in memory is thus assumed to increase with exposure and accumulating orthographic knowledge (e.g., Ziegler & Goswami, 2005; Castles, Davis, Cavalot, & Forester, 2007). A progressive knowledge and sensitivity to the written system develops over time and with experience, and with it an advanced understanding of language-specific orthographic conventions is acquired that can be used to increase the precision of our orthographic representations, as evidenced by our

increased use of conventional spelling (see for e.g., Frith, 1985; Read, 1986; Ehri & McCormick, 1998; Ehri, 2005).

How meaningful connections are learned between orthographic and semantic forms in lexical memory is less well understood, though associative learning is also believed to play a role in forming these links in memory. Existing associations between phonological and semantic forms, coupled with the correlation between phonological and orthographic forms in alphabetic languages, is believed to contribute to the connection of orthographic and semantic forms in memory (Nation, 2009). Further hypotheses surrounding the nature of the associations between lexical constituents are expanded upon in a later section. Of primary interest to the current study is the more direct relationship between orthographic and phonological forms, and factors that influence the effectiveness of children's mappings between written and spoken words. While orthographic knowledge leads not only to increased conventional reading and writing, it also appears to fundamentally change the way that literate individuals process spoken language. The impact of literacy on spoken word perception is discussed in the following section.

Literacy's Influence: Orthographic Effects on the Processing of Spoken Language

Literacy acquisition results in the development of a fundamental and lasting link between spoken and written language. In languages with alphabetic orthographies, the alphabetic principle provides its users with a code for mapping speech sounds and letters in print. While initially this code is exploited primarily in processing and producing written language, amassing research evidence indicates that these mappings also

contribute to literate individuals' speech processing. Likened to the influence of a "virus" (Frith, 1998), it is widely held that alphabet knowledge impacts the way listeners of languages with alphabetic orthographies analyze speech sounds. Studies with children and adults alike have consistently demonstrated positive correlates between phonemic awareness (i.e., the ability to detect and manipulate the sounds in one's language) and the establishment of grapheme-phoneme correspondences (e.g., Morais, Cary, Alegria, & Bertelson, 1979; Read, Zhang, Nie, & Ding, 1986; Ehri, 2006; Caravolas, Hulme, & Snowling, 2001). Even children at very early stages of reading acquisition find it difficult to separate letters and sounds (Treiman & Cassar, 1997). Despite such evidence of children's early sensitivity to mappings between speech and print, the majority of the research currently available and reviewed here uses literate adult samples to illustrate the impact of orthographic knowledge on the processing of familiar speech sound and spoken language across several alphabetic orthographies.

Several studies have demonstrated that sensitivity to phoneme-grapheme mappings and/or knowledge of a word's spelling can bias listeners on a variety of tasks. Divergences between phonological input and existing orthographic knowledge have been shown to influence participants' ability to identify syllable boundaries. When asked to count the number of syllables in the spoken words *rich* and *pitch*, English children who could read reported more often that there were more syllables in the word that contained more letters, despite them both containing the same number of syllables (Ehri & Wilce, 1980). Adults have also demonstrated false perceptions of syllable breaks in spoken words (e.g., Taft & Hambly, 1985). Other factors that have influenced literate

listeners' speech processing include their expectations based on existing knowledge of word-specific orthography (e.g., French students hearing /b/ rather than /p/ in *absurde*[/apsyrd/]; Hallé, Chéreau, & Segui, 2000), and their sensitivity to the frequency of available orthographies (e.g., French students' detection of /p/ and /t/ in real words was faster than their detection of /k/, a phoneme that has numerous legal orthographic forms; Frauenfelder, Segui, & Dijkstra, 1990).

Beyond the phoneme-level of spoken words, the availability and dominance of a syllable's rime unit orthography (or end-of-word "rhyming unit") have also been shown to influence performance on auditory tasks involving spoken word recognition. For example, studies in several languages have all corroborated the finding that when orally presented words can only be spelled in one way (e.g., in English /-ʌk/ can only be spelled *-uck*) participants are faster to judge them to be real than when there are multiple ways to spell the word (e.g., in English /- i:p/ could be spelled *-eap* or *-eep*) (e.g., Ziegler & Ferrand, 1998; Ventura, Morais, Pattamadilok, & Kolinsky, 2004). This effect has also recently been documented with children who can read, in a Portuguese sample of students in grades two through four (Ventura, Morais, & Kolinsky, 2006). Pre-readers tested separately showed no evidence of an influence of orthographic knowledge on spoken word recognition, supporting literacy as the key to orthography's effect on spoken language.

Stronger evidence still for the influence of orthography on spoken word recognition is provided from studies that orthogonally manipulated phonology and orthography of target words. When priming techniques are employed, participants are

asked to perform a task in response to a word stimulus; however, the immediately preceding presentation of a *prime* (word or nonword) is believed to influence the target word's perception. Studies have identified primes that are both phonologically and orthographically similar to be optimal for influencing results in auditory word recognition tasks (e.g., Jakimik, Cole, & Rudnicki, 1985; Chéreau, Gaskell, & Dumay, 2007). For example, responses to the word "fantasy" would be fastest when primed with the word "FAN" than when primed with "PHAN" or "CHALK." This effect has also been documented in an even more authentic task: spoken neighbourhood generation. When asked to produce a similar-sounding word in response to hearing a real word, participants generated more phonographic neighbours (i.e., words that share both phonological and orthographic similarities to the prime) than would be expected by chance, leading researchers to conclude that orthographic representations are also accessed during speech production (Muneaux & Ziegler, 2004).

While the majority of the available research focuses on literate adults, a few examples of research with children exist. Children's use of memory for orthographic forms, their sensitivity to the availability and dominance of orthographic forms corresponding to sounds in speech, have shown that even beginner readers employ their orthographic knowledge in processing speech – but pre-readers do not. A recent developmental study provides additional evidence to substantiate this claim, and it appears to be the only study as of yet to investigate the impact of literacy development on orthography's influence in spoken word recognition (Ziegler & Muneaux, 2007). Samples of French monolingual beginner (grade 1), advanced (grade 5), and dyslexic

(grade 5) readers were compared on their ability to quickly and accurately identify real words in an auditory lexical decision task (Ziegler & Muneaux, 2007). While all children were sensitive to the number of phonological neighbours available for the word stimuli, only the skilled readers were affected by the number of orthographic neighbours available (Ziegler & Muneaux). Of interest to the current study is the finding that all literate individuals, regardless of their level of proficiency, experienced an influence of orthographic knowledge on their spoken word recognition.

That literacy development appears to correspond with orthography's influence on spoken word recognition suggests that literate individuals are able to draw on an additional source of information in processing auditory input that is unavailable to pre-literates: orthographic knowledge. Together, these studies provide strong evidence for the existence of orthographic representations that are distinct from phonological forms in lexical memory, and indicate that listeners frequently make use of their existing orthographic knowledge during speech processing. False perceptions of speech sounds within words due to acquired knowledge of word-specific orthography, sensitivity to the existence of inconsistent mappings between speech sounds and letters, and to the frequency of these mappings, all suggest that orthographic representations may employ alphabetic images in their storage of words in lexical memory that could provide an alternative direct route to the lexicon for literate individuals. While alternative views exist, this perspective is adopted in the current study, and is consistent with connectionist accounts in which phonological, orthographic, and semantic components of lexical memory are believed to interactively contribute to word recognition (Seidenberg, 2005).

How these lexical dynamics might contribute to oral language acquisition is discussed in the following section.

Accessing the Lexicon “By Ear and By Eye”

Amassing research has shown that orthographic knowledge exerts a powerful influence on speech processing, and yet little research has assessed whether it may contribute to oral vocabulary acquisition. Considering the complementary nature of spoken and written language, orthography may provide an additional source of analogous information to support oral word learning. Some support for this notion comes from research indicating that coding information in more than one modality has been shown to provide advantages for learning. For example, English children that ranged in age from seven to 11 years old found it easier to learn pairings between verbal and visual information than verbal-verbal or visual-visual pairings, when stimuli consisted of spoken nonwords and visual abstract shapes (Hulme, Goetz, Gooch, Adams, & Snowling, 2007). Clearer benefits for the provision of orthography during spoken language learning come from studies investigating the use of multi-modal sources of information in language learning.

In one study employing a multimedia setting, university-level second-language learners were provided with either text, pictorial annotations, or both to support their listening to an oral text passage (Jones & Plass, 2002). Results indicated that providing multiple sources of congruent information increased learners' comprehension and memory for vocabulary words, more so than when they were provided with a single source of information (Jones & Plass, 2002). Additional finding from studies using video

subtitles alongside auditory input indicate that providing second-language information in a bimodal format can promote content and vocabulary learning, even in inexperienced second-language learners (Baltova, 1999; Zarei, 2009). In second-language studies that varied the types of subtitles used, subtitles that were consistent with the language of the audio provided significantly more support than those that were standard or reversed, supporting the notion that their complementary nature and the congruency between text and speech is what reinforced learning, rather than the provision of dual modality alone (Baltova, 1999; Zarei, 2009). Indeed, both first- and second-language learners have demonstrated increased performance on measures of comprehension and memory for oral vocabulary when subtitles were presented alongside auditory input, indicating that there exist benefits to providing orthography that go *beyond* simply disambiguating speech input (Bird & Williams, 2002).

While studies investigating the provision of multiple modalities on vocabulary retention suggest benefits to providing textual annotations alongside auditory input, attention is generally not drawn to the task of acquiring spoken words, and testing usually occurs in a written format. What these studies have revealed, however, is that when complementary spoken and written information is presented congruently – whether in the first or second language – it increases spoken language comprehension and vocabulary retention. Considering the previously provided evidence that orthography can influence spoken language processing for literate individuals, the potential that it may also play a role in the acquisition of oral vocabulary is certainly worth considering. In particular, there exists the possibility that orthographic information presented congruently with the

phonological input of a spoken word might allow literate individuals to exploit their knowledge of the link between printed words and pronunciations in order to increase phonological retention and storage in memory. Such an account is consistent with connectionist models, which attempt to mimic neural networks and trace patterns of activation among multiple units of lexical information in memory (Seidenberg, 2005).

While debates remain on the precise nature of the units and their access, interactive patterns of activation are believed to create strong links between visual and spoken language, bonding (Perfetti & Hart, 2001) or amalgamating (Ehri, 1978) phonological and orthographic representations in the lexicon. The foundation for these strong associations between speech and print is believed to lie in an understanding of grapheme-phoneme correspondences, which permit individuals to acquire word-specific orthographies by decoding print to familiar spoken words (Share, 1995) and ultimately “glue” orthographic and phonological forms in lexical memory (Ehri, 1978). Subsequently, lexical representations that contain multiple sources of information are believed to enhance their quality and the efficiency of their retrieval.

Although these accounts are complementary in their opinion that strong links are formed between orthographic and phonological forms, relatively little research has been done to directly investigate the existence of an *orthographic facilitation effect* on oral vocabulary acquisition. The existing literature remains limited to studies of English children, as of yet not supporting its generalization to other languages. Ehri and Wilce (1979) conducted a series of experiments to demonstrate orthographic facilitation of oral word learning. They proposed that literate children were able to use their orthographic

knowledge to help store pronunciations in memory, and specified that the source of this benefit was in their ability to use orthographic images as symbols for retaining speech sounds in memory. To test their hypothesis, they employed a paired-association oral word learning paradigm. As their learning paradigm has been used in subsequent research and is relevant to the current study, it is worth introducing in greater detail. Within this paradigm, pairings between spoken labels and either image referents, text referents, spoken definitions, or a combination of these are taught to children. Following a series of training trials in which spoken label-visual/auditory referent pairings are introduced to and repeated by children, children are asked to recall the spoken labels for each referent as they are presented in a random order during production trials. This procedure is repeated, with slight variations, until a criterion or maximum number of learning sets have been completed. Children's oral word learning is assessed through their performance across learning sets (e.g., trials to criterion, quantity of word learned), and in posttests of expressive and productive vocabulary retention.

In Ehri and Wilce's (1979) study, four experiments used paired-association oral word learning paradigms to teach English grade 1 (M age = 6;5 yrs) and grade 2 (M age = 8;0 yrs) children oral monosyllabic nonword labels for visual referents. Within-subjects designs were employed to assess learning across several conditions, using variants of symbols, numbers, and letters as referents. In some conditions, referents were accompanied by a visual "study aid" during training, in the form of orthography that corresponded to the pronounced nonword label. In these conditions attention was drawn to study aids ("look at this"), though no instructions for their use were provided and they

were never displayed during recall trials. Results from the first and second experiments revealed a learning advantage for all children in conditions that provided spelling study aids with letter referents, while in conditions where spelling was not provided, letter referents showed an advantage as compared to symbols. It is important to note, however, that the outcome measure was the number of learning trials to reach criterion, therefore these results were based solely on an analysis of children who managed to reach learning criterion. When comparing grade 1 children in the second experiment who reached criterion ($N = 12$) with those who did not ($N = 18$), reading skills were found to be the only significant differentiating factor between the groups. Children who did not reach criterion only read 1 to 2 words successfully as compared to the 20 words read by the successful group, leading to the conclusion that for *literate* children orthography provided a means of securing pronunciations in memory.

Ehri and Wilce (1979) did two further studies were conducted in order to eliminate several alternative explanations for the previous results. In their third study, grade 2 children ($N = 24$) learned spoken labels for number referents (1-4) in four training conditions: with visual orthography aids, oral orthography aids (spelled aloud by the experimenter), additional repetition (by the child), and phonetic segmentation (sounded-out by the experimenter). An analysis of children's learning growth across trials revealed that although learning occurred in all four conditions, expressive vocabulary learning was significantly superior when visual orthography aids were provided, supporting the existence of an orthographic facilitation effect. Learning growth across the other conditions was not significantly different, suggesting that orthography

presented in the visual modality allowed children to take full advantage of the symbolic mnemonic system that it provided. Evidence that orthographic facilitation supported children's acquisition of oral nonwords even when referents were not alphabetic in nature led to the conclusion that providing orthography does not enhance the learning of pairings, but rather the acquisition of *spoken labels themselves*. A fourth, final experiment with eighteen grade 2 students reinforced the conclusion that symbolic alphabetic images provided by orthography are what helps to improve one's memory for pronunciations: children who were instructed to visualize oral spellings for the spoken labels being learned showed significantly better expressive vocabulary than those who rehearsed the sounds several times. Such results provide strong support that orthographic facilitation stems from its ability to provide a congruent and complementary support in the maintenance and subsequent storage of pronunciations.

Despite this early evidence supporting claims of orthographic facilitation in oral vocabulary acquisition for individuals with decoding skills, studies in subsequent years turned to examining phonetic cue effects, exploiting young pre-literate children's sensitivity to the relationship between sounds in speech and letters in print in the creation of associations between phonetically-accurate orthographic cues and familiar spoken words (e.g., Ehri & Wilce, 1985; Rack, Hulme, Snowling, & Wightman, 1994).

Recently, Rosenthal and Ehri (2008) re-examined the orthographic facilitation effect. In separate studies, grade 2 (Study 1) and grade 5 (Study 2) children were taught oral paired associations between spoken words and their meanings by presenting them with spoken rare nouns paired with simplified oral definitions that drew on familiar

knowledge, as well as picture referents. The presence of orthography during training was manipulated, and in separate learning sessions within each study, half of the items contained orthography below the picture referent. No attention was drawn to orthography in either of the studies, and spelling was absent during recall trials. Hence, the studies test whether the *incidental* presence of orthography would facilitate learning and retention of oral vocabulary.

