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**Learning about Language and Literacy**

Sandra R. Waxman

Northwestern University

Usha Goswami

University of Cambridge

Language acquisition is critical not only in infancy, but also for later school achievement. Early word-learning represents infants' entrance into a truly symbolic system and brings with it a means to establish reference. Language thereby aids conceptual development, the development of a theory of mind, memory development, the development of reasoning, and also underpins the development of executive function – the child's ability to organize and manage their own behaviour. For example, good language skills improve memory because children are able to construct extended, temporally-organised representations of experienced events that are narratively coherent. There is considerable variability in the language experiences and the vocabulary sizes of young children when they enter school. Hart and Risley (1995) estimated that children from high SES families in the USA had been exposed to around 44 million utterances by the age of 4 years, compared to 12 million utterances for lower SES children (see also, Huttenlocher, Vasilyeva, Cymerman, & Levine, 2002). This enormous difference in language exposure seems likely to affect language learning. Notably, interventions based on language in the preschool years, for example shared reading, are among the most effective for improving educational outcomes. Providing young children with richer and more complex linguistic experiences (and avoiding "empty language" such as "Don't do that", "bring it here") have well-documented positive effects on how well children flourish in school (Landry, 2005).

Because a primary function of language is of course communication, infants need to learn what words *mean*. To succeed, infants must identify not only the relevant linguistic units and conceptual units, but must establish a mapping between them. But how do infants accomplish this task? And how do they

learn that for any given scene (e.g., a cardinal flying behind a stone fence), we can use not only different words (e.g., bird, cardinal) but also different *kinds* of words (e.g., nouns, adjectives, verbs) to focus in on different aspects of the scene (e.g., “bird”, “red”, “darting”, respectively). Waxman has proposed that infants cross the threshold into word-learning equipped with a broad initial expectation linking words (in general) to commonalities (in general), and that this initial expectation becomes increasingly fine-tuned on the basis of infants’ experience with the objects and events they encounter and the native language they hear. In this chapter, we illustrate this cross-linguistic developmental proposal with evidence from infants and young children acquiring English in word learning tasks. In addition to establishing mappings between conceptual and linguistic units, infants and young children must also be able to identify the unique auditory correlates of words and phrases, and also become able to produce these auditory patterns themselves. The infant brain must learn the sound structure of spoken words, and the articulatory structures in the brain must learn how to reproduce these sound structures exactly. The development of an awareness of sound structure, or phonology, is also critical for learning to read, a key educational achievement. Goswami has developed a cross-language theory of phonological development and reading acquisition, which we also illustrate in this chapter.

### **Learning What Words Mean**

Even before they begin to speak, infants establish a repertoire of words and concepts. Consider first, infants’ conceptual capacities. In the first year of life, they begin to form categories that capture important relations among the objects and events that they encounter. Moreover, the evidence suggests that they use these early concepts as an inductive base to support inferences about new objects and events. During these first few months, they also relate categories to one another, implicitly, on the basis of taxonomic relations (e.g., birds are a kind of animal), thematic relations (e.g., birds live in nests), and a host of other relations (e.g., birds sing, lay eggs, eat worms). These early object and event categories provide strong starting points in infancy for the more elaborated concepts and theories that

emerge later in development. In other words, there is conceptual continuity from infancy through adulthood.

Consider next, infants' burgeoning language capacities. Infants typically produce their first words by their first birthdays. These tend to be words that refer to salient individuals (e.g., "Mama"), categories of objects (e.g., "cup", "birdie"), social routines (e.g., "night-night"), and actions (e.g., "up"). Across languages, infants tend to show a "noun advantage", with nouns referring to basic-level object categories (e.g., cup, bird) being the predominant form (Bornstein, Cote, Maital, Painter, Park, & Pascual, 2004 provide an excellent cross-linguistic review). By their second birthdays, infants typically have command of hundreds of words, and different *kinds* of words (e.g., nouns, verbs, adjectives) and have begun to combine them to form phrases that are short, but reveal an appreciation of the grammatical properties of their native language.

### ***The puzzle of word-learning***

To learn the meaning of a word, infants are faced with a difficult three-part puzzle: they must (1) parse the relevant word from the ongoing stream of speech, (2) identify the relevant entity or relation in the ongoing stream of activity in the world, and (3) establish word-to-world mapping. Put differently, successful word-learning rests on an ability to discover the relevant linguistic units, the relevant conceptual units, and the mappings between them.

Solving each piece of this puzzle depends upon infants' ability to recruit other perceptual and psychological capacities. For example, consider what it takes for an infant to parse a word from fluent speech. We know that newborns prefer human speech—and particularly infant-directed speech — over other sources of auditory stimulation. We also know that the function of infant-directed speech changes with development (Fernald, 1992b). Within the first six months, infant-directed speech serves primarily to engage and modulate the infant's attention. But in the latter six months, particular "...words begin to emerge from the melody" (Fernald, 1992a p. 403) as infants become increasingly

sensitive to the cues (morphologic, phonetic and prosodic cues) that mark word and phrase boundaries in their language (Jusczyk & Aslin, 1995; Kemler Nelson et al., 1989).

Infants use their sensitivity to these perceptual cues to distinguish two very broad classes of words: *open class* words (or, *content* words, including nouns, adjectives, verbs) and *closed class* words (or, *function* words, including determiners and prepositions). Infants as young as six months of age prefer listening to open class words (Gomez, 2002; Shi & Werker, 2003), probably because they are perceptually more salient than closed class words. This perceptually-based preference represents an important step on the way to establishing meaning, for it insures that infants will pay particular attention to just those words (the open class, content words) that will serve to anchor their first word-to-world mappings. (Jusczyk & Kemler Nelson, 1996; Morgan & Demuth, 1996; Werker et al., 1996).

