



Becoming a written word: Eye movements reveal order of acquisition effects following incidental exposure to new words during silent reading



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ABSTRACT

We know that from mid-childhood onwards most new words are learned implicitly via reading; however, most word learning studies have taught novel items explicitly. We examined incidental word learning during reading by focusing on the well-documented finding that words which are acquired early in life are processed more quickly than those acquired later. Novel words were embedded in meaningful sentences and were presented to adult readers early (day 1) or later (day 2) during a five-day exposure phase. At test adults read the novel words in semantically neutral sentences. Participants' eye movements were monitored throughout exposure and test. Adults also completed a surprise memory test in which they had to match each novel word with its definition. Results showed a decrease in reading times for all novel words over exposure, and significantly longer total reading times at test for early than late novel words. Early-presented novel words were also remembered better in the offline test. Our results show that order of presentation influences processing time early in the course of acquiring a new word, consistent with partial and incremental growth in knowledge occurring as a function of an individual's experience with each word.

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1. Introduction

Once children have grasped the principle that letters code for speech sounds, at least in an alphabetic orthography such as English, they have in place the tools available to build orthographic knowledge via their reading experience. Early in reading development it is likely that children are reading words that they are already familiar with in the oral domain – they are learning to map orthography onto

their existing phonological and semantic knowledge. At the same time however, we know that children learn new words from their reading experience and that from mid-childhood onwards, most new vocabulary is learned via reading (e.g., Anderson & Freebody, 1981; Landauer & Dumais, 1997; Nagy, Anderson, & Herman, 1987; Nagy, Herman, & Anderson, 1985). It follows from this that children must regularly see novel words in print, yet we know relatively little about how children learn new words in this situation, or the parameters that influence learning. In this paper, we examine incidental word learning during reading by focusing on an effect which has been reported across many studies: that words which are acquired early in life are processed more quickly than those acquired later.

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1.1. Orthographic learning in children and adults

The self-teaching hypothesis (Share, 1995) sets out how children acquire orthographic knowledge. A growing literature supports the central tenants of this hypothesis, namely that phonological decoding is the fundamental basis of orthographic learning and that each decoding attempt provides the child with a word-specific encounter, as well as adding to their accumulated knowledge base about how orthography works in their language (see Share, 2008 for a review). Experiments conducted within the self-teaching framework have considered a number of questions including the number of exposures children need to subsequently recognise newly learned words and discriminate them from a phonological or visual foil and the durability of learning over time (e.g., Nation, Angell, & Castles, 2007; Share, 2004), whether learning is influenced by words being presented or tested in context or in isolation (e.g., Landi, Perfetti, Bolger, Dunlap, & Foorman, 2006; Martin-Chang, Levy, & O'Neil, 2007; Nation et al., 2007; Wang, Castles, Nickels, & Nation, 2011), whether knowledge of the meaning of the phonological form of new words prior to orthographic exposure influences ease of learning (Ouellette & Fraser, 2009; Wang et al., 2011) and the extent to which learning is modulated by orthographic consistency (e.g., Wang, Castles, & Nickels, 2012; Wang et al., 2011). Summarizing a complex and sometimes contradictory literature, there is evidence that children learn new orthographic forms relatively easily from minimal incidental exposure, at least when tested using recognition paradigms, and this knowledge is retained over time. For example, Share (2004) found that children learning to read Hebrew showed no decline in learning when re-tested one month after exposure. Nation et al. (2007) reported a different pattern in children learning to read in English: although retention declined when the children were re-tested one week after exposure, significant learning was still evident. Knowledge of the meaning of the to-be-learned words facilitates learning, as does presenting the words in context, but only when the words are irregular in terms of spelling-sound mappings (Wang, Nickels, Nation, & Castles, 2013; Wang et al., 2011).

One issue with the orthographic learning via self-teaching literature concerns how to measure learning. Generally, two types of metric are employed: recognition paradigms that are variants of orthographic choice in which children have to discriminate learned items from foils, and recall paradigms in which they attempt to spell the words. It is not unusual for these two metrics to provide a different estimate of learning, even within the same experiment. Learning is typically better when assessed via recognition paradigms. Arguably however, these are not sensitive as performance tends to be high. Assessing learning via spelling also tends towards lack of sensitivity as performance levels tend to be quite low, presumably because recalling a spelling requires a greater specification of its orthographic form than recognising it does (Wang et al., 2011). In addition, although the learning of orthographic forms in Share's earlier experiments was a consequence of incidental exposure, in line with the notion of self-teaching, efforts to induce meaning to the target

words has resulted in paradigms that contain a hefty dose of explicit teaching. For example, Wang et al. (2011) pre-exposed children to the meaning of the phonological forms of words by showing them pictures that illustrated each word's referent and function. Children were explicitly instructed to learn the meanings and this was tested multiple times, before the orthography of the new words was presented. This is quite different to children's naturalistic reading experiences in two ways. First, children are rarely taught and tested on new vocabulary in this explicit and direct way and second, knowledge of vocabulary does not always pre-date orthographic exposure: many new words are initially encountered in text, at least by mid-childhood. It is also worth noting that only a small number of words can be trained in this explicit way as children find this type of learning difficult (e.g., Ricketts, Bishop, Pimperton, & Nation, 2011).

Parallel to these studies, experiments with adults have explored the acquisition of new orthographic forms from a different theoretical perspective. Bowers, Davis, and Hanley (2005) exposed adults to new forms (e.g., *banara*) via a repeated typing exercise and then examined the effect this had on the processing of existing words (e.g., *banana*). Introducing a new neighbour resulted in slower semantic classification times for the existing base word, consistent with the new word inducing lexical competition. Qiao, Forster, and Witzel (2009) questioned whether Bowers et al. provided convincing evidence of lexicalisation, arguing that their data could be explained via an episodic learning account. Subsequent studies have shown that if learners are exposed to new orthographic forms in the context of quite extensive and explicit semantic training, lexicalisation does occur, as evidenced by the emergence of a prime lexicality effect (Qiao & Forster, 2012) and reliable semantic priming under masked conditions (Tamminen & Gaskell, 2013).

It is important to note the repetitive and explicit nature of the training regimes employed in these studies with adults, with many exposures to the new orthographic forms and multiple sessions needed to induce meaning to the new forms using tasks such as word-picture matching, picture-word matching and word-definition matching. These studies with adults demonstrate the interactive and dynamic nature of lexical learning, but they fail to touch base with the developmental literature, though studies have begun to explore these issues for *spoken* words, e.g., Henderson, Weighall, Brown, & Gareth Gaskell, 2012, 2013). A small number of studies have examined *written* word learning in adults from a developmental perspective, attempting to mimic the learning conditions facing a child. These though have focused on the influence of orthographic consistency and regularity on reading single words aloud, and have used intensive training regimes with explicit instruction and feedback (e.g., McKay, Davis, Savage, & Castles, 2008; Taylor, Plunkett, & Nation, 2011).

1.2. Age-of-acquisition and lexical processing

It is well established that the age at which new words are acquired during childhood influences how quickly they

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