Rosenthal and Ehri (2008) told the children to try and learn the name and meaning of each picture, as they would be asked to recall it later. Posttesting was completed the day following each training session, and tested children's recall for pronunciations (expressive vocabulary), meaning (receptive vocabulary), and spelling. Results from both studies were similar: *incidental orthographic facilitation* enhanced children's acquisition of expressive vocabulary across trials compared to no orthography, and resulted in increased recall of pronunciation and accuracy of children's spellings a day later. Receptive vocabulary, however, was at ceiling in Study 1 with grade 2 students, although the use of a different receptive vocabulary task in Study 2 revealed that grade 5 students performed better when words were learned with orthography.

Although Rosenthal and Ehri's (2008) results were strong, Ricketts, Bishop, and Nation (2009) argued that the use of real words (although rare) and oral definitions that were closely related to children's existing knowledge might create individual biases in learning. Rather than providing an experimental context for investigating the acquisition of novel oral vocabulary, Rosenthal and Ehri's (2008) study had addressed learning new labels for known concepts. Additionally, the oral definitions provided varied in length,

descriptiveness, and abstraction, which may have resulted in item-based differences in learning due to the varying difficulty of maintaining and storing such information in memory (e.g., grade 2: nib, a pen; hun, someone who destroys things; tot, a small, young child; yag, fake jewelry; grade 5: muleta, a red cape; fribble, a foolish, shallow person; hicatee, a kind of turtle that lives in the water; frenulum, a tongue).

Reflecting differing methodological choices but the same goal of investigating the potential benefits of an incidental orthographic facilitation effect on oral vocabulary acquisition, Ricketts et al. (2009) examined whether incidental exposure to orthography during learning trials would help children acquire novel labels for new referents. A second goal of the research was to test whether incidental exposure to orthography would also facilitate learning the associated orthographic forms implicitly. In their study, English children between the ages of eight and nine years old (approximately end of grade 2, beginning of grade 3, for comparison with those of the previous studies) learned twelve pairings between spoken monosyllabic nonword labels and novel pictures of real objects as presented by a computer program. Nonwords were used to ensure novelty, and pictures depicting what were described by an adult pilot sample as unknown objects with functions were used as semantic referents. Unlike the previous study reported by Rosenthal and Ehri (2008), this ensured novelty of both stimulus words and their referents, which were introduced as “things an alien might use.” In half of the trials, incidental exposure to orthography was provided during word training. All items were decodable (i.e., could be “sounded out”), and children received pretraining on the sound patterns of nonwords in order to ensure they would be able to accurately reproduce the

target pronunciations. Consistent with past findings, children's expressive vocabulary showed an advantage to training with orthography, and regardless of reading proficiency, all literate children benefitted significantly from incidental orthographic facilitation.

Findings similar to those of both Rosenthal and Ehri (2008) , and Ricketts et al. (2009) also were obtained with second-language learners. Hu (2008) also used a paired-association word learning paradigm to teach Chinese grade 3 children ($N = 74$) six monosyllabic English nonword spoken labels for sketches of cartoon characters. Half of the sketches were displayed containing orthography, and the other half were displayed with contour-matched symbol strings. Only three items were presented at a time, and each was only three letters and phonemes in length, offering little challenge to learners other than the unfamiliarity of the language. Letter-sound pretraining was provided to equip children with the necessary sound and grapheme-phoneme correspondence knowledge that could be used to exploit incidental spellings in the learning training.

In a posttest of children's oral production accuracy, Hu (2008) found that learning of spoken labels benefitted from orthographic facilitation, rather than visually-matched symbols. In addition, having pretrained all of the children on grapheme-phoneme mappings, her results support the conclusion that *all decoders* are able to use feedback consistency to help them acquire and maintain stronger memories of pronunciations. This is consistent with Rosenthal and Ehri's (2008), and Ricketts et al.'s (2009) findings that all literate children benefit from orthographic facilitation during oral vocabulary training.

Together, these results suggest that children can exploit their available knowledge of mappings between speech and print to facilitate oral word learning. The current study seeks to extend existing research on incidental orthographic facilitation by investigating the acquisition of spoken labels in another language with an opaque orthography: French. The current study employs a methodology that draws elements from both Rosenthal and Ehri (2008) and Ricketts et al.(2009) in order to extend existing research by addressing incidental orthographic facilitation of French-language oral vocabulary. Prior to describing the current study in further detail, it is of interest to address the assumption being made concerning the locus of the incidental orthographic facilitation effect: literacy.

Becoming literate can be relatively easy or difficult depending on the challenges imposed by language-specific written notation systems. Languages using alphabetic orthographies require that individuals acquire knowledge of, and are able to exploit, conventional links between sounds in speech and letter(s) in print. As the current study is interested in investigating the usefulness of providing words in print to help support the acquisition of French spoken nonwords by children, the predictability of mappings in French is of primary interest here, and the focus of the following section is thus on reviewing research and particular characteristics of French and English orthographies for comparison. Cross-language considerations due to the bilingual environment of French speakers in the Ottawa-Gatineau region are discussed further in the Method section.

Mapping Speech and Print: Characteristics of Alphabetic Orthographies

Transparent orthographies have predictable one-to-one mappings, while more opaque orthographies are characterized by multiple-mappings between graphemes (i.e., letter or letter combinations used to represent sounds in print) and phonemes (i.e., sounds of a language) (Katz & Frost, 1992). The less transparent the mapping, the more difficult it is to exploit mappings between speech and print. Although both French and English are considered to have opaque orthographies, they offer differential challenges to their learners (Jaffé & Fayol, 2006). Therefore, it is of interest to determine whether characteristic differences in the mappings between two somewhat similar inconsistent orthographies might influence the degree to which incidental exposure to spelling can support oral vocabulary acquisition. Alternatively, obtaining similar results in French to those previously reported in English would support generalization of the orthographic facilitation effect to other alphabetic orthographies.

With the multiplicity of grapheme-phoneme mappings available in opaque orthographies, it becomes valuable to consider how predictable these associations are in one's written language. The statistical probability, or proportional frequency, with which these mappings are accurately predictable is referred to as *consistency* (Ziegler, Petrova, & Ferrand, 2008). *Feedforward consistency* describes the degree to which letters (or groups of letters) in print will reliably lead to the production of the target sounds if they are decoded (e.g., based on words that exist, how probable is it that the letter *c* in an English word is pronounced as /k/? as /s/?). Evidence of this effect has been well documented in reading research, with read-aloud performance being influenced by

feedback consistency (e.g., Jared, McRae, & Seidenberg, 1990; Seidenberg, Waters, Barnes, & Tanenhaus, 1984; Taraban & McClelland, 1987). In the last fifteen years, the reverse effect has also been proposed by Stone, Vanhoy, and Van Orden (1997), who posited that speech-to-spelling consistency could also affect visual word recognition through a recurrent feedback model. *Feedback consistency* describes the degree to which a word's target spelling can be produced accurately from speech (e.g., it is more probable that the /k/ sound in an English word be represented in print as *k*, *c*, *ck*, or *ch*?). In either direction, if the goal is to elicit the production of a target sound or spelling, the *consistency* with which one can reliably predict the desired target in the midst of possible alternatives is reflected as a measure of probability. The more alternatives, the lower the consistency rating, and the less reliable is the match.

In transparent orthographies, because mappings are one-to-one, the probability for any mapping would by nature be 1.0, or completely consistent. With opaque orthographies, however, the placement of the mapping within the word also becomes important, and must be taken into account if a feasible estimate of consistency is to be calculated. Consider, for example, that *ck* is never used to represent /k/ at the beginning of English words, but it is used at the end (e.g., *luck*). Similarly, although it is possible for the letter *t* in English to represent either /t/ or /ʃ/ sounds (e.g., *tailor* /teɪləʁ/, *nation* /neɪʃən/), it would never represent /ʃ/ at the onset. While these examples describe statistical frequencies of a written language, it may also be observed that they reflect language-specific spelling conventions. That spelling patterns may alternatively be viewed as rule-based constructions governed by language-specific regularities will be

discussed in a later section, though it is considered here as complementary to the statistical view. Regardless of the preferred perspective, this results in the availability of two consistency measures (feedforward and feedback) for each letter or sound unit combination which will vary depending on where the unit is placed within the word. For this reason, language-specific lexical databases have been created that provide multiple measures of consistency for words and word units based on language-wide frequencies (e.g., with reference to all the words of a language), or specific word construction frequencies within a language (e.g., with reference to all monosyllabic words of a language). These serve as important reference tools for researchers selecting or building word stimuli for experimental purposes, and were employed in the construction of stimuli for the current study (further details provided in the Method section).

Though both English and French languages have opaque orthographies, they differ in their consistencies. For literate individuals, French has been described as “easy to read, but difficult to spell,” while English, in comparison, is the reverse (Ziegler, Jacobs, & Stone, 1996). Thus, it is possible that providing orthography might increase the potential for it to be useful to French language learners. In a statistical analysis of the bidirectional consistency for French and English monosyllabic words, Ziegler et al. (1996) reported that 12% of monosyllabic French words were feedforward inconsistent (i.e., spelling has more than one pronunciation), compared to 33% of English words reported as inconsistent by Stone et al. (1997). Conversely, 79% of French monosyllabic words were reported as being feedback inconsistent, compared to 76% of English words, reflecting increasing difficulty spelling words in French as compared to English (Ziegler

et al., 1996). It should be noted, however, that these languages have different roots, and thus the nature of their inconsistencies are not the same: French spellings preserve their Latin roots (e.g., *doigt* “finger” from Latin *digitus*; *froid* “cold” from Latin *frigidum*), while English spellings often preserve morphological roots (e.g., *anxious*, *anxiety*; *heal*, *health*), despite neither of these spelling conventions being evident in their language’s speech (Lukatela & Turvey, 1998). Reflecting language-specific spelling differences, the majority of inconsistencies in English are believed to lie in vowel pronunciations, while those in French surround the ambiguity in the pronunciation of final consonants (Content, 1991).

The existence of language-specific consistency measures suggests that English and French language learners are faced with differential challenges in learning and using their language’s orthography. In light of the subject of the current study, this also suggests that the orthographic facilitation of oral word learning may be reliant upon a language’s unique level of orthographic transparency, and within the words of that language, be subject to ratings of feedback consistency. The findings of Ricketts et al. (2009) provide partial support for this notion. In addition to manipulating the presence of orthography during oral word learning, they also manipulated feedback consistency in order to explore how children acquire orthographic knowledge in English. Their nonword items reflected three levels of feedback consistency, distributed evenly across learning trials: nonwords with feedback-consistent spelling, containing an inconsistent consonant (e.g., *knarb*, /nab/), or an inconsistent vowel (e.g., *dowf*, /dauf/).

The findings of Ricketts et al. (2009) indicated that children acquired significantly more pronunciations for consistent and inconsistent-consonant nonwords than inconsistent-vowel nonwords, perhaps reflecting the English language-specific vowel inconsistency mentioned earlier. It is worth noting that stimuli across the three consistency conditions were not matched on number of letters and phonemes, and the small number of items in each condition (four) to be counterbalanced across conditions in which orthography was incidentally exposed leaves the possibility that item availability (two per orthography condition) and construction may have influenced their results. An additional concern is that training consisted of only six learning trials for all twelve items in a single set, which placed large demands upon children's memories and few exposures to permit effective learning. Three trials required children to repeat the pronunciation, and three trials required children to recall and produce the nonword label from memory in response to the display of the picture referent, providing little learning practice (three learning sets) and resulting in children being able to recall on average less than half the items by the end of training (.40 proportion). Employing so many items and so few trials did not reflect a naturalistic context for oral vocabulary instruction, nor did conducting posttesting immediately following training. Despite these weaknesses in face validity, their study added to the results of Rosenthal and Ehri (2008) by demonstrating that feedback consistency may moderate the incidental orthographic facilitation effect, although its influence was unreliable across tasks.

The current study sought to extend previous findings of incidental orthographic facilitation to another language, French, and also sought to better define the conditions

under which it is most effective by investigating the potential moderation of language-specific feedback consistency. Frequently in French, an open vowel sound at the end of a word can map onto multiple possible spellings, many of which may contain *silent consonant endings* that are not available in speech, but most of which would be predictably read (e.g., /o/ in *chaud*, *faux*, *haut*, *trop*, *mot*) (Content, 1991). This language-specific feedback inconsistency was exploited in the construction of French nonwords for the current study, with the goal of assessing whether the predictability of the orthography children are exposed to while learning pronounced nonwords will influence the orthographic facilitation of oral vocabulary acquisition. Prior to describing the current study in further detail, the following section serves to present a summary of the processes by which orthography is hypothesized to be acquired incidentally.

Acquiring Orthography Incidentally

Incidental exposure to print can facilitate the acquisition of orthography. Indeed, the research on orthographic facilitation of oral vocabulary learning has also revealed that children exposed to the written representations during learning trials were learning about the spelling of the new words as compared to children for whom the word learning trials did not include orthographic representations – even if no attention was drawn to them (Rosenthal & Ehri, 2008; Ricketts et al., 2009; Hu, 2008). That is, children were acquiring orthography implicitly from exposure to the written words during the oral word learning trials. According to Rosenthal and Ehri, it is the amalgamation of orthography with pronunciations that enhanced children's memory for novel words. In the present section, we examine implicit learning further.

Artificial grammar learning provided the earliest insight into the processes and products of implicit learning. Within this paradigm, comparisons of performance between an experimental group and a control group whose letter strings were randomly created have consistently shown an influence of the grammatical strings on learning and memory, despite their rules not being made explicit. When participants in the experimental group were asked to memorize new sets of strings generated with the same grammar but with different letters, they were able to transfer their “implicitly acquired knowledge” to perform the new task, in comparison to control subjects, who faced the same poor memory results (Reber, 1969; Mathews et al., 1989). When told that strings were rule-governed and asked explicitly to “look for rules” that could help them to memorize the strings, the experimental group’s learning performance decreased significantly and they were unable to report having consciously detected any of the complex rules forming the grammar (Reber, 1976). When rules were made more salient in stimuli, however, this interference of explicit and implicit task demands disappeared, leading to the conclusion that “looking for rules works only if you can find them” (Reber, Kassin, Lewis, & Cantor, 1980).

Several debates continue to exist concerning what features characterize implicit learning, and diverging views exist on the nature and processes involved. Disputed areas include the degree of abstraction of the implicitly acquired knowledge, the learner’s consciousness of the learned knowledge and their ability to verbalize what has been learned, the relationship (or lack thereof) between implicit and explicit learning, and the underlying nature of implicit learning contents as being governed by the acquisition of

rule-based or association-based knowledge (for a current review, see Perruchet & Pacton, 2006). Despite these controversies, results from three different implicit learning paradigms (artificial grammar learning, process control, and sequential pattern acquisition) continue to converge on findings that participants are able to acquire procedural knowledge not only without being able to articulate what they have learned, but even without being aware that they had learned anything (Cleeremans, 1993). In addition, a new area of research termed *statistical learning* has appeared within the last fifteen years and provides an alternative – though complementary – interpretation of the phenomenon (for a detailed comparison, see Perruchet & Pacton, 2006).

Statistical learning involves developing a sensitivity to the systematic distribution of statistical features or probabilistic relations among stimuli in a complex environment (Perruchet & Pacton, 2006). Frequently applied to the study of language processing, statistical learning was developed as a means of assessing children's unconscious internalization of abstract (or less abstract) language regularities. These systematic rules (or, alternatively, statistical probabilities) have been studied as they relate to governing speech sounds (phonotactics), spelling patterns (graphotactics), and units of meaning (morphotactics) (Perruchet & Pacton, 2006). Here, they are discussed as they relate to children's spelling performance, as these reflect their internalized orthographic knowledge. Some of these spelling regularities have already been described, as they concern the grapheme-phoneme mappings, consistency, frequency, and availability of "chunks" of orthography, and their word unit-specific probabilities for use. This will not be reviewed again here, but can be referred to in previous sections on orthography and

literacy. In light of the current study, a specific focus is placed on literature from children learning English and French orthographies.