Early word-learning also calls upon the infants' ability to identify objects and events in their environment, and notice commonalities among them. Even in the first six months of life, infants have a great deal of core knowledge about abstract relations, including notions of animacy, intentionality and physical causation (Baillargeon, 2000; Spelke, 2000). They also form a repertoire of pre-linguistic concepts, including category-based (e.g., cup, bird) and property-based (e.g., red, soft) commonalities. Since they appreciate so many of these concepts before the advent of word-learning, it is reasonable to assume that they are independent of language and are universally available. Each concept that the infant is capable of representing is, in essence, a candidate for word-meaning. What infants must do, then, is to home in on which candidate meaning maps to the word that they have parsed.

If infants are to solve the third piece of the word-learning puzzle—grasping the symbolic and referential power of words—they must draw upon fundamental notions related to human behavior: inferring the goals and intentions of others (Waxman & Gelman, 2009). For example, the ability to map a word to its referent is predicated upon an ability to infer that the speaker *intended to name* the designated object (Fennell & Waxman, 2009; Jaswal, 2004). By their first birthdays, infants have begun to make such connections (Baldwin & Baird, 1999; Guajardo & Woodward, 2000).

In addition to solving these three pieces of the puzzle, successful word-learning requires infants to go beyond a simple word-to-object mapping. To use a word consistently over time, infants must be able to generalize a newly-learned word appropriately beyond the individual(s) on which it was introduced. For example, to apply the word *bird* to a new, and (as yet) unlabeled object, that child must make an inference regarding its extension; they must go beyond word-to-object mappings to establish word-to-concept mappings (Gelman, 2006; Waxman & Leddon, 2009; Waxman & Lidz, 2006).

***Different kinds of words highlight different aspects of a scene***

To make matters more complicated, many different *types* of words can be appropriately offered in a single naming episode, with each type of word highlighting a different aspect of the very same scene and each supporting a unique pattern of extension. For example, across languages, nouns (count nouns, if there is a mass-count distinction in the language) (“Look, it’s a *bird*”) typically refer to the named object itself and are extended spontaneously to other members of the same object kind (other birds); proper nouns (“Look, it’s *Clara*”) also refer to the named individual, but these are not extended further. Adjectives can also be applied correctly to that individual (“Look, it’s *red*”); they refer to a property of the individual, and are extended to other objects sharing that property, whether or not they are birds. Verbs, in contrast, are used to describe the event, or the relation in which the individual(s) are participating (“Look, it’s *pecking*, or *flying*”), and are extended to other relations of the same type.

For over a decade, we have known that by two-and-a-half years of age, children are sensitive to many of these links between kinds of words and kinds of relations among objects, and recruit them in the process of word learning. For a review, see Waxman & Lidz (2006). Thus, they have the *linguistic* capacity to distinguish among the relevant syntactic forms (e.g., count noun vs. adjective) and the *conceptual* or *perceptual* ability to appreciate many different kinds of relations, and a tacit expectation that these linguistic and conceptual abilities are linked.

But how do these links emerge? Which, if any, are available as infants begin the process of word-learning, and how are these shaped over the course of development? As we have pointed out,

even before they reach their first birthdays or produce their first words, infants have a perceptual preference for listening to open class words and a rich repertoire of concepts and perceptual categories. But in addition, they harbor a broad tacit expectation that novel (open class) words, independent of their grammatical form, highlight commonalities among named objects. This broad initial link serves (at least) three essential functions. First, words direct attention to commonalities, and in this way facilitate the formation of an expanding repertoire of concepts, including those that infants may not have detected as readily in the absence of a novel word. Second, this initial expectation (that words refer to commonalities) supports the establishment of a rudimentary lexicon. Third, and perhaps most radically, this broad initial expectation sets the stage for the discovery of more specific expectations linking *particular* types of words (nouns, adjectives, verbs) to *particular* types of meaning (object categories, object properties, event categories) in the particular language being acquired by the infant. In other words, infants' initial expectation (linking words in general) to commonalities (in general) will direct their attention to just the sorts of information in the input that will promote the rapid discovery of the distinct grammatical forms present in the language under acquisition, and will support the induction of more specific expectations.

### ***Naming and categorization***

In a classic series of experiments, Waxman and her colleagues examined the influence of novel words in infants ranging from 12 months of age (see Waxman & Markow, 1995 for a complete description). We used a novelty-preference task (See Figure 1 for a sample set of stimuli and introductory phrases). During a familiarization phase, an experimenter offered an infant four different toys from a given category (e.g., four animals) one at a time, in random order. This was immediately followed by a test phase, in which the experimenter simultaneously presented both a) a new member of the now-familiar category (e.g., another animal) and b) an object from a novel category (e.g., a fruit). To identify the influence of novel words, infants were randomly assigned to different conditions, each varying in the experimenter's comments during familiarization. See Figure 1. Each infant completed

this task with four different sets of objects. Infants manipulated the toys freely. Their manipulation served as the dependent measure.

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Insert Figure 1 here

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We reasoned as follows: If infants detect the novel word, and if novel words direct infants' attention to commonalities among objects, then infants who hear novel words during familiarization should be more likely than those in the No Word condition to form object categories. Including both a Novel Noun and Novel Adjective condition permitted us to test the specificity of infants' initial expectation. If the expectation is initially general, as we have proposed, then infants hearing either novel nouns or adjectives should be more likely than those hearing no novel words to form object categories.