Children who understand the symbolic representational function of print will spell words based upon their understanding of the alphabetic code, the reliance on predictable links between written and spoken words, and their written language's imposed constraints and regularities. Sensitivity to orthographic regularities increases with print exposure. Children's awareness of orthographic regularities in French and English has been shown to occur very early. Sensitivities to letters that can and cannot be doubled, the placement of doubled letters within words, and the frequency of adjacent consonant-vowel combinations have all been observed in school-age children's performance on tasks involving judgements of nonword "word-likeness" and spelling dictations (for English, see Treiman & Cassar, 1997; Treiman & Kessler, 2006; Hayes, Treiman, & Kessler, 2006; for French, see Pacton, Fayol, & Perruchet, 2005; Pacton, Perruchet, Fayol, & Cleeremans, 2001).

Although demonstrating early sensitivity to orthographic knowledge, the acquisition of accurate orthographic representations for words that are spelled irregularly or contain spelling inconsistencies are challenging for even more seasoned literates. In some cases, it is possible for spellers to exploit their knowledge of morphological regularities to create an accurate orthographic representation for unknown words. Morphemic graphemes may contain knowledge of a word's plurality (e.g., *s* used to indicate plural in both French and English), verb tense (e.g., *-ed* used to indicate the past tense in English, rather than *t*), root word (e.g., *health* contains the word *heal* in English;

citronnier [lemon tree] contains the word *citron* [lemon] in French) or status (e.g., /et/ transcribed as *-ette* in French as a diminutive suffix, rather than *-ète*, *-aite*, or *-ête*).

Studies manipulating nonwords' status in sentence contexts and in cloze tasks have provided evidence that both English and French children are able to impose morphological regularities, though these children were at least eight years old (e.g., Pacton, Fayol, & Perruchet, 2005).

The use of a morphological strategy has offered particular advantages for French spellers, due to the large proportion of graphemes that do not have phonological counterparts (15%; see *Mapping speech and print* for a review). Without a surrounding context, however, the use of such a strategy to spell words that contain silent letters is limited. In two separate studies, French children's spellings were assessed for real words that had phonological (decodable) spellings, morphological spellings (containing a derivative that made evident a silent-letter ending), and lexical spellings (containing unpredictable silent consonant endings) (Sénéchal, 2000; Sénéchal, Basque, & Leclaire, 2006). Both studies revealed that spellings for children in grade 2 and grade 4 were most accurate for decodable items, moderately accurate for morphological items, and poor on lexical items. The same pattern of spelling errors was reported in both studies, with predominance of errors with silent consonant endings (87% in Sénéchal et al., 2006; 63% in morphological words in Sénéchal, 2000). These were reported as confusion with another consonant (48%; 27% of morphological words in Sénéchal, 2000), omitted (42%; 63% of morphological words in Sénéchal), or replaced with the letter *e* (10%; 10% of morphological words in Sénéchal, 2000). Together, these findings suggest that the less

predictable are silent letters within a word, the less likely it is that they will be captured in children's spelling.

In order to acquire word-specific spellings for words with silent letters that are not morphologically predictable, they must either be taught explicitly or acquired implicitly through exposure to words in print. Studies exposing literate adults to correct spellings and misspellings have shown evidence that they can influence participants' subsequent spellings in positive or detrimental ways respectively, however findings from similar studies with children remain unclear (e.g., Dixon & Kaminska, 1997; Dixon & Kaminska, 2007; Bradley & King, 1992). While implicit learning studies have focused on measuring children's awareness and assessing their demonstration of orthographic regularities, studies examining their implicit acquisition of *irregular* spellings appear absent from the literature. One study that provides support for children's implicit acquisition of irregular spellings is provided by Ehri (1980). In this study, grade 2 children were asked to write down made-up words they were previously exposed to in a reading task. Their spellings indicated that they recalled more pronounced letters than silent letters, however there was evidence to indicate that an effort had been made to preserve the orthographic form as it was originally seen (e.g., *GHIRP* recalled *H*, *I*, or both, but never as *GURP* or *GERP*). In light of the previously described findings that the majority of spellings errors for French children appear to occur in final silent consonants of irregular words, a secondary interest of the current study is to determine whether incidental exposure to orthography during oral vocabulary training can provide support

for the acquisition of word-specific orthographic representations for words spelled inconsistently.

The Current Study

In the context of the current study, children's knowledge of the alphabet, as a symbolic "code" for mapping speech and print, is hypothesized to be the tool that allows orthography to function as an "anchor" for pronunciations of novel spoken words in memory (e.g., Ehri, 1978). In addition, the provision of spelling during oral word learning provides children with an opportunity to implicitly acquire word-specific orthographic representations, and associate these to other word forms in lexical memory. This amalgamation of orthographic with phonological forms ultimately enhances the contents of lexical memory, and strengthens one's memory of pronunciations (Ehri, 1978; Perfetti & Hart, 2002; Ricketts et al., 2009).

In previous studies, the more accurately the orthography reflected the pronunciation to be learned in spoken word-image pairings, the more effective it was at supporting the acquisition and retrieval of phonological forms from memory (Ehri & Wilce, 1979; Rosenthal & Ehri, 2008; Ricketts et al., 2009). This reinforces the value of congruency between orthographic and phonological input, and indicates the potential impact of feedback consistency on orthography's facilitation effect, even though this effect has not been documented reliably (Ricketts et al., 2009). As there has been some evidence to suggest that orthographic representations might be stored as alphabetic "images" in lexical memory and tightly associated to phonological representations, if the orthography provided is irregular or provides an inconsistent spelling pattern which is

unfamiliar to the learner it will conflict with the incoming pronunciation and cause strain to the simultaneous acquisition of the word-specific orthography. If this is indeed the case, then this incidental orthographic facilitation effect should also occur in languages other than English with alphabetic orthographies, and feedback consistency may impact the degree to which it supports the acquisition and retrieval of phonological forms from memory. It may equally be beneficial to second-language or bilingual learners, provided the overlap between alphabetic orthographies does not result in interference. In order to extend findings to other languages with alphabetic orthographies, the current study seeks to investigate the facilitative effect of incidental exposure to orthography on oral vocabulary acquisition by exploiting a particular orthographic pattern in another opaque language, French, with grade 3 children.

An adapted version of the paired-association oral word learning paradigm used by Rosenthal and Ehri (2008) and Ricketts et al. (2009) was employed to teach French nonword spoken labels for novel picture referents to grade 3 French children. Children underwent an initial decoding criterion task in order to ensure that they had the ability to make functional use of orthography, should it be provided during training. They also completed a grade-normed French reading measure to assess their reading level. Of primary interest was whether incidental exposure to orthography during oral word learning helped children to more quickly acquire expressive vocabulary, and whether it influenced children's recall of pronunciations a day later. Feedback consistency was also investigated to determine whether it moderated this effect. A secondary interest was

whether spelling results would provide support for word-specific orthographic forms having been acquired implicitly.

Children were randomly assigned to one of three conditions. In the orthography-absent condition, children completed one-on-one oral vocabulary learning sessions in which spoken labels were paired with a novel picture referent. In two separate orthography-present conditions, spoken labels were paired with picture referents that also contained incidental exposure to orthography during word-learning sessions. Feedback consistency was manipulated in the two conditions where spelling was displayed such that separate groups of children learned either nonwords ending in open vowels paired with consistent grapheme-to-phoneme mappings (consistent orthography), or inconsistent mappings due to the presence of a silent letter at the end of the word (inconsistent orthography). Because manipulating feedback consistency could only be influential if spelling was present during training, there is no need for it to be tested in the no orthography condition, therefore only the consistent nonword list was used in this condition. Due to the bilingual environment in the Ottawa-Gatineau area and cross-linguistic similarities between English and French (e.g., alphabetic, phonetic), care was taken to create nonwords that clearly appeared to belong the French language, and for which there did not exist English words that sounded or looked like the target nonword. Words in both consistency lists reflected French legal orthographic patterns, however inconsistent items contained words with a silent consonant ending – a frequent occurrence in French orthography.

In addition to the efficiency with which children accomplished their learning, the *quality* of children's acquired lexical representations was assessed by measuring their performance on three post-learning tasks: accurate oral labeling of pictures alone (expressive vocabulary knowledge), correct matching of target word with picture (receptive vocabulary knowledge), and spelling dictation (orthographic knowledge). Expressive vocabulary learning efficiency, posttest expressive vocabulary recall, and spelling accuracy were used as dependent variables on which planned orthogonal contrasts assessed whether incidental exposure to orthography and/or feedback consistency exerted an influence on learning and memory for words a day after learning. Posttested receptive vocabulary for learned words, assessed by a recognition task, was used only as a check of children's ability to learn, as it was expected to be at ceiling as reported in previous studies (Rosenthal & Ehri, 2008; Ricketts et al., 2009).

It was hypothesized that, consistent with previous studies mentioned above, children in the two groups that were incidentally exposed to orthography (both consistent and inconsistent groups) would take fewer trials to learn spoken word labels to image referents, and would show increased levels of retention for expressive vocabulary at posttest, compared to children in the orthography-absent condition (feedback-consistent group). Feedback consistency was also expected to moderate spoken vocabulary acquisition and recall a day later: that is, when comparing the two conditions in which orthography was displayed during spoken word learning, children in the consistent condition were expected to learn faster (i.e., more efficiently) than children in the inconsistent condition and retain more of what they learned. Spelling results were

predicted to support the claim that children were acquiring orthographic forms alongside phonological forms in conditions in which they were incidentally exposed to orthography during word learning. A subsequent analysis of the influence of incidental exposure to orthography based on reading skills was expected to reveal that children with higher levels of reading skills gained more from the presence of orthography than those with lower levels of reading skills, consistent with past findings in English samples.

Method

Participants

Grade 3 children were recruited from seven different classrooms in three monolingual French schools in Gatineau, Québec. Of the 159 letters sent, 59% were returned, and of these, 84% agreed to have their child participate. Of the 79 children tested, 67 were included in the analyses. Initial exclusions resulted from attrition (five students), evidence of hearing difficulties (one student), not having achieved a minimum of 80% success on the criterion decoding task (one student), and well below grade-level performance on French word reading (two students removed, with 54% and 58% success rates, respectively). Additional exclusions came from having more than one day between learning and posttest sessions (three students). Children ranged in age from 7;11 to 10;11 years ($M = 9;2$ years, $SD = 0;6$ years), with approximately equal numbers of girls and boys in each learning condition (consistent orthography condition, $n = 11$ girls, 11 boys; inconsistent orthography condition, $n = 12$ girls, 10 boys; no orthography condition, $n = 13$ girls, 10 boys). All parents or guardians reported their child to have normal hearing. While some were identified as having received speech therapy (20% overall), these

children all successfully completed the learning session without apparent difficulty and were not outliers, therefore they were retained in the sample. Eighty-five percent of children were reported as having French as the language most spoken in the home, while at least half of the children in each learning condition came from homes in which French was the only language spoken. Remaining respondents reported French as the second language within the home, with English (30%) reported more frequently than other languages (4%).

All guardians reported their highest level of education. These ranged from graduating from high school to completing a postsecondary doctoral program. The majority of respondents reported having completed a university degree, with 45% having completed an undergraduate and 30% having completed a post graduate degree. Remaining respondents reported having completed college or vocational training (22%), or having completed high school (3%).

Family income was reported for all but six children, two in each learning condition (consistent orthography, $n = 20$; inconsistent orthography $n = 20$; no orthography $n = 21$). Reported annual income ranged from 0 to 30,000 dollars, to above 90,000 dollars. Over half of the respondents for children in each learning condition indicated that their yearly income was at or above 90,000 dollars (64%), while fewer indicated a yearly income between 70,001 and 90,000 dollars (15%), between 50,001 and 70,000 dollars (11%), or between 0 and 30,000 dollars (8%).

Design

Approximately equivalent numbers of boys and girls matched as closely as possible across conditions on word reading and decoding ability were randomly assigned to one of three paired-associate spoken-word learning conditions: (a) learning feedback-consistent nonwords whose orthography was visible during training; (b) learning feedback-inconsistent nonwords whose orthography was visible during training; and (c) learning feedback-consistent nonwords whose orthography was not present during training.

Two lists of six two-syllable nonwords were created with word pairs across lists having an identically pronounced final syllable. In the feedback-consistent condition, the second syllable ended with a vowel (e.g., *reuglo*, /ʁəglo/) whereas in the feedback-inconsistent condition it ended with a silent consonant (e.g., *reglot*, /ʁəglo/). Because the pronunciation of the last syllable was identical across conditions, children in the condition where orthography was not present during training learned the same nonwords as those exposed to feedback-consistent orthography. Dependent variables were: expressive vocabulary learning efficiency, posttest expressive vocabulary recall, and spelling accuracy. Posttest receptive vocabulary was measured and used as a learning check, because expressive vocabulary recall assumes having previously acquired receptive vocabulary. Receptive vocabulary was expected to be at ceiling. The influence of incidental exposure to orthography on oral word learning was assessed with a series of two planned orthogonal contrasts. First, the incidental orthographic facilitation effect was assessed by comparing performance in the two conditions in which orthography was

present against children's performance in the condition in which it was absent. Second, the moderating effect of feedback consistency was assessed by comparing performance on the two conditions that were trained in the presence of orthography. Contrasts were conducted on each of the three dependent measures separately, using a Bonferroni correction to control for Type 1 error across the six contrasts. Because results in the opposite direction would be equivalent to null results, one-tailed tests were reported.

Stimuli

Nonword construction. To address the impact of incidental exposure to orthography on the quality of representations formed for novel words learned orally, nonwords were used to ensure that children had never been exposed to them as well as to their invented referent. Paired with picture referents of unfamiliar objects, nonwords (located in Table 1) were presented as concrete nouns with alien functions. An example is given in Table 2. To ensure consistency across children and trials, audio recordings of the stimuli were created for use in training by recording the pronunciations of a French first-language male adult using a neutral tone of voice and a reasonable articulation speed.

Twelve decodable nonwords with legal French spellings (located in Table 1) were constructed, six with consistent orthographies and six with inconsistent orthographies. Nonwords across consistency conditions were equated on number of letters, number of phonemes, and approximate number of phonological and orthographic neighbours. Feedback consistency (sound-to-spelling) was manipulated to test whether it moderated the degree of facilitation afforded by incidental exposure to orthography.

Table 1

Characteristics for Constructed Pairs of Feedback-consistent and Inconsistent Nonwords

Consistent					Inconsistent				
Ortho.	ON	Pron.	PN	Length of utterance (seconds)	Ortho.	ON	Pron.	PN	Length of utterance (seconds)
boncli	0	/bɔ̃kli/	0	.862019	boclid	0	/bokli/	0	.835881
poncra	3	/pɔ̃kʁa/	1	.835881	pocrat	3	/pokʁa/	0	.835888
moubla	2	/mubla/	2	.862011	mublap	1	/mybla/	0	.862011
loudri	1	/ludʁi/	0	.835881	ludrit	1	/lydʁi/	0	.835881
reuglo	0	/ʁøɡlo/	0	.835881	reglot	0	/ʁøɡlo/	0	.835888
teuvro	0	/tøvʁo/	0	.835881	tevrop	0	/tøvʁo/	0	.835588
<i>M</i> =	0.83		0.50		<i>M</i> =	0.83		0.00	

Note. Ortho = Orthography; ON = orthographic neighbours; Pron = Pronunciation; PN = phonological neighbours, as calculated by Lexique 3 neighbourhood generator tool (New, Pallier, Ferrand, & Matos, 2001). Length of utterance as recorded on open source software program Audacity (Version 1.2.6).

Note. If this study were to be replicated in a within-subjects design, one might want to increase the phonological contrast between reuglo-reglot, and teuvro-tevrop, by instead employing the pairings reuglo-réglot (/ʁeglo/) and teuvro-tévrop (/tevʁo/).