The data were consistent with this prediction. The results revealed that infants on the threshold of producing language can reliably detect novel words presented in fluent speech, and that these novel words (both adjectives and nouns) direct infants' attention to commonalities among objects. We have interpreted this finding as evidence that words serve as "invitations to form categories". This invitation has several consequences. First, novel words invite infants to consider together objects that might otherwise be perceived as distinct; words promote comparison among objects, and that this process of comparison supports the discovery of other commonalities that might otherwise have gone unnoticed (Booth, 2006; Chambers, Graham, & Turner, 2008; Gelman, 2006; Gentner & Namy, 1999; Keates & Graham, 2008; Welder & Graham, 2006). We also suggest that naming has dramatic consequences in situations in which infants have already formed groupings and noticed (some of) the commonalities among objects. For although infants in this series successfully formed object categories, their knowledge about these categories is not on a par with that of an older child or adult (Gelman, 1996; Keil, 1994). We suspect that novel words are instrumental in motivating infants and young children to

discover the deeper commonalities that underlie our richly-structured object categories (Ahn & Luhmann, 2004; Barsalou, Santos, Simmons, & Wilson, 2008; Gelman, 1996; Gelman, Coley, & Gottfried, 1994; Gelman & Kalish, 2006; Kalish & Gelman, 1992; Keil, 1994; Landau, 1994; Landau, Smith, & Jones, 1988; Lassaline & Murphy, 1996; Macnamara, 1994; Markman, 1989; Medin & Heit, 1999; Murphy 2004). Most importantly, the results of this series of experiments document that a link between word-learning and conceptual organization is in place early enough to guide infants in their very first efforts to establish word-to-world mappings.

*But when do infants tease apart different kinds of words and map them to different kinds of meaning?* Another closely-related experimental series reveals the emergence of more précised and more nuanced effects. By 14 months of age, there is evidence that different *kinds* of words highlight different *kinds* of commonalities. When infants were familiarized to objects sharing *both* category- and property-based commonalities (e.g., four purple animals), the relation that they focused on (either the category (animal) or the property (purple)) at test depended upon the grammatical form of the word used to describe them (See Figure 2).

Figure 2 about here

At 11 months, their link was broad: they mapped both nouns and adjectives to both category- and property-based relations (Waxman & Booth, 2003). But by 14 months, their expectations were more nuanced: infants mapped count nouns specifically to category-based (not property-based) commonalities (Waxman & Booth, 2001). Later, at roughly 18- to 21-months, they have discovered that adjectives map specifically to property-based (not category-based) commonalities (Booth & Waxman, 2009; Waxman & Markow, 1998).

Finally, another recent series of experiments illustrated infants' acquisition of verbs. For most infants, and across most languages, verbs do not appear in appreciable number in infants' lexicons until roughly 20- to 24-months of age, several months after the appearance of nouns. For recent reviews, see Gleitman, Cassidy, Nappa, Papafragou and Trueswell (2005); Waxman and Lidz, (2006).

What accounts for this developmental phenomenon, favoring the acquisition of nouns over verbs? The conceptual underpinnings of verb meaning appear to be in place, at least in rudimentary ways, by the time infants reach their first birthdays. By 8 – 12 months, infants are sensitive to fundamental components of events, including notions of animacy, agency, and cause (Buresh, Wilson-Brune & Woodward, 2006; Casasola & Cohen, 2000; Gergely & Csibra, 2003; Gergely, Nádasdy, Csibra, & Bíró, 1995; Gertner, Fisher, & Eisengart, 2006; Golinkoff & Hirsch-Pasek, 2006; Leslie & Keeble, 1987; Meltzoff, 2007; Muentener & Carey, 2006; Sommerville, Woodward, & Needham 2005; Wagner & Carey, 2005). Between 12 and 24 months, infants demonstrate sensitivity to other key elements of events, including changes of state, result, manner and path of motion (Bunger, 2007; Bunger & Lidz, 2004; Pruden, Hirsh-Pasek, Maguire, & Meyer, 2004; Pulverman, Hirsh-Pasek, Pruden, & Golinkoff, 2006).

Findings like this make it clear that infants' relative delay in acquiring verbs cannot be attributed to an inability on their part to represent the kinds of concepts that underlie verb meaning. What, then, might be holding them back?

Recent evidence suggests that this relative delay reflects a fundamental feature of verbs: the meaning of a verb depends upon the linguistic arguments that it takes (and the relation among them). That is, to identify the event labeled by a verb, learners depend upon the noun phrases that represent the event participants and the linguistic relations among these phrases (Arunachalam & Waxman, 2009; Fisher, Hall, Rakowitz, & Gleitman, 1994; Gillette, Gleitman, Gleitman & Lederer, 1999; Gleitman, et al., 2005; Landau & Gleitman, 1985; Lidz, Gleitman & Gleitman, 2003; Piccin & Waxman, 2007; Waxman & Leddon, 2009; Waxman & Lidz, 2006). If this is the case, then infants must first acquire at least some nouns before they can establish the meaning of verbs.

This fits well with the evidence that nouns predominate in infants' earliest lexicons, and that verbs do not figure largely until roughly 24 months (Fenson, Bates, Dale, Goodman, Reznick, & Thal, 2000). At this point, infants not only begin to produce an appreciable number of verbs, but also take

into account syntactic information, including the number and types of frames in which novel verbs appear and the relations among the noun phrases in these frames, to establish a novel verb's meaning (Akhtar & Tomasello, 1996; Bungler & Lidz, 2004; Fernandes, Marcus, DiNubila, & Vouloumanos, 2006; Fisher, 2002; Gertner, Fisher, & Eisengart, 2006; Gleitman, 1990; Gleitman et al., 2005; Hirsch-Pasek, Golinkoff, & Naigles, 1996; Landau & Gleitman, 1985; Naigles, 1990, 1996; Naigles & Kako, 1993). At the same time, however, infants' efforts at verb-learning in the laboratory also reveal some striking failures, many of which persist beyond infancy into the preschool years (Imai, Haryu, & Okada, 2005; Imai, et al., 2008; see also Behrend, 1989; Kersten & Smith, 2002; Meyer et al., 2003).