Table 2

Example of Pairings Between an Oral Label and a Picture Referent in Separate Learning Conditions

a.	b.	c.
<i>loudri</i>	<i>ludrit</i>	<i>ludri</i>
/ludri/	/lydri/	/ludri/

Note. Conditions are: (a) Consistent orthography; (b) Inconsistent orthography; (c) No orthography.

Picture originally published in article by Ricketts, Bishop and Nation (2009). Permission granted by Psychology Press, Taylor & Francis Group (publisher of The Quarterly Journal of Experimental Psychology), to reproduce content in thesis.

Feedback consistency was manipulated by including (or not) silent consonant endings at the end of the second syllable of two-syllable nonwords (e.g., *reuglo*, /ʁøɡlo/ vs. *reglot*, /ʁəɡlo/). Hence, the second syllable was pronounced identically across conditions, but spelled differently. Consistency and clarity of the pronunciation of the final syllable

across word pairs was verified by having another French first-language adult listen blindly to the second syllable alone, and also by having French children known by the experimenter reproduce aloud all of the nonwords from a recording. The use of two-syllable nonwords was necessary to equate the stimuli across conditions on number of letters and phonemes, a precaution that was not taken in Ricketts et al.'s (2009) study that may have contributed to their mixed results. In the current study, given that the consistency manipulation occurred in the second syllable, it is of interest to discuss details concerning the construction of this target syllable first.

Due to bilingual language environment considerations, construction of target (i.e., second) syllables was accomplished in several steps. First, silent final consonants were isolated as an inconsistent spelling pattern that was more characteristics of French than of English words (see Table 3).

Second, a legal French monosyllabic word form was selected that contained the characteristic inconsistency: a four-letter CCVC (where C = consonant and V = vowel) orthographic form with three-phoneme CCV pronunciation was used for the construction of the target syllable. The same form, less the silent consonant ending, was used to construct consistent syllables with identical pronunciations.

Table 3

*Comparison of Feedforward Consistency for Consonant-Vowel-Consonant (CVC)
Orthographic Endings in English and French Lexical Monosyllabic Databases*

	English (CELEX ^a)	French (BRULEX ^b)
CVC print endings	40%	20%
CVC print endings		
CVC is pronounced	50%	25%
Other pronunciation	50 %	75%
CVC other pronunciation		
Final C is silent	< 1%	94%
Other pronunciation	> 99%	6%

^aBased on 1-word entries with three or more letters ($N = 118,932$) (Source: Baayen, Piepenbrock, & Gulikers, 1995)

^bBased on 1-word entries with three or more ($N = 34,533$) (Source: Content, Mousty, & Radeau, 1990)

Third, common French word-part units were selected according to their LEXOP (Peereman & Content, 1999) monosyllabic bidirectional consistency properties and frequency characteristics (see Table 4). The goal was to construct pairs of nonword syllables that varied in feedback (sound-to-spelling), but not feedforward (spelling-to-sound) consistency, while maintaining identical pronunciation across consistency groups. In order to verify that selected target endings provided suitable manipulations of feedback consistency, feedback consistency was approximated manually by compiling lists of existing French words ending in the target pronunciation from a more extensive and current online French lexical database, Lexique 3 (New, Pallier, Ferrand, & Matos, 2001). Results revealed that consistent endings (o, a, i) were more frequently used to capture the target pronunciation in print than selected inconsistent endings (op, ot; ap, at; it, id), providing face validity for their use in manipulating feedback consistency (see Table 5).

Fourth, pairs of feedback-consistent and inconsistent target final syllables were constructed using matched consonant blends and identical open-vowel pronunciations, and average bidirectional consistency and frequency ratings were calculated for each item based on the LEXOP (Peereman & Content, 1999) properties of their units.

Fifth, all nonwords with orthographies that existed in English or French were eliminated, as were those that could be perceived as sounding like real words. In addition, to help equate memory demands across items, nonword constructions were limited to those in which no letter or sound occurred more than once, and to pairs of nonwords that had a similar number of phonological and orthographic neighbours.

Table 4

*Detailed Characteristics of Beginning Consonant Blend (CC) and Ending Open Vowel
With and Without Silent Consonant (VC) Word Units*

Unit	O	P	PO_Type	OP_Type	PO_TKN	OP_TKN	TYPE.FRQ
CC	bl	/bl/	100.00%	100.00%	100.00%	100.00%	19
CC	cr	/kʁ/	91.30%	100.00%	100.00%	100.00%	42
CC	gl	/gl/	100.00%	100.00%	100.00%	100.00%	15
CC	br	/bʁ/	100.00%	100.00%	100.00%	100.00%	43
CC	dr	d/ʁ/	100.00%	100.00%	100.00%	100.00%	15
CC	cl	/kl/	96.15%	100.00%	100.00%	100.00%	25
VC	a	/a/	30.56%	100.00%	73.98%	100.00%	11
VC	ap	/a/	2.78%	50.00%	0.09%	83.33%	1
VC	at	/a/	8.33%	50.00%	0.26%	91.41%	3
VC	i	/i/	28.00%	100.00%	79.84%	100.00%	14
VC	id	/i/	4.00%	100.00%	0.09%	100.00%	2
VC	it	/i/	14.00%	87.50%	7.82%	93.41%	7
VC	o	/o/	9.30%	100.00%	2.56%	100.00%	4
VC	op	/o/	2.33%	20.00%	8.77%	99.40%	1
VC	ot	/o/	23.26%	83.33%	8.38%	99.01%	10

Note. O = orthography; P = pronunciation; PO = feedback consistency; OP = feedforward consistency; TKN = based on token counts, weighted relative to the frequency of the word unit in a larger French lexical database; Type = based on token counts, weighted relative to the number of relevant words in the LEXOP database; TYPE.FRQ = frequency of word unit reflecting these characteristics in monosyllabic database.

Source: *LEXOP French Monosyllabic Database, Peereeman & Content, 1999.*

Table 5

Frequency (Count) and Feedback Consistency of Orthographic End-Units Used To Construct Consistent and Inconsistent Nonword Target Final Syllables

Phonetic ending	Total frequency (%)	Relative frequency (%)
/o/	<i>N</i> = 2215	<i>N</i> = 347
spelled 'o'	28.89	75.56
spelled 'op'	0.14	0.35
spelled 'ot'	9.21	24.09
/a/	<i>N</i> = 7691	<i>N</i> = 5863
spelled 'a'	64.05	84.02
spelled 'ap'	0.03	0.03
spelled 'at'	12.16	15.95
/i/	<i>N</i> = 1702	<i>N</i> = 491
spelled 'i'	15.92	55.19
spelled 'it'	12.87	44.60
spelled 'id'	0.06	0.20

Note. Statistics derived from compiling lists of existing French words ending in each target pronunciations using the online French lexical database Lexique 3 (New, Pallier, Ferrand, & Matos, 2005). Total frequency based on all words; relative frequency based on subset of words that contained target consistent or inconsistent endings.

Sixth, unique pairs of consonant blends and open-vowel with-and-without silent consonant endings were purged and reduced to six pairs of target syllables : cli-clid; cra-crat; bla-blap; dri-drit; glo-glot; vro-vrop. Detailed characteristics for these syllables are located in Table 6. Independent samples *t*-tests revealed no significant differences between consistency groups in the mean number of phonological neighbours ($t(10) < .01$, $p = 1.0$), orthographic neighbours ($t(10) = -.133$, $p = .897$), or unit frequency ($t(10) = .686$, $p = .508$). As desired, mean feedforward consistency (spelling-to-sound) was not significantly different between the groups (Type, $t(5) = 2.469$, $p = .057$; Token, $t(5) = 1.464$, $p = .203$) while feedback consistency (sound-to-spelling) was significantly different (Type, $t(10) = 2.950$, $p = .015$; Token, $t(5.113) = 3.095$, $p = .026$), with a higher mean level of consistency favouring the consistent syllable group.

Seventh, in order to ensure an identical number of letters and phonemes across conditions, initial syllables that varied slightly in their construction were attached to the onset of phonologically-matched pairs of consistent and inconsistent target syllables, creating two-syllable nonwords with CV-CCV pronunciations (e.g., consistent, *reuglo*, /ʁøglo/; inconsistent, *reglot*, /ʁəglo/). Because the second syllable is the critical syllable of interest, first syllables for pairs of consistent-inconsistent items were constructed to be as similar as possible. As such, they share identical consonant onsets followed by a similar vowel sound, which is captured in print by either a frequently occurring two-letter vowel digraph (consistent items) or a single-letter vowel (inconsistent items).

Table 6

Detailed Characteristics of Targeted Final Syllable For Nonwords Learned

Item		Mean Type Consistency		Mean Token Consistency		Mean Type Frequency	Neighbours	
O	P	PO	OP	PO	OP	FRQ	O	P
Inconsistent items								
drit	dʁi	52%	100%	50%	100%	11.00	4	1
clid	kli	50%	100%	50%	100%	13.50	5	11
blap	bla	51%	75%	50%	92%	10.00	3	18
crat	kʁa	50%	75%	50%	96%	22.50	5	1
glot	glo	62%	92%	54%	100%	12.50	1	13
vrop	vʁo	51%	60%	54%	100%	2.50	6	0
<i>M</i> =		53%	84%	51%	98%	12.00	4.00	7.33
Consistent items								
dri	dʁi	64%	100%	9%	100%	14.50	6	1
cli	kli	62%	100%	9%	100%	19.50	7	11
bla	bla	65%	100%	87%	100%	15.00	5	18
cra	kʁa	61%	100%	87%	100%	26.50	2	1
glo	glo	55%	100%	51%	100%	9.50	2	13
vro	vʁo	55%	100%	51%	100%	4.00	1	0
<i>M</i> =		60%	100%	76%	100%	14.83	3.83	7.33

Note. O = orthography; P = phonology; PO = feedback consistency (sound-to-spelling); OP = feedforward consistency (spelling-to-sound). Consistency and frequency ratings calculated based upon word unit components provided by LEXOP (Peereman & Content, 1999). Neighbours calculated using Lexique 3 toolbox (New, Pallier, Ferrand, & Matos, 2004).

Three fixed pairings of vowel orthographies were used across conditions, such that vowel digraphs always contained the single-letter vowel with which they were consistently paired (*o* /o/ with *on* /ɔ̃/; *u* /y/ with *ou* /u/; *e* /ə/ with *eu* /ø/). Eighth, reductions of two-syllable nonword pairs occurred according to the same criteria as previously described for target syllables.

Ninth, six pairs of two-syllable nonwords were selected to be used as stimuli in the current study, each of which contained one of the six pairs of target syllables: *boncli/boclid*, *poncra/pocrat*, *moubla/mublap*, *loudri/ludrit*, *reuglo/reglot*, *teuvro/tevrop*. Initial-syllable characteristics were purged such that all two-syllable nonword pairs began with a unique consonant, and each of the three possible vowel pairings was employed twice. Detailed characteristics for two-syllable nonwords to be learned are located in Table 1. Independent samples *t*-tests indicated there were no significant mean differences between consistency groups on number of phonological ($t(10) = .237, p = .817$) and orthographic ($t(5) = 1.464, p = .203$) neighbours. To verify that nonwords did not resemble existing French words, and to authenticate that they look and sound as though they *could* be French words, nonwords were piloted with adult friends and family of the experimenter who are fluent in French. An additional constructed nonword with consistent properties that shared the same construction but different orthography and pronunciation from those being used as learning stimuli was employed as a training item at the beginning of all learning sessions, to ensure that task instructions were understood by children.

Picture cues. Unfamiliar pictures, in place of definitions or pictures and definitions together, were chosen to serve the function of holding semantic knowledge for the nonwords to be learned. This was done in order to avoid the confounds of attempting to balance phonological working memory demands across nonword definitions (length/complexity), and the unintentional lexical priming of other words in children's memory which may facilitate or interfere with the association to be learned.

Pictures of unfamiliar objects served as fixed referents for the nonwords to be learned (see example in Table 2). The same seven picture referents from Ricketts et al. (2009) were used in all three learning conditions: six for items to be learned, and a seventh as a training item. Ricketts et al. piloted these items in a survey of 14 adults, wherein the displayed objects were all judged as being unfamiliar and non-identifiable by name, but were all able to be attributed a function (e.g., a bell tree as an instrument). Results of their pilot study, as well as their use in the previous study, support the assumption that children perceived the nonwords paired with these piloted referent pictures as concrete nouns. Introduction to the items being learned as “words for things an alien might use” reinforced this notion, as was employed by Ricketts et al..

Learning Paradigm

The paired-associate word learning paradigm that was employed to teach children new oral vocabulary in the present studies was adapted from versions used by Rosenthal and Ehri (2008), and Ricketts et al. (2009). Children completed a one-on-one learning session on fixed pairings between six orally presented nonwords and picture cues of novel object referents. The learning session was comprised of six to nine *training sets*,

Dual-modality word learning

which each consisted of one cycle through alternating blocks of *repetition trials* and *production trials*. Each trial block contained all six nonwords presented in a preset randomized order. As in previous work, a learning criterion of three accurate successive blocks of production trials was employed. In order to provide optimal opportunity for assessing learning, children completed a minimum of six and a maximum of nine training sets, consistent with Rosenthal and Ehri. This was done in order to ensure that children would be given sufficient exposure and practice such that all three groups would succeed at a similar level by the end of the training session, permitting posttesting to assess differences in memory a day later.

All communication with children was done in French. In order to successfully complete each trial, children were required to accurately produce each nonword's pronunciation (repetition trials), and provide it appropriately in response to the randomized presentation of the corresponding picture (production trials). Due to the goal being to assess children's oral word-learning, feedback was provided following each unsuccessful trial to ensure that learning took place. Picture cues during training and feedback in conditions where orthography was present contained spelling for the target nonword written in lowercase letters above the picture in black Arial font, size 40, but were otherwise identical to those in the condition in which there was no orthography. Due to the potential for increased exposure to pronunciations through decoding in conditions where orthography was present, pronunciations were provided twice instead of once in training and feedback trials for the no orthography condition in an attempt to

equate the number of exposures across conditions, similar to the procedure of Rosenthal and Ehri (2008).

A laptop was used to control the simultaneous display of picture cues and audio recordings of the nonword pronunciations, in order to ensure consistency of presentation across items and testers. Microsoft Powerpoint slideshow presentations were created for learning conditions and item orders to be used, and one additional experimenter was trained to navigate the presentations in accordance with the procedures described herein. Duration of exposure to picture cues during training and feedback trials was five seconds in length. The use of technology provided a source of interest for the children, and helped motivate their participation. Two sets of headphones attached to a splitter were used when testing took place in a more noisy and public location within the school, in order for the stimulus to be audible to both the child and the tester. When testing was in a quiet location, the laptop's built-in speakers were used at the maximum volume level.

Experimenters performed online scoring of children's responses during the learning session, recording their accuracy on each trial item (accurate, inaccurate). When children did not provide a response, this was scored as inaccurate. Observational notes were also taken, to identify any children whose results may have reflected task challenges due to difficulties in hearing or articulation of the target sound sequence, rather than memory for pairings. Audiorecording of all sessions permitted an early implementation check on the first ten participants conducted by the trained tester, as well as the calculation of interrater agreement by comparing online scoring of one tester with

audiotaped scoring by the other tester on four children from each learning condition.

These results are reported later when discussing outcome measures.