In a recent series of experiments, Waxman and colleagues address several empirical and theoretical concerns that have surfaced within the verb-learning literature (Waxman, Lidz, Braun & Lavin, in press). Their results help to reconcile what, until now, has been a large and largely unexplained gap between 24-month-old infants' well-documented ability to acquire verbs in the natural course of their lives and their rather surprising failures in many laboratory-based tasks. They presented 24-month-old infants with dynamic scenes (e.g., a man waving a balloon), and asked a) whether infants could construe these scenes flexibly, noticing the consistent action (e.g., waving) as well as the consistent object (e.g., the balloon) and b) whether their construals were influenced by the grammatical form of a novel word used to describe them (verb or noun). See Figure 3. Their results reveal that 24-month-olds' representations of novel words are sufficiently precise to permit them to map novel verbs to event categories (e.g., waving events) and novel nouns to object categories (e.g., balloons). This outcome, and others like it, beckon us to move beyond asking whether or not infants can represent verb meanings, and to consider instead the conditions that support successful verb learning in infants and young children.

Figure 3 about here

These nuanced effects reveal that by 14 months, infants are sensitive to distinct kinds of words, and recruit these distinctions precisely in establishing meaning. To establish meaning, infants attend

not only to the novel word itself: they depend crucially upon its surrounding linguistic elements (e.g., determiners; arguments). Even in infancy, then, words support conceptual flexibility.

*Prelinguistic infants: Effects of naming.* In the previous section, we traced the evolution of infants' expectations regarding word-to-world mappings as they crossed the important developmental threshold of producing words on their own, and later combining them. But do words have any cognitive consequences on infants who have not yet begun to speak? Surprisingly, the answer seems to be "yes". For example, 10-month-old infants look longer at objects that have been named than to objects presented in silence (Baldwin & Markman, 1989). But does this increased attention stem from a general attention-engaging functions of auditory stimuli, or does it reflect something special about words? And does naming focus infants' attention to a named individual only, or does it support categorization, as we have described in infants at 11 months and older?

To address these questions, researchers have compared the effect of novel words to tone sequences on infants' categorization behavior, and have discovered that words are indeed special (Balaban & Waxman, 1997; Fulkerson & Haaf, 2003, 2006; Fulkerson & Waxman, 2007). For example, Fulkerson and Waxman (2007) assessed 6-month-old infants' categorization when presented with words versus tones in a novelty-preference task. During the familiarization phase, infants saw a sequence of colorful slides, each depicting a different member of a category (e.g., dinosaurs). To examine the influence of words, infants were randomly assigned to either a Word or a Tone condition. For infants in the Word condition, a naming phrase (e.g., "Oh look, it's a *toma*! Do you see the *toma*?") accompanied the familiarization trials. For infants in the Tone condition, a sine-wave tone (matched to the naming phrase in amplitude, duration, and pause length) accompanied the familiarization trials. Infants then viewed a test trial, including a) a new member of the now-familiar category (e.g., another dinosaur) and b) an object from a novel category (e.g., a fish). Test trials were presented in silence.

If words focus attention on commonalities among objects, then infants in the Word condition should notice the commonalities among the familiarization objects. In that case, the infants should reveal a preference for the novel test object (e.g., the fish). If this effect is specific to words, and not to auditory stimulation more generally, then infants in the Tone condition should be less likely to notice these commonalities and less likely to reveal a novelty preference at test. The results supported this prediction entirely. Thus, for infants as young as 6 months of age, there is indeed something special about words. Providing a shared name for distinct individuals highlights commonalities among them. This facilitative effect of words on categorization behavior is evident as early as 3- to 4-months (Ferry, Hespos & Waxman, 2009).

Naming also supports infants' abilities to trace the identity of distinct objects over time (Waxman & Braun 2005; Xu & Carey, 1996). For example, 10-month-olds can find it taxing to keep track of the unique identities of two distinct objects (e.g., a ball and a duck), especially if these objects are presented in constant motion, with one appearing and disappearing from one side of an opaque screen, and the other appearing and disappearing from the other side (Xu & Carey, 1996). However, infants' difficulty tracking the identity of these distinct objects diminishes dramatically if each is labeled with a distinct name as it emerges from behind the screen.

Together, these results reveal that even before the advent of productive language, naming has powerful cognitive consequences. Naming supports the establishment of a repertoire of object categories and provides infants with a means of tracing the identity of individuals within these categories throughout development (Waxman & Braun, 2005).

### ***Summary***

The evidence from early word-learning provides considerable support for the proposal advanced by Waxman and her colleagues. Even before infants begin to speak, they are sensitive to a broad initial link between words (independent of their grammatical form) and a wide range of commonalities among named objects and events. By roughly 14 months, this general expectation had

become more fine-tuned. They not only distinguish nouns from adjectives, but also treat this distinction as relevant to establishing the meaning of novel words, mapping nouns specifically to category-based (and not property-based) commonalities. Yet discovering the specific links between adjectives and properties of objects emerges later, toward the end of the second year of life. At this point, infants also successfully link verbs to event categories. In essence, then, there is a developmental cascade. At the same time, there is substantial developmental continuity. From infancy, words are powerful engines, promoting conceptual development, advancing us beyond our initial groupings, and fueling the acquisition of the rich relations that characterize our most powerful concepts. The increasingly precise links between kinds of words and kinds of concepts are supported by a broad initial expectation and fine-tuned by the infants' interactions with objects, events and the structure of their native language.

### **Learning How Words Sound**

We noted earlier that open class words, the nouns and verbs that are fundamental to acquiring word meanings, receive greater stress and more interesting melodic contours. We saw also that newborns prefer to listen to human speech, particularly infant-directed speech, rather than to other sources of auditory stimulation. The rhythmical and melodic contours of infant-directed speech appear to have a specific language-learning function, for example in word boundary segmentation (e.g., Echols, 1996). Infant-directed speech emphasizes prosodic cues: pitch is typically heightened, duration is increased and rhythm and intonation are exaggerated. These features are found across the world's languages (Fernald et al., 1989), and the use of infant-directed speech is universal. So the acoustic features that are important for phonological acquisition seem to be similar across languages.

Learning how words sound depends on incremental learning. Child phonologists propose that infants learn language-specific 'phonotactic templates' (Vihman & Croft, 2007). A phonotactic template is basically a phonological pattern. Each template contains variations in sound intensity, pitch, duration and rhythm which together constitute a unit, usually of meaning. For spoken English, a

common template is a bi-syllabic pattern with stronger first syllable stress (a strong – weak stress template). In the English template, the ‘strong’ first syllable is typically louder, longer and higher in pitch than the second syllable. Early-acquired words that follow this pattern are “Mummy”, “Daddy”, and “baby”. This rhythmic pattern is so strong in English that carers frequently change the words that they use with babies and young children to fit the pattern (“milkie”, “doggie”). Developmental phonologists like Vihman and Croft (2007) have shown that babies’ own babbling also conforms to these rhythmic patterns. Babies do not babble single-syllable words. So both auditory perception and spoken language production appear to converge onto these rhythmic templates.

These first acquisitions have been termed ‘prosodic structures’ by the linguist Pierrehumbert (2003). Of course, typical prosodic structures or phonotactic templates vary across languages. In French, the dominant prosodic pattern depends on lengthening the final syllable, whereas Hungarian utilizes first-syllable stress. Prosody is a term used in linguistic theory to cover all aspects of grouping, rhythm and prominence, from sub-parts of the syllable up through the organisation of words in the phrase (Lehiste, 1977; Pierrehumbert, 2003). Prosody and speech rhythm are intimately linked, and languages conform to different rhythm ‘types’. English is a stress-timed language. It has a rhythm determined by the stressing of syllables that occur at roughly equal intervals in speech. French and Hungarian are syllable-timed languages. They have rhythms determined by stressing particular syllables in particular words. The phonotactic templates that organize a pre-literate child’s phonological development will therefore differ across languages. This will naturally have implications for learning to be literate.

### ***Cross-language similarities***

Despite these differences in prosodic organisation, there is widespread agreement among linguists that the syllable is the primary perceptual phonological unit across languages. Young children can be asked to reflect upon their knowledge of spoken language by asking them to perform ‘phonological awareness’ tasks. Phonological awareness tasks are performed most easily at the syllable

level. For example, young children can be asked to tap once with a wooden dowel for each syllable in a word (e.g., butterfly = 3 taps), to put out a counter for each syllable in a word (e.g., president = 3 counters), or to make ‘same-different’ judgments about words (e.g., whether “repeat” and “compete” share a syllable). High levels of performance are found across languages in tasks measuring children’s awareness of syllabic structure, from age 3 – 4 years (e.g., Liberman, Shankweiler, Fischer & Carter, 1974; Treiman & Zukowski, 1991, Cossu, Shankweiler, Liberman, Katz & Tola, 1988). When Treiman and Zukowski used a same-different judgment task to measure syllable awareness, 100% of 5-year-olds, 90% of 6-year-olds, and 100% of 7-year-olds made accurate same-different judgments about syllables. Similar performance levels have been reported for Turkish kindergartners (Durgunoglu & Oney, 1999), who tapped out 94% of syllable structures correctly, Norwegian kindergartners, who counted out 83% of syllable structures correctly (Hoiem, Lundberg, Stanovich & Bjaalid, 1995), and German kindergarten children, who performed at 81% correct in a syllable counting task (Wimmer, Landerl, Linortner & Hummer, 1991). Clearly, when pre-reading children are asked to reflect upon the phonological structure of spoken language at the syllable level, they can perform extremely well, across languages.

### *Cross-language differences*

Despite the ubiquity of the syllable as a perceptual linguistic unit across languages, structural elements of the syllable will vary across languages. Different factors that vary systematically across languages include the number of sound elements within syllables (syllable complexity – a consonant-vowel or CV syllable is ‘simple’, a CCVCC syllable is ‘complex’), the types of sound elements within syllables (‘sonority profile’), and phonological ‘neighborhood density’ (the number of similar-sounding syllables to a particular target syllable in a given language). All of these factors affect the development of well-specified phonological representations of words and the development of phonological awareness skills by young children.