Procedure: Learning sessions. At the beginning of training, the experimenter showed the picture of an alien and said: “Today you will be learning some made-up words. They are words for some new things. They are things that an alien might use.” Following establishment of the premise, children completed a block of *repetition trials*. They were told: “You will see a picture on the screen, and you will hear the name of the object in the picture spoken [once/twice]. Listen carefully, because I want you to repeat it back to me [just once]. Let’s try one: listen, then say the word back to me.” The experimenter then initiated a practice trial, prompting the appearance of the training picture cue (with or without orthography) in the middle of the screen and an audio clip of the pronounced training nonword label. Following a five-second exposure, the picture disappeared automatically. If the child did not provide an accurate response, or provided their response twice instead of once, additional instructions were given by the experimenter to address the child’s understanding of the task. Once the child acknowledged their understanding of the instructions, the experimenter proceeded with repetition trials on all nonwords in the block (either consistent or inconsistent, according to learning condition). If children produced an accurate response, they were provided with encouragement from the experimenter “Good! Let’s try the next one” before proceeding to the following item.

If the child’s response was inaccurate, they received encouragement and feedback on the item before continuing, in order to correct the nonword’s pronunciation prior to

being asked to produce it from memory in the block of production trials that followed. Feedback was consistent with the orthographic condition in which children received training. Feedback in orthography-present conditions consisted of displaying the picture cue (with orthography) and providing the pronunciation a second time, which children were asked to repeat. Feedback in the no orthography condition consisted of displaying the picture cue (without orthography) and providing the pronunciation twice to equate exposure across orthography conditions, which children were asked to repeat once.

Following the completion of a block of repetition trials for all nonwords, a black screen served as an indicator to the experimenter that they should provide instructions to the child to clarify changes in the task: “Now I will show you all of the pictures again, one at a time. The pictures will be mixed up, so look carefully. I want you to try and tell me the name of the object in each picture. If you aren’t sure, give me your best guess.” A block of *production trials* on the same six stimuli presented one at a time in a preset randomized order required children to produce the appropriate nonword labels for each picture cue alone from memory, without the support of audio recordings or spellings. Similar to the repetition trials, all responses received encouragement, while inaccurate responses received feedback that was consistent with the learning condition. Following completion of production trials for all six stimuli in the block, a black screen signified the transition to a second training set, beginning with a block of repetition trials with a new fixed-randomized item order.

A minimum of six learning sets, or cycles between alternating blocks of repetition and production trials, was completed by all children. The learning session continued

until the child reached either a learning criterion of three perfect blocks of production trials in a row, or a maximum of nine learning sets (i.e., nine cycles through alternating blocks of repetition and production trials). When children achieved the pre-established ceiling by demonstrating perfect recall for all items on three subsequent production sets the learning session ended, and they were scored as correct on all sets that remained. This number of learning sets and criterion for success was consistent with that used by Rosenthal and Ehri (2008) with grade 2 children, and was chosen due to the overall low success rate reported by Ricketts et al. (2009) after only completing three cycles through repetition and production trials (.40 proportion correct on 12 items).

Measures

All scoring was completed online by either the primary investigator or a trained tester. Audiorecording of all sessions permitted an implementation check on the first ten participants conducted by the trained tester. Listening to recordings across sessions confirmed that the trained tester employed the test script and was following procedure appropriately with children in each of the three learning conditions. It was therefore decided that online scoring would be maintained and used in analyses.

Expressive vocabulary learning efficiency. The efficiency with which children were able to learn novel picture-nonword pairings was measured by the number of trial sets necessary to recall the nonword labels successfully. Learning growth was compared from trial to trial across the three conditions, and planned one-tailed contrasts were conducted on the average number of words produced across sets. Descriptions of children's learning success according to criteria are also provided below. To allow for

comparison with previous studies, the number of production sets (range 3-9) it took for children to accurately produce the nonword labels to all six picture referents in three consecutive sets (i.e., reach learning criterion) is reported.

For the seven children out of 67 who consistently produced approximations of the target pronunciations and demonstrated an inability to reproduce the word accurately, scoring accuracy was based upon the consistency of their responses. Internal reliability was poor for the six consistent words summed across repetition sets ($\alpha = .37$, 95% CI [.03, .61]), as well as for the six inconsistent words ($\alpha = .73$, 95% CI [- .11, .71]), however as will be seen, children on average achieved ceiling on this task. Internal reliability was adequate for the six consistent words summed across production sets ($\alpha = .86$, 95% CI [.79, .92]), as well as for the six inconsistent words ($\alpha = .73$, 95% CI [.50, .87]). A visual inspection of children's performance across conditions revealed similar rates of success on each pair of consistent-inconsistent items for both repetition and production sets (see Appendices A and B).

Posttests. Vocabulary recall, recognition and spelling were assessed at posttest to determine whether incidental exposure to orthography would influence not only children's learning of oral vocabulary, but also their memory for learned vocabulary a day later. The same experimenter assessed both learning and posttest sessions, as much as possible, in order to ensure familiarity with each child's pronunciations and score their recall in accordance with their acquired pronunciation. For the eight children in which this was not possible, recordings from the learning session were verified, and the other experimenter was consulted to verify the scoring of children's expressive vocabulary

recall. In all cases where this was done, experimenter agreement was perfect.

Expressive vocabulary. On posttest, children's memory for the pronunciations of nonwords a day after learning was assessed by asking them to produce the spoken labels for each picture cue. Picture cues (without orthography) were presented one at a time to children on 6 x 6 inch cards, printed in greyscale. Changing the nature of the stimulus by providing it on a card instead of a computer screen, and in greyscale instead of colour, provided a means of assessing whether children were able to transfer their acquired knowledge beyond the situational environment in which it was learned.

Children were instructed that: "Each card has a picture of something an alien can use, something you saw yesterday. I will show you each card once, and I want you to tell me the name for the object in the picture, like you learned yesterday. Try hard to remember the right name." Cards were shuffled at the beginning of the task, and the top card was turned onto the table facing the child to provide the first item for recall. Children were given five seconds to respond, after which the experimenter provided encouragement and prompted the following trial, "Let's try the next one." No feedback was provided, and the item was turned over into a separate pile so that it was not visible on subsequent trials. The accuracy of children's responses was recorded, and summed (range 0 to 6). Internal reliability for the six consistent words was adequate ($\alpha = .73$, 95% CI [.58, .84]), while for the six inconsistent words it was poor ($\alpha = .48$, 95% CI [.06, .76]), however, as will be described later, children in all three learning conditions reached ceiling. Performance by item as a function of learning condition is provided in Appendix C, and a visual inspection does not reveal that any one item stands out from the others.

Receptive vocabulary. A label-to-picture matching task was used as a check to assess whether children learned to match the nonwords to the picture referents. Upon hearing the pronunciation of a nonword, children were asked to point, from an array of four pictures on the laptop screen, to the picture of the object being named. Their accuracy was recorded. While previous studies have indicated children were performing at ceiling on this task, it was included here in order to verify their retention of word-referent pairings, and act as an assessment of children's acquired receptive vocabulary. In order to help offset the possibility of correct "guessing" responses and the potential for children's decisions on each array to interfere with their subsequent identification on arrays that follow, the counterbalancing procedure used by Ricketts et al. (2009) was employed.

Array construction involved using an online random sequence generator (Haahr, 1998) to determine possible unique combinations of four integers using the numbers one through six, as placeholders for the six images to be assessed. Sequences were randomly ordered, and were sifted through starting with the first sequence until six unique combinations were found in which each number appeared four times, once in each corner of the array, such that targets and distractors were counterbalanced. With these six fixed arrays, permutations of possible target combinations were determined. Six possible target combinations were created, such that the target area within each combination was counterbalanced across combinations, and all of the individual targets were equally as likely across arrays to be in either of the array corners (see Appendix D). Arrays were presented in a fixed randomized order, but the target sequence was determined

systematically such that an equal number of children completed each of the possible combinations. Internal reliability was adequate for the six consistent words ($\alpha = .70$, 95% CI [.54, .82]), and excellent for the six inconsistent words ($\alpha = .97$, 95% CI [.95, .99]). While not analyzed, performance by item as a function of learning condition is provided in Appendix E.

Spelling dictation. To assess children's implicit acquisition of word-specific orthographies, children were asked to spell to dictation each nonword learned the previous day. Words were said twice for each of the six nonword item. Items were presented in a randomized order for each child. Children received encouragement to "take their best guess." Spelling was scored for accuracy in two ways: (1) relative to the target orthography for words in the consistent or inconsistent word list; and (2) according to having provided a legal French homophonic alternative spelling. For the measure of accuracy relative to the target orthography, internal reliability was adequate for the six consistent words ($\alpha = .72$, 95% CI [.58, .83]), and poor for the six inconsistent words ($\alpha = .55$, 95% CI [.18, .79]). For the measure of accuracy based on homophony and legality, internal reliability was poor for both the six consistent words ($\alpha = .46$, 95% CI [.17, .67]), and the six inconsistent words ($\alpha = .33$, 95% CI [- .22, .69]). While not analyzed, performance by item is provided in Appendices F and G.

Scoring agreement on outcome measures. Following completion of testing, audio recordings permitted the calculation of scoring agreement by comparing online scoring of one tester with audiotaped scoring by the other. An interrater reliability analysis using the Kappa statistic was performed on a subset of four randomly selected

children from each condition (18% of the sample, within and across conditions) to determine the consistency of scoring on outcome measures, with the exception of receptive vocabulary, which would have required video in order to capture children's responses. Agreement between the two scorers was near perfect on learning session measures, for both repetition trials (consistent orthography, $\kappa = 1.00$; no orthography $\kappa = 0.83$, $SE = 0.09$, 95% CI [0.65, 1.02]) and production trials (consistent orthography, $\kappa = 0.95$, $SE = 0.02$, 95% CI [0.91, 0.99]; inconsistent orthography $\kappa = 0.94$, $SE = 0.02$, 95% CI [0.90, 0.99]; no orthography, $\kappa = 0.82$, $SE = 0.04$, 95% CI [0.75, 0.90]). Due to all scores for repetition trials in the inconsistent orthography condition occurring in the same row of the interrater agreement matrix, Kappa could not be calculated, however scorers were in 99% agreement. Agreement on scoring of posttest measures of expressive vocabulary and spelling (both accuracy and legality) was perfect. These results support the decision to preserve online scoring for analyses.

Other Measures

Decoding (selection criterion). Children's ability to accurately decode in French was assessed by presenting them with a series of fifteen two-syllable nonwords adapted from items in the French BELEC MIM decoding subtest (Mousty, Leybaert, Alegria, Content, & Morais, 1994). The MIM nonwords were adapted to test the word units used in the to-be-learned stimuli because it was important to ensure that all children were able to employ a decoding strategy in the presence of orthography during oral word-learning. Each of the twenty word-units that make up the nonword stimuli to be learned (six consonants, five vowels, three vowel-digraphs, and six consonant blends) appeared in at

least two criterion nonword items, and were employed in construction combinations that differed from those being used in the learning task. The 15 adapted nonwords and their target pronunciations are located in Table 7.

Decoding task procedures were adapted from the BELEC MIM subtest (Mousty et al., 1994). Nonwords were presented four at a time in an array on a flashcard and children were asked to try and read them aloud. Responses were recorded online, and sessions were audiorecorded to allow for verification of scoring. A training card containing four real words was presented at the beginning of the task with instructions (in French) to “try and read the following words out loud, as clearly as possible. Start here at the top, and read every word, like this (demonstrate with a left-to-right motion). Try not to skip any words, even if they are hard; do your best and I will let you know when you can go on to try the next one.”

Once they had completed the training card, they were told “Now I have some made-up words to show you. I would like you to try and read them, just like you did for the real words on this card. Remember, they are made-up words, so there is no right or wrong way to read them. Just do your best, and if you get stuck I will tell you when you can go on to the next word. Are you ready?” Their accuracy at decoding each item was scored by a trained experimenter.

Table 7

Characteristics of Nonwords in Criterion Task (15 items)

Orthography	Pronunciation
rogla	/ʁogla/
torel	/toʁəl/
pobsu	/pobsy/
clovra	/klovʁa/
glouvre	/gluvʁə/
deblou	/dəblu/
tubli	/tybli/
blume	/blymə/
glonba	/glɔ̃ba/
drumal	/dʁymal/
boucre	/bukʁə/
tidron	/tidʁɔ̃/
leucra	/ləkʁa/
meucli	/møkli/

As this was not a standardized measure of decoding, results for the first ten children sampled were examined prior to further testing in order to assess whether particular items proved more difficult due to the irregularity of their units or the combination of units being used. There did not appear to be a pattern to children's mistakes, therefore testing continued to employ the same 15 items throughout the remainder of the study. Internal reliability for the 15 items that made up this scale was reported as poor ($\alpha = .23$, 95% CI [- .07, .47]), however, as will be seen, children performed at ceiling on this task.

Reading (French). In order to match children's reading levels across learning conditions, children's French reading ability was measured using the BELEC REGUL French Reading subtest (Mousty et al., 1994). The BELEC is a battery of tests designed to assess speech segmentation, reading, and spelling abilities in French, in order to help in the identification and diagnosis of developmental difficulties in children ages 7 to 12. The tests within are not standardized, but were normed on samples of normally-developing elementary school students in grades 2, 3, and 5. The REGUL subtest required that children read aloud twenty-four isolated words matched on frequency and length (same number of letters and syllables): twelve with regular orthography, and twelve with irregular orthography. The test took under five minutes to administer.

This task was administered immediately following the criterion decoding task, and was recorded within the same audio track as the previous task (no break). Children were told: "Now I'd like you to read some more words, but this time they are all *real* words." Cards displaying six words were presented to the child one at a time, in the

order prescribed by the test procedures. Testing ended when all words had been read. Children who experienced difficulty were encouraged to “look at the letters” and “give their best guess.” Children’s reading and decoding scores were used to help in their assignment to a learning condition, as efforts were made to balance gender and reading measures across conditions. Internal reliability for the 48 items that made up this scale was reported as moderate ($\alpha = .74$, 95% CI [.64, .82]), and no single item stood out as being different from others.

Parent questionnaire. Letters to parents and consent forms were distributed and collected with the support of teachers. A questionnaire was included with the consent form to collect household demographics, language(s) spoken within the home, and child information. Respondents were asked to provide the child’s age and indicate whether the child had or had ever been diagnosed or received treatment for hearing or language difficulties. Demographics and child characteristics were examined to ensure that there were no group differences that might have contributed to learning outcomes.

General Procedure

Recruitment and testing took place in May and June of 2011. All tasks were completed individually with the experimenter in a quiet space in the school. Testing was completed in three sessions held on consecutive days, in order to prevent children from tiring and to permit a one-day delay between learning and posttesting. Participating children completed the criterion decoding task and the reading measure during Session 1. In Session 2, children completed oral word-learning in their assigned learning condition with the corresponding set of nonwords. In Session 3, children were post-tested for their

knowledge of nonwords learned the previous day. Posttest order was fixed. Expressive vocabulary was assessed first, to prevent the influence of additional exposure to nonwords on children's recall performance. Receptive vocabulary and spelling dictation followed. The first and third sessions took between 5 and 10 minutes each, while the second session took between 10 and 20 minutes.

T-tests performed on vocabulary learning and posttest measures for learning conditions separately revealed no evidence of tester effects (*Mdn* $p = .55$, range $p = .12$ to $p = 1.0$), with the exception of spelling, which was near significance (*Mdn* $p = .07$, range $p = .06$ to $p = .16$). This is likely due to one tester having completed the majority of the learning sessions overall (57%), as well as at posttest (53%), and having completed over two-thirds of testing in the inconsistent orthography condition (15 of 23 children). A lack of significant Pearson correlations between tester and spelling outcomes support this interpretation.

Results

Preliminary Analysis

All children included in analyses performed at or above expected performance on screening measures. Children were able to decode at least 80% of the fifteen words on the criterion decoding task, and received instructional feedback on their errors (no orthography, $M = 14.30$, $SD = 0.88$; consistent orthography, $M = 14.32$, $SD = 0.89$; inconsistent orthography, $M = 14.09$, $SD = 1.11$). The average reading score fell directly at the grade 3 level (success reading 42 out of 48 items), according to the norms provided by the BELEC French reading subtest: no orthography, $M = 42.35$, $SD = 3.51$; consistent

orthography, $M = 42.00$, $SD = 3.74$; inconsistent orthography, $M = 42.14$, $SD = 3.56$ (Mousty et al., 1994).