*Syllable complexity.* A simple syllable is a CV syllable, comprising a consonant sound and a vowel sound. Strikingly, most world languages have syllables with a simple CV structure. Logically, it should be easier to become ‘phonologically aware’ of the individual sound elements in syllables that have this simple CV structure. Developing an awareness of these individual sound elements is an integral part of learning to read. However, despite its prominence as a written world language, English has primarily complex syllables. The primary syllabic structure in English is CVC. For single syllable words (of which English has more than most languages), this structure accounts for 43% of monosyllables (e.g., “cat”, “dog”, “soap”, “look”; see De Cara & Goswami, 2002). English also has many CCVC syllables (15% of monosyllables, e.g., “trip”, “plan” and “spin”), CVCC syllables (21% of monosyllables, e.g., “fast”, “pant” and “jump”), and some CCVCC syllables (6%, e.g., “crust”). Only 5% of monosyllabic words follow the CV pattern (“sea”, “go”, “do”). Because children find it perceptually challenging to segment a complex syllable like “pant” into four distinct elements, they often omit sounds like the penultimate consonant phoneme when they learn to spell (e.g., writing PAT for “pant”, or JUP for “jump”, Treiman, 1998). The dominant phonological CVC template in English does not necessarily correspond to a CVC spelling pattern, however – “coat”, “book”, and all ‘magic E’ words like “make” and “time” follow a CVC phonological pattern. However, if a child spells these words using a CVC orthographic pattern (for example, MAK, TIM) – this spelling is orthographically incorrect. In fact, children’s ‘invented spellings’ are a rich source for understanding their phonological insights (see Read, 1986; Treiman, 1993; for systematic analyses).

*Sonority profile.* There is also variation across languages in the types of sound elements that comprise syllables. This variation is described by the linguistic term ‘sonority profile’. Vowels are the most sonorant sounds that the vocal tract can make, followed in decreasing order by glides (e.g., /w/), liquids (e.g., /l/), nasals (e.g., /n/), and obstruents or plosive sounds (e.g., /p/, /d/, /t/). Linguists have investigated whether there is an optimal sonority profile, that is a profile that is frequently represented across languages because it is easy to produce (e.g. Clements, 1990). Theoretically, more sonorant

sounds should be nearer to the vowel (we say “tra” but not “rta”). The majority of syllables in English end with plosive or non-sonorant sounds (like “dog” and “cat” – around 40%). In contrast, the majority of syllables in French either end in liquids or have no coda at all (almost 50%). To date, the effects of sonority profile have not been investigated systematically across languages with respect to the development of phonological awareness. Nevertheless, it seems likely that sonority profile will affect children’s ability to segment syllables into smaller elements of sound. This may be particularly important with respect to the development of spelling (De Cara, Goswami & Fayol, 2001).

*Phonological neighbourhood density.* Phonological neighbourhood density is an interesting structural factor for an incremental learning approach to child phonology. It was originally proposed by psycholinguists (e.g., Landauer & Streeter, 1973; Luce & Pisoni, 1998) as a metric for describing similarities and differences between words in terms of shared single sound elements or phonemes (a ‘phoneme’ corresponds to the sounds made by single letters or letter clusters, like the sound /f/ which corresponds to F and PH). However, phonological neighbourhood density analyses for spoken English, turned out to highlight the perceptual salience of phonological similarity at the level of rhyme rather than the phoneme (De Cara & Goswami, 2002). In these phonological neighbourhood density analyses, phonological ‘neighbours’ are defined as words that sound similar to each other. The classical linguistic definition of a phonological neighbourhood is the set of words generated by the addition, deletion or substitution of one *phoneme* to the target (e.g., Landauer & Streeter, 1973; Luce & Pisoni, 1998). For example, the neighbours of the target *tin* would include *tint*, *in*, *tip* and *tan*. When many words resemble the target, the neighbourhood is said to be dense. When few words resemble the target, the neighbourhood is said to be sparse. Developmental psycholinguists have also argued that a phonological neighbourhood density metric based on the phoneme was unsatisfactory. For example, Dollaghan (1994) reported that the one-phoneme-different criterion led to many intuitively dissatisfying exclusions when she was calculating childrens’ phonological neighbourhoods. In

particular, the one-phoneme different criterion excluded many rhyme neighbours, such as *clock* and *sock* (you cannot create *clock* by adding or substituting a single phoneme of *sock*).

De Cara and Goswami (2002) provided empirical data that supported Dollaghan's view. They carried out statistical neighbourhood analyses for all monosyllabic English words in the CELEX corpus (4086 words; Baayen, Piepenbrock, & van Rijn, 1993), as well as for a number of smaller English lexica controlled for age of acquisition. These statistical analyses demonstrated that most phonological neighbours in English are rhyme neighbours (e.g., *clock/sock*). This means that the phonology of English is rhyme-based, at least at the monosyllabic level. A good example of a dense phonological neighbourhood in English is words that rhyme with *fair*. A good example of a sparse phonological neighbourhood in English is words that rhyme with *moth*. In later work (Ziegler & Goswami, 2005), we carried out similar statistical analyses for German, French, and Dutch. The German and Dutch analyses were based on the monosyllabic words in the CELEX database (Baayen et al., 1993), and the French analyses were based on the monosyllabic words in BRULEX (Content, Mousty & Radeau, 1990). The analyses showed that rime neighbours predominate in French, Dutch, and German phonology as well. In all of these languages, the percentage of rime neighbours in the monosyllabic lexicon is between 40 – 50%. The phonological neighbourhood density structure of different European languages may explain why rhyme awareness is also an early-emerging skill. As well as having developed good syllable awareness by 3 – 4 years of age, young children have also developed a good awareness of rhyme, across languages.

### ***Changes in phonological representation as literacy is learned***

Once reading skills are acquired, however, the way in which the brain represents phonology changes. As Port (2007) commented, once we are literate “speech [seems to present] itself to our consciousness in the form of letter-like symbolic units”. The ease or difficulty with which the spelling system of a language supports the development of these ‘letter-like symbolic units’ (classically, these units are called *phonemes*) will play a role in literacy acquisition in different languages, and in the

transfer of literacy skills between languages. This factor is called *orthographic consistency* or *orthographic transparency*.

We have provided detailed analyses elsewhere to demonstrate that the orthographic consistency of different European languages has dramatic effects on how rapidly children learning those languages develop an awareness of phonemes (Ziegler & Goswami, 2005). We have also shown how differences in orthographic consistency are related systematically to how rapidly children learning different languages become efficient at single word reading (Ziegler & Goswami, 2005, 2006). Our analyses demonstrate that children acquiring reading in languages with high orthographic consistency, that is mainly one-to-one mappings between letters and sounds, learn about phonemes more rapidly. In languages like Finnish, Greek, German, Spanish, and Italian, a letter corresponds consistently to one phoneme, and children acquire phoneme awareness rapidly. In languages like English, French, Portuguese and Danish, there is a one-to-many mapping between letters and phonemes, and children acquire phoneme awareness more slowly (see Ziegler & Goswami, 2005, 2006, for more detailed evidence). English has a particularly high level of orthographic inconsistency. Many letters or letter clusters can be pronounced in more than one way. Examples include O in “go” and “do”, EA in “bead” and “bread”, and G in “magic” and “bag” (see Berndt, Reggia, & Mitchum, 1987; Ziegler, Stone, & Jacobs, 1997). Hence children who are learning to read in English show particularly slow acquisition of phoneme awareness.

Table 1 about here

A table based on studies using the phoneme counting task, which shows cross-language variation in the development of phoneme awareness, is provided as Table 1. Very similar differences between languages are found if children are asked to read aloud simple words and nonwords (that is, if grapheme-phoneme recoding to sound is the dependent variable). For example, Seymour, Aro and Erskine (2003) reported large differences in reading achievement during the first year of literacy instruction in 14 European Community languages. This was demonstrated using simple measures of

word and nonword reading (and importantly, the word and nonword items used in the study were matched for difficulty across languages). As an example, whereas Finnish children were reading 98% of simple words accurately, English children (in Scotland) were reading only 34% of matched items correctly. Whereas Italian children were reading 95% of items correctly, French children were reading 79% of items correctly. These data are also included in Table 1.

Table 1 about here

According to the theoretical analysis provided here, these cross-language differences in the development of phoneme awareness and simple reading skills are a product of *both* phonological factors and orthographic factors. Children learning to read in languages like Finnish, Italian and Spanish are not only learning orthographically consistent languages, they speak languages with predominantly CV syllables. This simplifies the segmentation problem considerably. However, children who are learning to read in languages like English are not only having to acquire an orthographically-inconsistent language, they also have a spoken language with predominantly complex syllables. The effects of both phonological and orthographic complexity on learning to be literate are considerable. As shown by the cross-language comparisons in Table 1, it takes children longer to learn about phonemes and to become efficient in simple reading skills for languages like English and French compared to languages like Finnish, Italian and Spanish. It should also be noted that another factor that is likely to be important for cross-language differences in phonological development is morphology (Goswami & Ziegler, 2006). Morphological or meaning-based changes are frequently signaled by small phonological differences. For example, in Turkish “evim” means ‘in my house’ and “evin” means ‘in your house’. This single phoneme change (/m/ to /n/) is critical for language comprehension. Therefore, it is *a priori* likely that Turkish morphology affects how rapidly Turkish children become aware of phonemes (Durgunoglu, 2006). However, the cross-language database on how morphological differences affect phonological development is currently too small to attempt a systematic analysis.

*Educational difficulties in learning to read*

So far, we have seen that the child's brain develops phonological 'representations' of words in response to spoken language exposure and learning to speak. Extensive cross-language research has shown that the quality of these phonological representations then determines literacy acquisition (see Ziegler & Goswami, 2005, for a detailed analysis). When phonological representations are impaired, then children will struggle to acquire functional literacy skills, across languages. For example, cognitive studies demonstrate that children with developmental dyslexia in all languages so far studied have difficulties with phonological awareness tasks. They find it difficult to count syllables, they find it difficult to recognise rhyme, they find it difficult to decide whether words share phonemes, and they find it difficult to substitute one phoneme for another (e.g., Kim & Davis, 2004, *Korean*; Wimmer, 1996, *German*; Porpodas, Pantelis & Hantziou, 1990, *Greek*; Share & Levin, 1999, *Hebrew*). Numerous studies in English in particular have shown that children with developmental dyslexia remain poor at tasks like deciding whether words rhyme (Bradley & Bryant, 1978). They remain poor at making accurate judgments in counting or same-different judgment (Swan & Goswami, 1997), they remain poor at making oddity judgments about phonemes (Bowey, Cain & Ryan, 1992) and they remain poor at Spoonerism tasks (Landerl, Wimmer & Frith, 1997). These difficulties persist into the teenage years (e.g., Bruck, 1992).

However, for dyslexic children who are learning to read transparent orthographies, reading has an impact on phonological awareness. Learning consistent letter-sound relationships appears to help children to specify phonological similarities and differences between words. For example, German dyslexic children show age-appropriate phonological skills in some phonological awareness tasks (those that can be solved using letters) by the age of 10 years. A Spoonerism task is an example of a phonological awareness task that can be solved using letter-sound knowledge. In Spoonerism tasks, the child has to swap the beginning sounds in words (like Reverend Spooner, who told students "You have hissed all my mystery lectures"). For example, the child may have to say "Dob Bylan" instead of "Bob

Dylan”. German dyslexic children eventually became able to do such tasks as well as typically-developing control children (Wimmer, 1993). However, when German dyslexic children are compared to age-matched English dyslexic children, the Germans perform much better in Spoonerism tasks (Landerl et al., 1997).