Children in each of the learning conditions were compared to determine whether there existed significant differences at the onset that might account for differences in performance on vocabulary learning or posttest measures. Chi-square tests of goodness-of-fit confirmed that children in each learning condition were distributed equally across the three schools, $X^2(4) = 2.06$, $p = .72$, and seven classrooms, $X^2(12) = 8.70$, $p = .73$, that participated in the study. Results from one-way between-subjects ANOVAs revealed no significant differences between groups on demographic or screening measures ($Mdn p = .81$, range $p = .22$ to $p = .99$). These are located in Table 8.

Additional investigation of the dataset for potential confounds revealed a significant positive correlation between household income and condition ($r = .244$, $p = .05$), indicating an imbalance in the within-group variance across learning conditions. This variable was included as a covariate when its inclusion changed the pattern of results on outcome measures. In order to retain the entire sample for analysis, missing income information for the six children for whom it was not provided was replaced with the mean for their learning condition (two per condition). Children's reading ability was also positively correlated with several outcome measures, however due to previous studies having indicated this possibility (Rosenthal & Ehri, 2008; Ricketts et al., 2009), the investigation of its impact is reserved for subsequent analyses. No additional significant correlations existed between outcome measures and demographic or child characteristics.

Table 8

Children's Demographic Characteristics Reflected in Percentage of Responses as a Function of Learning Condition

	No Orthography (n = 23)	Orthography	
		Consistent (n = 22)	Inconsistent (n = 22)
Mean age in years (SD)	9;3 (0;6)	9;2 (0;6)	9;3 (0;6)
	%	%	%
Has ever received speech therapy	13.00	27.27	18.18
Primary language in the home			
French	86.96	86.36	81.82
English	4.35	4.55	13.64
Other	8.70	9.09	4.50
Secondary language in home			
None (French only)	56.52	45.45	59.09
French	8.70	13.64	13.64
English	30.43	40.91	18.18
Other	4.35	0.00	9.09
Parent education			
Less than High School	0.00	0.00	0.00
High School	0.00	9.09	0.00
College or vocational training	17.39	13.64	36.36
Undergraduate University degree	52.17	45.45	36.30
Post graduate University degree	30.43	31.82	27.27
Household annual income ^a			
\$ 0 – 30,000	0.00	20.00	5.00
\$ 30,001 – 50,000	0.00	0.00	5.00
\$ 50,001 – 70,000	19.05	5.00	10.00
\$ 70,001 – 90,000	4.76	20.00	20.00
\$ 90,001 +	76.19	55.00	60.00

^a Two respondents from each group did not report their annual income, therefore consistent orthography n = 21, inconsistent orthography n = 20, no orthography n = 20.

Due to having witnessed a large amount of variability in the linguistic backgrounds of children, home language(s) were included as an additional covariate when this changed the pattern of results. While ideally the sample for analysis would have been restricted to French monolingual children, bilingualism in the region made it difficult to obtain a large enough sample in the small period in which data was being collected, and only including those who had reported French as their only home language would have reduced the sample by half. Therefore, employing a variable that coded for both children's French language status within the home, as well as their second language if they were exposed to one within the home, is believed to have provided a more fine-tuned linguistic covariate than employing children's first language alone.

The distribution of performance on outcome measures, both within and across groups, showed no evidence of outliers except for receptive vocabulary at posttest. Two children scored very low on receptive vocabulary, with scores of zero (inconsistent orthography condition) and one (no orthography condition) respectively. These children performed well compared to others on learning and posttest expressive vocabulary recall, and seem to have simply misunderstood task instructions. For example, clinical notes for one child indicate that instead of selecting the target object from among items displayed in an array, they stated that it was not present – even when instructions were repeated to “show me the object being named from the ones you see on the screen.” The two children were retained in the sample for analysis. Rather than repeat it throughout, it is noted here that all measures met the assumption for homogeneity of variance across learning conditions in all analyses reported.

Vocabulary Learning During Training

Vocabulary learning during training was examined in a number of ways. First, children's capacity to repeat the six target words across the nine learning cycles was assessed. Presumably, children should not have had any difficulty doing so, and this seemed to be the case, as indicated by the mean raw scores displayed in Figure 1. An examination of children's performance across repetition trials indicates that while some between-group differences existed early in the learning session, performance was overall at ceiling and showed little variability. However, the existing within-group variability and between-group differences on earlier repetition trials provided some initial weak evidence that incidental exposure to orthography may have helped to clarify incoming pronunciations of unrecognized words, despite them having been legal French-sounding constructions. Also, feedback consistency may have moderated orthographic facilitation in early trials, as children exposed to consistent orthography were the only group able to reproduce all spoken labels in the first repetition set.

Prior to assessing differences in learning efficiency, it was necessary to establish that the learning session was successful in teaching children spoken labels to picture referents. Production learning patterns in Figure 2 indicate this was the case. To investigate learning, a two-way mixed ANCOVA was performed with production sets as a repeated factor (9) and learning condition as a between factor (3), employing household income and home language(s) as covariates. The assumption of sphericity was not met, therefore results using the stringent Greenhouse-Geisser correction are reported.

Figure 1. Children's mean performance repeating six words across nine repetition sets during learning as a function of learning condition. Error bars represent standard errors. Raw, unadjusted scores are displayed.

Figure 2. Children's mean performance recalling six words across nine production sets during learning as a function of learning condition. Error bars represent standard errors. Raw, unadjusted scores are displayed.

Dual-modality word learning

Results confirmed that learning took place over time in all conditions, $F(4.85, 300.51) = 3.93, p = .002, MSE = 1.55$. Production sets accounted for 60% of the variance in children's recall of spoken words. The linear trend was significant, $F(1, 62) = 10.30, p = .022, MSE = 2.20, \eta^2 = .14$, indicating that children's recall increased at a constant rate over time. The condition main effect was not significant, $F(2, 64) = 2.63, p = .080, MSE = 12.56, \eta^2 = .08$, indicating that children across conditions learned approximately the same amount, on average, across the learning session (no orthography, $M = 2.53, SD = 1.20$; consistent orthography, $M = 3.34, SD = 1.20$; inconsistent orthography, $M = 3.08, SD = 1.18$). This would support existing differences at posttest being due to the learning condition, rather than the amount learned the previous day. Moreover, learning sets did not interact with learning condition, $F(9.69, 300.51) = 1.34, p = .211, MSE = 1.55, \eta^2 = .04$.

While children in all three learning conditions produced on average the same mean number of words across sets, their performance varied across conditions during the first six production sets as indicated in Figure 2. This was consistent with findings of Rosenthal and Ehri (2008), and Ricketts et al. (2009), who found that condition effects during learning were short-lived, and restricted to performance on earlier sets. Indeed, significant differences between group means were reported across only the first three, and five sets, respectively. It was therefore of interest to compare children's learning efficiency by performing planned contrasts on mean differences in vocabulary acquisition across the first six sets, which captured the largest period of learning growth.

The direction of the adjusted group means across the first six sets supported

predicted differences between learning conditions. One-tailed planned contrasts of children's mean production across the first six sets confirmed an orthographic facilitation effect benefitting those who were incidentally exposed to orthography during oral word learning, $t(64) = 2.45$, $p = .008$, $d = 0.61$, $SEM = 0.58$, 95% CI [0.26, 2.59] (no orthography, $M = 1.8$, $SD = 1.1$; orthography, $M = 2.5$, $SD = 1.1$). There was no statistical evidence of this effect being moderated by feedback consistency, despite the existence of a trend favouring consistent orthography, $t(64) = 0.85$, $p = .200$, $d = 0.21$, $SEM = 0.34$, 95% CI [- 0.39, 0.96] (consistent orthography, $M = 2.7$, $SD = 1.1$; inconsistent orthography, $M = 2.4$, $SD = 1.1$).

Having established that learning took place and described overall trends in vocabulary acquisition, it was of interest to further describe children's learning as a function of pre-determined learning criteria. As seen in Table 9, fewer than 25% of children achieved the criterion of producing all six words in three subsequent sets. To include more children in the analyses, the criterion was relaxed by examining the mean set at which some children produced all six words as well as the mean set for 5 or the 6 words (80% success in a single set). As can be seen in Table 9, these additional analyses, however, would still fail to show evidence of orthographic facilitation or of a moderating effect of orthographic consistency. That is, the children who produced all, or more than 80% of words in a single set, produced them on average during the same set across learning conditions. These analyses should be interpreted cautiously, however, because only approximately half of the children in each learning condition ever succeeded in producing all six words in at least one set.

Table 9

Mean Set (and Standard Deviations) At Which Some Children Reached Various Pre-determined Learning Criteria For Expressive Vocabulary Recall as a Function of Learning Condition

Learning Success Criteria ^a	No Orthography		Orthography			
			Consistent		Inconsistent	
	<i>M (SD)</i>	<i>n</i>	<i>M (SD)</i>	<i>n</i>	<i>M (SD)</i>	<i>n</i>
Set marking recall of all 6 words in three subsequent sets	8.18 (2.27)	4	6.99 (1.81)	6	7.39 (1.79)	6
Earliest set in which all 6 words were recalled	6.54 (2.76)	11	6.22 (2.60)	12	6.06 (2.96)	9
Earliest set in which at least 5 words were recalled	5.89 (2.35)	15	5.22 (2.16)	17	5.60 (2.39)	13

Note. Scores based on performance across six items.

^a All measures have been adjusted for language(s) spoken within the home, and household income.

Memory for Vocabulary at Posttest

Children's memory of oral vocabulary was assessed on the day following their completion of the learning session to determine whether the benefits of orthographic facilitation extended beyond the learning phase. As seen in Table 10, children's receptive vocabulary performance at posttest was near ceiling in all learning conditions and not surprisingly there was no condition effect, $F(2, 64) = 1.23, p = .298, MSE = 2.91, \eta^2 = .04$.

On posttest expressive vocabulary, children in each condition recalled on average more than half of the words they had been taught the previous day (see Table 10), and this was significantly different from zero: consistent orthography condition, $t(21) = 8.12, p < .001, d = 3.54, SEM = 0.47$; inconsistent orthography condition, $t(21) = 13.31, p < .001, d = 5.81, SEM = 0.31$; no orthography condition, $t(22) = 10.38, p < .001, d = 4.43, SEM = 0.34$. However, planned one-tailed contrasts on scores adjusted for household income and home language(s) failed to reveal a significant incidental orthographic facilitation effect, $t(64) = 1.50, p = .070, d = 0.37, SEM = 0.90, 95\% CI [-0.45, 3.15]$, on the number of words recalled a day after training (no orthography, $M = 3.4, SD = 1.7$; orthography, $M = 4.1, SD = 1.7$). Feedback consistency, however, did not appear to impact recall a day later for children who were incidentally exposed to orthography, and, not surprisingly, there was no statistically significant difference between the two orthography present conditions, $t(64) = 0.43, p = .335, d = 0.11, SEM = 0.52, 95\% CI [-1.26, 0.81]$ (consistent orthography, $M = 3.9, SD = 1.7$; inconsistent orthography, $M = 4.2, SD = 1.7$).

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Table 10

Children's Mean Performance (and Standard Deviations) on Posttest Measures of Vocabulary Retention as a Function of Learning Condition

Measure ^a	No Orthography (<i>n</i> = 23)	Orthography	
		Consistent (<i>n</i> = 22)	Inconsistent (<i>n</i> = 22)
	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)
Receptive vocabulary	5.5 (1.1)	5.6 (1.1)	5.7 (1.1)
Expressive vocabulary	3.4 (1.7)	3.9 (1.7)	4.2 (1.7)

Note. Scores based on performance across six items.

^a All measures have been adjusted for language(s) spoken within the home, and household income.

Spelling

Analyses of children's spelling at posttest were conducted in order to examine whether children's incidental exposure to orthography during spoken word learning resulted in their implicit acquisition of word-specific orthography. As previous studies have already provided support for this hypothesis (Rosenthal & Ehri, 2008; Ricketts et al., 2009), it was of greater interest to examine whether feedback consistency would moderate this effect. This question is addressed first. Children's raw spelling scores are displayed in Table 11 and were used in analyses. Note that household income and home language(s) were not used as covariates because doing so did not change the group means or the pattern of significance.

As seen in Table 11, incidental exposure to consistent orthography during oral word learning resulted, a day later, in better spelling performance as compared to exposure to inconsistent orthography, $t(64) = 6.67, p < .001, d = 1.67, SEM = 0.42, 95\% CI [1.97, 3.66]$ (consistent orthography, $M = 5.4, SD = 1.0$; inconsistent orthography, $M = 2.6, SD = 1.5$). Children's memory for words spelled consistently was more accurate (89% accuracy) than for words spelled inconsistently (43% accuracy). Converging evidence for this interpretation was provided by exploring the source of children's spelling errors.

As feedback consistency was manipulated through the inclusion of a silent consonant at the end of inconsistent words, it was of interest to determine whether this was the source of their spelling difficulty. Errors on the silent consonant ending accounted for 83% of all spelling errors made by children in the inconsistent condition,

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Table 11

Children's Mean Performance (and Standard Deviations) on Posttest Spelling of Six Items as a Function of Learning Condition

	No Orthography (<i>n</i> = 23)	Orthography	
		Consistent (<i>n</i> = 22)	Inconsistent (<i>n</i> = 22)
		<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)
Accuracy relative to target spelling	3.2 (1.6)	5.4 (1.0)	2.6 (1.5)
Legal homophonic spelling	5.0 (1.1)	5.9 (0.4)	5.5 (0.8)

Note. Scores based on performance across six items.

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confirming that their poorer spelling performance was not due to a lack of phonological recoding ability. In most cases, the silent-letter error was the omission of the consonant (55%), although substituting the silent consonant with another consonant (44%) or a silent *e* (1%) also occurred.

In contrast, children in the consistent orthography condition seldom made spelling errors (i.e., 11% errors). Of the 6% of total number of errors that were on the final letter (these words ended with a vowel), most were the addition of a silent *e* (50%) or a silent consonant (38%), and less frequently the use an alternative homophonic vowel ending (13%; e.g., *eau* or *au* in place of *o*).

Overall, this pattern of errors would support the conclusion that it is more difficult to implicitly acquire – or, alternatively, possibly to retain – accurate word-specific orthography from incidental exposure when its spelling is inconsistent compared to when it is consistent. It remains possible, however, that children in the consistent orthography condition did not actually acquire word-specific orthography in memory from exposure, but rather employed a recoding strategy to print the highly feedback-consistent words on the dictation task. In order to determine whether this was the case, I compared the spelling performance of children in the consistent orthography condition with that of children in the no orthography condition, who learned the same set of words but were never incidentally exposed to orthography. A second planned one-tailed contrast revealed that children who had been incidentally exposed to words in print during oral word learning more frequently produced the target spelling a day later than those who had learned the same words in the absence of orthography (90% compared to 53%

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accuracy), $t(64) = 5.24$, $p < .001$, $d = 1.31$, $SEM = 0.42$, 95% CI [1.35, 3.03] (no orthography, $M = 3.2$, $SD = 1.6$; consistent orthography, $M = 5.4$, $SD = 1.0$). This result supports the conclusion that children were able to implicitly acquire word-specific orthography from incidental exposure to print during oral word learning.

Finally, in order to verify that these effects were not due to between-group differences in children's phonological recoding abilities, a second set of spelling scores was calculated to reflect children's ability to provide a phonologically-accurate French language-specific alternative legal spelling for each word's pronunciation (see Table 11). When scoring children's provision of legal homophonic spelling for the words presented orally, spelling performance for children in the no orthography condition improved dramatically. This indicates that their spelling errors were for the majority homophonic in nature, as they were providing an alternative legal spelling for words that they had never seen. Secondly, children's spelling performance in the two conditions where they were incidentally exposed to orthography remained higher on average (95% accuracy) than the no orthography condition (83% accuracy), indicating that orthography did in fact help – even when the words were identical, as they were in the consistent orthography condition. Otherwise, as indicated by the lower spelling scores overall when scoring relative to word-specific target orthography, children relied upon the existence of legal French homophonic alternatives to capture the spoken words in print.

Secondary Analyses: Reading Ability and Outcome Measures

Due to previous studies having found that reading skills were linked to the magnitude of the orthographic facilitation effect in oral word learning (Rosenthal & Ehri, 2008; Ricketts et al., 2009), the current study attempted to control for this confound by balancing children's reading ability across learning conditions. Despite this control by design, it was possible that reading ability might still be linked to children's oral word learning patterns, and therefore that the facilitative effect of orthography could have been masked due to internal reading variability. Indeed, significant positive correlations existed between reading and several outcome measures. Secondary analyses were thus planned to determine whether incidental orthographic facilitation of oral word learning might be mediated by reading skill. In contrast to previous findings, when entered as a covariate, children's reading ability did not change the pattern of significance on planned one-tailed contrasts for any of the learning or retention measures (contrasts on orthography, $Mdn = .007$, range $p < .001$ to $p = .064$; contrasts on feedback consistency, $Mdn = .371$, range $p < .001$ to $p = .341$), nor did adjusted means appear noticeably different from those reported above (see Table 12). This may be due to testing having occurred at the end of the school year, with children performing on average at grade level, and little variance overall in their reading performance. The results as a function of reading ability will not be discussed further.

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Table 12

Children's Mean Performance (and Standard Deviations) on Learning and Retention Measures Adjusted for Reading Ability as a Function of Learning Condition

Measure ^a	No Orthography (<i>n</i> = 23)	Orthography	
		Consistent (<i>n</i> = 22)	Inconsistent (<i>n</i> = 22)
	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)
Learning			
Mean production, sets 1 to 9	2.5 (1.2)	3.3 (1.2)	3.1 (1.1)
Mean production, sets 1 to 6	1.8 (1.1)	2.7 (1.1)	2.4 (1.1)
Retention			
Receptive vocabulary	5.5 (1.1)	5.6 (1.1)	5.7 (1.1)
Expressive vocabulary	3.4 (1.7)	4.0 (1.7)	4.2 (1.7)
Spelling relative to target	3.2 (1.5)	5.4 (1.4)	2.6 (1.4)

Note. Scores based on performance across six items.

^a All measures, with the exception of spelling, have also been adjusted for language(s) spoken within the home, and household income.

Discussion

Vocabulary knowledge has been positively and robustly linked to the amount of reading adults and older elementary-school children report (Sénéchal, 2006; West et al., 1993), and yet we are only beginning to investigate how reading might support oral vocabulary acquisition. The current study employed pairings between spoken labels and picture referents to examine how incidental exposure to a word's orthography might facilitate the acquisition of oral vocabulary in literate French children.

According to Ehri's (1978) theory of amalgamation, literate individuals are able to employ their knowledge of symbolic mappings between written and spoken words to "amalgamate" the word's orthography and pronunciation in lexical memory. Consequently, consistent with Perfetti and Hart's theory of lexical quality (2002), "bonding" the pronunciation with other lexical forms in memory enhances the quality of the representation, and ultimately increases the availability of its contents. In the context of the current study, it was hypothesized that exposing children to the spelling of an unfamiliar word being learned orally may enhance their acquisition of phonological representations, as well as strengthen their memory for pronunciations a day later, by permitting their implicit acquisition of an orthographic representation in lexical memory. These predictions were partially supported. Results indicated that children who were incidentally exposed to orthography acquired spoken words more quickly and were more accurate at capturing the word-specific orthography than those who never saw the words' spelling. Such findings support children's implicit acquisition of word-specific orthography, and the earlier establishment of a phonological representation in lexical

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memory when supported by orthography. Despite mean trends suggesting that children who saw spelling had better recall of pronunciations a day later than those who never saw the words in print, there was no significant difference between children's memory for expressive vocabulary a day after training, indicating limited evidence for orthographic facilitation of oral vocabulary beyond the learning stage.

In addition to demonstrating that orthography can facilitate oral word learning, it is important to consider what factors might influence the *effectiveness* of orthography as an “anchor” for pronunciations in memory. As the locus of this effect is believed to lie in an individual's understanding and ability to exploit grapheme-phoneme correspondences, the lack of congruency between orthographic and phonological forms within opaque languages may moderate the extent to which spelling can act as a memory aid for pronunciations. For example, if the learner is shown an irregular or inconsistent spelling pattern that cannot be decoded accurately it may be less likely to support the acquisition of a pronunciation, and more likely to cause strain on the simultaneous acquisition of word-specific orthography. Therefore, not only does knowledge of orthography impact children's ability to exploit the predictable mappings between print and speech, but so does the language's consistency. In the current study, the predictability of French speech-to-spelling mappings (feedback consistency) was manipulated in order to determine whether the precision of the mapping would impact the degree to which it supported the acquisition and recall of pronunciations from memory. Results indicated that the predictability of mappings from speech to print did not impact children's learning or posttest recall of spoken words in conditions that were incidentally exposed to

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orthography. Children's spelling of words a day later, however, provided evidence that word-specific orthographic representations were more accurately constructed for children who were shown highly feedback-consistent spelling as compared to children whose saw spelling that contained a silent final consonant. Perhaps explaining why there were no differences on learning and recall of pronunciations a day later, the majority of children's spelling mistakes in the inconsistent condition were on the silent final letter, evidencing that they had acquired all portions of the orthography that would be necessary to support their memory of pronunciations. Therefore, while both groups of children who were incidentally exposed to spelling had formed word-specific orthographic representations, the quality of the lexical contents were overall richer and more accurate for children who saw spelling that was feedback-consistent, as compared to those who saw feedback inconsistent spelling.

In order to discuss the implications of these results, they will be expanded upon separately in the following sections. Potential limitations and suggestions for future research will also be outlined. The significance of the study overall will then be discussed as it relates to theory and practice. Despite some limitations, the current study has succeeded in extending the investigation of incidental orthographic facilitation of oral vocabulary into another opaque language, French, as well as made attempts to refine our understanding by providing a controlled investigation of whether feedback consistency boundaries might moderate this effect.

Learning and Delayed Recall of Oral Vocabulary

Incidental orthographic facilitation. When examining children's performance during the period in which the most learning growth occurred, children who were exposed to print learned spoken labels for picture referents more quickly than children who never saw print, replicating past results (Rosenthal & Ehri, 2008; Ricketts et al., 2009). The moderate effect size was similar in magnitude to that previously reported by Rosenthal and Ehri. These findings support the claim that exposure to spelling can help to establish phonological representations earlier in memory compared to when pronunciations are learned without spelling. In practice, this implies that showing literate children the spelling for a word they are learning orally might help them to acquire it more quickly, even if no attention is drawn to it.

It might be argued that findings of orthography enhancing children's acquisition of oral vocabulary were due to children in the no orthography condition having taken longer to repeat words successfully. However, their production success remained lower than other groups in later sets even once they were performing at ceiling on repetition trials. In addition, the no orthography condition heard each word twice as frequently during training and feedback trials, therefore this difference is not due to having received less exposure to the words. In fact, that a group difference persisted supports the conclusion that providing children with incidental exposure to orthography is what gave the other two groups an advantage in learning oral vocabulary.

Examinations of children's learning performance lend support to the conclusion that orthography may have helped to clarify and anchor words' pronunciations in

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memory. For example, children in the consistent orthography condition successfully repeated all items without error the first time they were presented (as shown in Figure 1), while children in the inconsistent orthography condition frequently erred on the first item – but only the first item – of the set due to having pronounced the silent final consonant visible in the word’s written form. While the nature of the errors was not verified across all recordings, 27% of all children in the inconsistent orthography condition erred in repeating the first item, while across the other five items error was 6% on average (range 0-18%) in the first repetition cycle. Following corrective feedback that asked them to “listen and repeat what they heard” children promptly began responding accurately, and did so in subsequent trials. Such an initial response indicates that children who were exposed to orthography appeared to attempt to decode it, regardless of it having never been explicitly presented. However, words were not displayed for very long, and having provided the pronunciation there was no need for children to decode the word in order to access it.

Anecdotal evidence of children having employed spelling as a memory support provides further support to the preferred interpretation of orthography’s benefits on oral word learning. Children showed evidence of calling upon an incomplete orthographic representation during recall of pronunciations on production sets with responses such as “It starts with a *t*” as opposed to “It starts with /t/.” Such occurrences indicate that these literate children were making use of orthography to support their acquisition of spoken labels. Results are interpreted as children having employed their knowledge of mappings between speech and print to amalgamate or bond pronunciations with the congruent

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orthography to which they were exposed, subsequently anchoring the pronunciation more securely in memory. Such an account is in accordance with Ehri's (1978) theory of amalgamation, as well as Perfetti and Hart's (2002) theory of lexical quality, as it supports the claim that children who were exposed to orthography had formed a richer lexical representation by having acquired an additional form into memory. Further support of children's acquisition of word-specific orthographic representations is provided in the children's spelling at posttest.

In addition to assessing orthographic facilitation during learning, children's memory for spoken labels was assessed the day following training in order to determine whether the benefits of orthography would extend beyond the learning stage. Consistent with past results, children had no trouble recognizing spoken labels and matching them appropriately with their picture referents, and performed at ceiling (Rosenthal & Ehri, 2008; Ricketts et al., 2009). This would imply that any differences found in children's posttest recall of pronunciations were not due to their lack of learning the associations but were genuine differences in their ability to recall pronunciations from memory. As previously reported by Rosenthal and Ehri, recalling labels from memory proved to be a more difficult task. The current study failed to replicate their finding of an orthographic facilitation effect on memory for pronunciations, however. While the effect size in the current study was much smaller than that reported previously ($d = 0.37$ compared to Rosenthal & Ehri's $d = 0.73$), considering the current study employed approximately the same number of observations per group but in a between-subjects rather than a within-subject design, and with an additional condition, it is possible that a larger effect was not

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detected due to within-condition variability in the current study. With mean trends favouring children in the two conditions that were exposed to orthography over children who never saw spelling (68% recall on average compared to 57%), it is likely that there was simply not enough power to obtain significance on vocabulary recall at posttest. Further discussion of limitations is provided in the following sections.

Lack of moderation by feedback consistency. In contrast to the findings reported by Ricketts et al. (2009), the current study did not detect an influence of feedback consistency on children's acquisition of spoken words in conditions that were exposed to orthography. On average, children who were exposed to consistent compared to inconsistent orthography learned spoken words at a similar pace, and demonstrated learning with the same degree of efficiency during the period of greatest growth. Despite such overlap, there was variation in their learning patterns when examining mean production performance across sets, especially earlier sets (see Figure 2, page 78). In fact, mean performance patterns across the first three production sets replicated patterns reported by Ricketts et al., indicating predicted – but short lived – advantages of showing children an orthographic form that is more congruent with the phonological form being learned. In addition, that children in the inconsistent orthography condition in the current study frequently erred in their initial repetition response further supports the claim that feedback consistency has the potential to impact the acquisition of spoken words in the presence of orthography.

Having exerted a great deal more control in the creation of balanced consistent-inconsistent nonword pairs than Ricketts et al. (2009), however, the existence of a

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feedback consistency effect on learning remains questionable. Notably, attempts were made to match consistent-inconsistent nonword pairs on feedforward consistency, number of letters, number of phonemes, approximate number of phonological and orthographic neighbours, and as closely as possible on pronunciations and spelling. While allowing for a controlled manipulation of feedback consistency that was naturalistic in that it reflected common legal inconsistent spelling patterns in French, the existence of a small learning effect - which was not found to be significant - might be interpreted as impressive ($d = 0.21$), given the extent of the control over the feedback consistency manipulation. However, the unreliability and small size of such an effect, as documented here under more controlled circumstances, puts into question the previous and unreliable results of an effect documented by Ricketts et al. (2009). Further considerations of the lack of significance and suggestions for future research are discussed later.

While Ricketts et al. (2009) reported significant group differences in oral word learning early-on, children in their study did not complete enough training sets to determine whether these differences were lasting. Having examined children over a much larger learning window, the current study extends previous findings of feedback consistency's effect on oral vocabulary learning in at least two ways: (1) by providing preliminary evidence that differential trends continue to exist across the period in which children achieve the greatest amount of learning growth, suggesting a persistent advantage of more consistent as opposed to inconsistent spelling to support the acquisition of pronunciations; and (2) by demonstrating that all children were ultimately

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just as successful learning spoken words paired with consistent as opposed to inconsistent orthography. This second point is most valuable in practice, as it implies that a lack of congruency between orthographic and phonological forms did not impede children from learning spoken words, but rather that it influenced their efficiency in doing so.

A third way in which the current study has improved upon previous research is that it assessed children's memory for expressive vocabulary a day after training, thus also permitting an investigation of whether feedback consistency created a lasting impact on children's memory for pronunciations. Counter to predictions, no impact of feedback consistency was detected on children's recall of expressive vocabulary. Unlike the small effect documented on learning pronunciations, the effect on recalling pronunciations a day later was negligible ($d = 0.11$). This suggests that although the congruency between orthographic and phonological forms may be valuable to the efficiency with which pronunciations are initially anchored into memory, benefits of feedback consistency do not appear to extend beyond the learning phase. Of note, however, is that by the end of the learning session on the previous day all groups of children had been performing on average with approximately the same degree of recall success. It is possible that a one-day delay was too short to detect more long-term benefits of exposure to orthography during oral word learning, as some children made explicit statements that they had attempted to "practice the words" overnight. Should the delay have been longer before posttesting, perhaps a few days, a week, or a month, this might have removed the more immediate salience of a pending third visit from an experimenter and allowed a more naturalistic assessment of children's lasting memory for expressive vocabulary. It might

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also have allowed for a better assessment of the strength with which pronunciations were anchored into memory, as current predictions based on past research were that orthography's effectiveness at anchoring pronunciations in memory relied upon the precision of its mapping (Ehri & Wilce, 1979; Ricketts et al., 2009). Alternatively, it may be worthwhile to replicate the length of Ricketts et al.'s training session and perform a delayed posttest of expressive vocabulary recall, as it would be of interest to determine whether differences in vocabulary recall between feedback consistency conditions would be maintained a day later. Such results would support the claim that the more precise the mapping, the more strength with which orthography is able to anchor phonology into memory.

An additional remark on unexpected results from posttest recall is necessary. Results reflected the reverse of what was predicted, suggesting a slight advantage for children who learned words with feedback inconsistent spelling, rather than the predicted advantage for children exposed to consistent spelling. While the difference is small (0.3 of a word), it is worth acknowledging, but is left to future researchers to replicate and argue convincingly for its existence. Though only speculation, it may be that the corrective instruction received by children exposed to feedback inconsistent orthography unintentionally highlighted the incongruence between the spoken word and its written counterpart, and these children were *more likely* to pay attention to its presence in future trials. This unprompted attentiveness to the presence of orthography may have encouraged children to make more explicit attempts to acquire the word-specific orthographic representations in lexical memory, although this does not appear to be

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reflected in learning trends or in spelling results. Future researchers may nonetheless find it of interest to compare the effectiveness of orthographic facilitation in explicit and incidental exposure contexts, in order to determine how to best translate results into effective teaching practices. The utilization of eye-tracking software might also allow for a comparison of the degree to which children in feedback-consistent and feedback-inconsistent spelling conditions were consciously aware and exploiting the presence of orthography, as well as a more fine-tuned record of the amount of time or frequency with which the inconsistency is fixated upon.

Although explanations and implications for learning results remain unclear and difficult to generalize, at the very least, results from the current study suggests that the influence of feedback consistency on oral word learning in the presence of orthography is worth further investigation. In the context of the manipulation employed in the current study, the present findings imply that making the spelling of words with silent consonant endings visible to literate children is just as effective as providing the spelling for a feedback-consistent word during oral word learning. It would be premature, however, to generalize results further and conclude that children are just as likely to benefit from orthography in oral word learning, regardless of its predictability from speech to print. As described in the introduction, consistency effects have been widely documented within opaque orthographies, and the current study employed a very specific one among many that exist within the language, therefore it is far too soon to dismiss its potential influence on orthographic facilitation of oral word learning. For example, it may be that the location of the inconsistency (at the end of words) made it easy for children to dismiss

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its presence, and that it did not impact subsequent learning trials following their initial repetition response. Employing the inclusion of a silent consonant as the feedback consistency manipulation did not alter the pronunciation in any way if its presence was ignored, or prevent children from successfully decoding the word otherwise. While Ricketts et al. (2009) attempted to include words with inconsistencies located at the beginning, in the middle, and at the end of words, there were far too few items to perform an item analysis. Future studies might find it useful to vary the location and the nature of the inconsistency, in addition to improving the design used in the current study by increasing power, for example by using more words and/or employing a repeated measures design.

An additional way in which feedback consistency might be varied in future studies that could offer some insight into how orthography strengthens one's learning and recall of pronunciations is by manipulating to what degree a word's spelling can be *meaningful* to a word learner. For example, learning an English nonword such as "glumping," a listener could deduce that the word is a verb without having seen its spelling. In the French language, however, morphological information such as plurality, gender, and even in some cases size can be indicated in the language's written form while remaining absent from its pronunciation (e.g., *s* indicating plurality is not pronounced but may become blended with a word that follows; *t* at the end of a word may only be pronounced when a derivation of the word or its gender changes, such as *chat* – *chatte*). For the current study, such morphological markers were avoided in order to permit a simplistic approach to studying the effect of the presence of orthography during oral

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word learning. Previous studies, however, have indicated that English and French children as young as eight years old show evidence of the ability to impose morphological regularities in their spelling of words presented orally in sentences and cloze tasks (e.g., Pacton et al., 2005), which suggest that they could also potentially make use of them if exposed during oral word learning. In line with Perfetti and Hart's theory of lexical quality (2002), exposing children to spelling that contains "meaningful chunks" might encourage their implicit acquisition of an increasingly defined semantic form alongside the orthographic, both of which could help to anchor the phonological form being learned explicitly.

In addition to manipulating meaningful chunks in isolated words, studying different kinds of words and providing them within a context that allows the reader to attach meaning to words being learned will be valuable to investigate in future research. Varying the nature of the orthography, such that it is regular, irregular, morphological, or a sight word might also shed light on the usability of findings in practice. In addition, a growing awareness and sensitivity to other language-specific orthographic characteristics (e.g., frequency, neighbourhood density) have also been shown to influence the processing of spoken language, and were not explored in the current study (for English, see Treiman & Cassar, 1997; Treiman & Kessler, 2006; Hayes, Treiman, & Kessler, 2006; for French, see Pacton, Fayol, & Perruchet, 2005; Pacton, Perruchet, Fayol, & Cleeremans, 2001). Noting the number of potential sources for orthography to influence spoken language processing, in addition to the variants in which feedback consistency may be further explored, this study provides food for thought for future research.

Implicit Acquisition of Spelling

The current study replicated past results of English children acquiring orthography implicitly from incidental exposure to words during learning trials, as well as the influence of feedback consistency on the accuracy of their spelling a day later (Rosenthal & Ehri, 2008; Ricketts et al., 2009). As assessed through a dictation task a day following the learning session, French children who saw the target feedback-consistent spelling during oral word learning captured it more often on average than children who learned the same words but who were never exposed to orthography ($d = 1.31$). This difference was not due to children in the no orthography group demonstrating spelling difficulty, but rather to their frequent use of legal French homophonic spelling alternatives. This implies that incidental exposure to orthography may help clarify word-specific orthography, even if the target spelling was consistent, in an opaque language such as French where multiple possible legal homophonic mappings between speech and print can exist. In addition, it indicates that children incidentally exposed to orthography had acquired a word-specific orthographic representation in memory, which supports the claim that orthography had become amalgamated with pronunciation, and helped anchor it in lexical memory.

Further to the results discussed above, children demonstrated more accurate memories for consistent orthographic forms than inconsistent orthographic forms, indicating that while children were implicitly acquiring orthography the resulting representation was more precise when spelling was more predictable ($d = 1.67$). These results corroborate the interpretation that feedback consistency may contribute to spoken

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word-learning by providing a more predictable congruent orthographic representation that is less likely to conflict with one formed by listeners employing phonological recoding. In so doing, orthographic representations can be stored more quickly and more accurately, ultimately increasing the quality of the orthographic representation, and the richness of the lexical representation as a whole. Consistent with past findings (Ehri, 1980) spelling errors in the inconsistent orthography condition most frequently occurred with the silent letter at the end of words to which they had been incidentally exposed. These errors occurred with comparable frequencies to previously documented studies with French children (Sénéchal, 2000; Sénéchal et al., 2006), with children most frequently having omitted the silent final letter (59%) or substituted it for another letter. Such findings are consistent with the notion that orthographic forms for words that initially are spelled inconsistently establish a “frame” in memory using the clearly specified letters or letter-units and that underspecified “spacers” take the place of portions that do not have a clear spoken counterpart (McKague et al., 2008). It equally reflects challenges to spellers of opaque languages, French simply being the example used in the current study. In light of the finding that orthography can be implicitly acquired, and evidence of a “frame” being formed in memory, even for inconsistent words, displaying a word’s spelling while it is being taught orally may provide additional benefits to users of opaque orthographies, as they will at least *begin* to acquire orthographic representations for inconsistent words that would otherwise remain unknown.

While noticeably less frequent, children in conditions employing feedback-consistent targets also included silent final consonants in their spelling of words learned

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orally (exposed to orthography, 38% of errors; not exposed to orthography, 32% of errors). This may reflect grade 3 children's growing orthographic awareness and sensitivity to the frequency of this occurrence within the language's orthography, as has previously been documented in studies of children's spelling (e.g., Pacton et al., 2005; Pacton et al., 2001). As the feedback consistency manipulation for the current study controlled the relative consistency and frequency of two spellings for an open-vowel ending, there do exist alternative endings that capture the same sound and occur with more frequency than those used in the consistent-spelling condition (e.g., the morphological use of *e* or *s*). In addition, initial syllables in nonword constructions were chosen for their high degree of consistency, but this was not perfect. It is therefore acknowledged that stimulus construction may have contributed to the results, and appendices have been provided to allow the reader to examine performance by item if they so wish. However, the amount of control exerted in the construction of the stimuli for the present study cannot be ignored, and future researchers are challenged to make further improvements to stimuli construction to explore other facets of the present topic. Despite limitations, children's performance on the dictation task in the current study indicates that incidental exposure to orthography can support literate children's acquisition of orthography, clarify word-specific spelling among homophonic alternatives, and encourage the formation of an orthographic "frame" for words that contain spelling inconsistencies. In practice, these are all encouraging reasons to provide spelling to children when teaching them new spoken words in a language with an opaque orthography. Ultimately, however, spelling results make clear that the provision of a

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more predictable orthographic form resulted in children acquiring better quality orthographic representations in addition to pronunciations being learned, suggesting that feedback consistency be explored further in conjunction with orthographic facilitation.

Limitations

As with all research, there are limitations to the current study. Despite recruiting from French schools in the hopes of obtaining a monolingual sample, children were included that came from homes with multiple languages, and in which French was not the first language. Home language(s) was therefore used as a covariate, where necessary, to maintain some degree of control and account for it in outcome measures. Indeed, considering children's language knowledge in the study of vocabulary acquisition is important, as bilinguals' lexical knowledge encompasses their available knowledge across *both* languages rather than just one (De Groot & Kroll, 1997). Positive transfer of alphabetic knowledge and phonemic awareness from first- to second-language have been documented across alphabetic writing systems (e.g., Comeau, Cormier, Grandmaison, & Lacroix, 1999; Durgunoglu, Nagy, & Hancit-Bhatt, 1993; Geva & Wang, 2001; Cárdenas-Hagan, Carlson, & Pollard-Durodola, 2007; Verhoeven, 2007). Conversely, mismatches can occur when different letters in each language represent the same phoneme, or when the same letter represents different phonemes in different languages. For example, French and English alphabets share a great deal of overlap, however in a few cases there exist conflicts which may interfere with reading or spelling (e.g., /i/ in English is represented by the letter *e* in print, while in French it is represented by *i*). Second-language spelling errors that reflect the inappropriate use of first-language

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orthographic knowledge have been widely documented (e.g., Raynolds & Uhry, 2010; Fashola, Drum, Mayer, & Kang, 1996; Wang & Geva, 2003a, b). In addition, as previously described for monolinguals, the predictability of mappings between speech and print, the sensitivity to inconsistent mappings, and the frequency of these mappings within and across *both* languages appears to provide cues for bilingual speech processing in cross-language tasks (for a review, see Kroll, Sumutka, & Schwartz, 2005). Therefore, children's language and reading experience within the home can influence their language-learning at school – for better or worse.

Efforts were also made to randomly assign children to learning conditions according to their matched reading abilities and gender. However other demographic variables were overlooked that might have proven useful to control for, such as income, which was also employed as a covariate. In addition, while making attempts to balance certain characteristics across groups, there existed a large amount of within-group variability on several variables that may have accounted for smaller effects in the current study as compared to those reported previously. As mentioned earlier, it is likely that the between-group design, the sample size, and the small number of words being learned resulted in their simply not being enough power to detect predicted effects of feedback consistency on oral word learning in the presence of orthography, and of orthographic facilitation on recall of pronunciations a day later.

Overall, the current study made deliberate efforts to balance stimuli on several features and characteristics, and adapted a previously employed associated learning paradigm to provide children with an opportunity to learn new words. Children did not

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all succeed in learning all six words by the end of the learning session, however. This discrepancy in the amount learned may be due to the session's length, as the number of repetitions each item received may have depleted children's phonological loop resources. Future studies may thus find it useful to minimize the number of sets employed and increase the number of learning sessions, in order to maximize children's oral vocabulary acquisition during the greatest period of learning growth and prevent depletion of phonological loop resources. Such a paradigm would also provide a more naturalistic examination of children's vocabulary acquisition within an explicit learning context, as generally when a word is introduced in the classroom learning is reinforced with repetition at different intervals over a short span of time following its introduction. Additional considerations of the nature of the feedback consistency manipulation, the length of the training session, varying attention drawn to the presence of spelling, and increasing the delay before posttesting have already been discussed above.

Implications and Conclusions

While teachers may display a word in print on a classroom word list or pocket chart, they often do so following its oral presentation, and will explicitly draw children's attention to the spelling when it is being presented. Some teachers might argue that presenting the spelling for a word being learned orally could "bog down" the learner and distract them from the focus of the task, to learn the pronunciation, in order to validate the practice of presenting it subsequently – or not at all. To the contrary, as seen in previous research, and replicated in the current study, providing words in print does not impede decoders from learning pronunciations. In fact, it facilitated the task of acquiring

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oral vocabulary, even when no attention was drawn to it. In theoretical terms, providing orthography helped children to clarify novel spoken words, and establish phonological representations in memory more quickly than when they were not exposed to words in print. This is very promising, especially when considering the possible benefits spelling might offer to second language learners. Consider, for example, how useful it is when meeting someone from another culture to be able to look at their nametag when they are introducing themselves. It may be difficult to hold onto an unfamiliar combination of sounds in memory, but seeing their name in print might help you to remember it. Even more so, you may find yourself attempting to visualize the nametag to later recall the pronunciation from memory. This reinforces the added value of an orthographic form in memory, as it can provide a means to anchor and access pronunciations from memory.

Indeed, children who were exposed to words in print were also more likely to have acquired word-specific orthography, suggesting that children are able to acquire this additional source of lexical information without additional or explicit instruction, as long as the occasion is provided to them. While children found it difficult to correctly recall the spelling to words with silent consonant endings, they showed evidence of having established a “frame” in memory, and applied their knowledge of orthographic regularities within the language to fill in the memory blanks. Therefore, although more frequently erring, children exposed to words in print that contained a speech-to-spelling inconsistency demonstrated that they were more likely to use existing knowledge gained from incidental exposure to orthography than they were to employ a recoding strategy when spelling words that had been presented in print as well as in spoken form during

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learning. With the challenges of learning how to spell in an opaque language, this would suggest additional benefits to providing words in print when they are being learned orally, as there is evidence that they are acquiring spelling information without explicit teaching. Whether teachers find it intuitive or not, results of the current study support an evidence-based practice that includes the provision of spelling during oral vocabulary teaching.

In sum, the current study has extended previous findings of incidental orthographic facilitation to another opaque language, French, and made an attempt to establish parameters around this effect through a controlled investigation of feedback consistency. The current study controlled several factors that might have potentially influenced outcomes, including balancing reading and gender across conditions, assessing and training decoding skills, constructing cross-group stimuli matched on several characteristics, and controlling for income and home language(s). Having adapted the associative learning paradigm used in previous research, it was possible to compare current results more directly to those used in previous studies (esp. Rosenthal & Ehri, 2008; Ricketts et al., 2009), complimenting existing literature and providing support for the understudied contribution of orthography to oral vocabulary learning. Overall, results support the claim that oral vocabulary acquisition is influenced not only by ear but also by eye, and suggest that providing orthographic forms corresponding to the phonological forms being acquired helps to enrich children's lexical representations by providing them with another source of congruent information that can "anchor" pronunciations in memory.

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Dual-modality word learning

Appendix A

Graph of children's mean performance by item across nine repetition trials during learning as a function of learning condition. Error bars represent standard errors.

Dual-modality word learning

Appendix B

Graph of children's mean performance by item across nine production trials during learning as a function of learning condition. Error bars represent standard errors.

Dual-modality word learning

Appendix C

Graph of children's mean performance by item on posttest expressive vocabulary recall as a function of learning condition. Error bars represent standard errors.

Dual-modality word learning

Appendix D

Array Combinations for Posttesting of Receptive Vocabulary

a.

4	1		3	4
2	6		6	2
2	3		1	2
4	5		5	4
5	6		6	5
1	3		3	1

2	
2	

b.

4	1		3	4
2	6		6	2
2	3		1	2
4	5		5	4
5	6		6	5
1	3		3	1

2	
2	

c.

4	1		3	4
2	6		6	2
2	3		1	2
4	5		5	4
5	6		6	5
1	3		3	1

	2
2	

d.

4	1		3	4
2	6		6	2
2	3		1	2
4	5		5	4
5	6		6	5
1	3		3	1

2	
	2

e.

4	1		3	4
2	6		6	2
2	3		1	2
4	5		5	4
5	6		6	5
1	3		3	1

	2
	2

f.

4	1		3	4
2	6		6	2
2	3		1	2
4	5		5	4
5	6		6	5
1	3		3	1

	2
	2

Note. Targets bolded. Numbers within squares below each array combination indicate the number of times double occurrences occur within that location for that array.

Dual-modality word learning

Appendix E

Graph of children's mean performance by item on posttest receptive vocabulary recall as a function of learning condition. Error bars represent standard errors.

Dual-modality word learning

Appendix F

Graph of children's mean performance by item on posttest spelling accuracy based on target orthography as a function of learning condition. Error bars represent standard errors.

Dual-modality word learning

Appendix G

Graph of children's mean performance by item on posttest spelling accuracy based on legal homophonic spelling as a function of learning condition. Error bars represent standard errors.