Despite measurable phonological difficulties in children with developmental dyslexia across languages, for most of the world’s languages, differences in the *accuracy* of decoding is only found in the very earliest stages of reading. Studies of young German and Greek children who later turned out to have specific reading difficulties showed that word and nonsense word reading was significantly poorer than that of age-matched controls in the first year of reading instruction, but this difference soon disappeared (Wimmer, 1993; Porpodas, 1999). Although difficulties with phonology remain for children learning to read transparent orthographies, these difficulties do not impede reading accuracy. Rather, they impede reading *speed* and *spelling* accuracy. Developmental dyslexia in most languages other than English is usually diagnosed on the basis of extremely slow and effortful reading, and strikingly poor spelling.

For English children, however, developmental dyslexia is characterised by both inaccurate and effortful reading and by inaccurate spelling. Even dyslexic adults in English remain poor at decoding words accurately (Bruck, 1992). Hence the same cognitive phonological deficit can manifest differently in different languages. In fact, English children with developmental dyslexia perform significantly more poorly in tasks such as nonsense word reading compared to German children with developmental dyslexia, even when they are trying to read the same items (e.g., nonsense words like “grall”, see Landerl et al., 1997). This demonstrates the pervasive effects of learning to read an inconsistent orthography on reading development. The consequences of having a phonological deficit are more profound in developmental terms for literacy in English.

***Implications for education: Phonological interventions***

Current early screening tools for identifying developmental dyslexia are relatively ineffective, generating many false positives. On the other hand, we know that the effective interventions for developmental dyslexia are based on phonology. The most effective interventions are thus likely to be *generic* interventions that develop excellent phonological skills in *all* children during the early years. Such generic intervention can then be followed by differentiated interventions for those most at risk. For example, teachers can be trained to recognise children who are unresponsive to generic enrichment, thereby identifying those with likely learning difficulties. These children could then receive more specific interventions such as individualised treatments. For phonological difficulties and literacy, early generic intervention with later individualised and differentiated intervention seems likely to offer the highest return on educational investment.

Targeted phonological interventions that include teaching children about letters across languages generally are effective in improving developmental dyslexia (mean effect size 0.67, Bus & van Ijzendoorn, 1999). Many interventions considered by Bus and van Ijzendoorn were for school-aged children, but they reported greater effects for preschool children. The effects can be considerable. For example, a successful generic phonology-based intervention in German with younger pre-reading children (the 20 week programme “Hearing, Listening, Learning” developed by Schneider and his colleagues, which is delivered by German kindergarten teachers), reported an effect size of 0.57 for spelling development by Grade 2, with a smaller effect size for reading (0.26; see Schneider, Roth & Ennemoser, 2000). Further studies by Schneider and his colleagues have revealed similar enhancement of reading and spelling following phonological training for migrant children from other language backgrounds, and also for children with spoken language difficulties. Importantly, the phonological training for the migrant children was delivered in the mother tongue (for example, Turkish migrant children received oral language interventions in Turkish, and this had an impact on learning to read in German). Phonological interventions with older at-risk children in English also show large effect sizes

(0.69), which translate into gains of around 7 standardised score points in reading (Hatcher et al., 2006). These scientific studies suggest that phonological interventions which link phonological training to letter-sound relations offer an important tool for early educational intervention.

Parents and the home environment also play a crucial role in literacy development. Connor et al. (2004) estimated that the family environment was the major source of the variability in children's literacy skills at school entry. The learning environment provided by the home influences both phonological development (for example, via oral language practices in the home such as nursery rhymes and singing) and how much exposure to print the child receives (e.g., the number of books in the home, parental valuation of literacy etc.). Unsurprisingly, therefore, interventions that are designed to introduce books into the home and to demonstrate optimal "shared reading" practices are also effective in fostering early literacy skills (e.g., Whitehurst et al., 1994). Typical effect sizes are about 0.50, which is medium to large. Interventions that involve shared reading enhance the spoken language that carers use with young children as well as providing exposure to print. The spoken language input is important, as overall language skills (vocabulary development and use of complex language) as well as phonological awareness and letter knowledge are extremely strong predictors of later literacy. Effective shared reading programmes also teach caretakers to use books as a starting point for dialogue. The books thereby increase the complexity of the language used with the child and also make the parent more responsive to the interests of the child ("responsive contingency", Bornstein & Tamis-LeMonda, 1989). Responsive contingency is also an important predictor of later independent learning. Hence interactions around books affect more than the developmental trajectory for later literacy learning. These interactions also affect memory and conceptual development, the development of social cognition and reasoning skills, and the child's ability to manage their own behaviour.

### **Conclusion**

The research reviewed here illustrates some of the developmental trajectories that make early language acquisition so critical for later school achievement. Word learning (vocabulary development)

is exponential in early childhood. Using the 'Child Language Checklist' (now translated into 12 languages), Fenson et al. (1994) showed that median English spoken vocabulary size was 55 words by 16 months of age, 225 words by 23 months, 573 words by 30 months, and 6000 words by age 6. Comprehension vocabulary at age 6 is around 14,000 words (Dollaghan, 1994). However, the developmental range can be enormous. For example, at 2 years, the range in word production was from 0 words to more than 500 words (Fenson et al., 1994). New word learning is extremely rapid, with around 10 new words acquired daily at age 2. Clearly, talking to children and enriching their language experiences via books and other media can play an important role in enhancing later achievement. Most importantly of all, language is symbolic. This symbolic system enables children to detach themselves from the immediate situation, enabling cognition itself to become the object of thought and reflection. The long-lasting and pervasive effects on memory, reasoning, self-regulation and theory of mind mean that enhancing early language enhances the child's entire cognitive repertoire.

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**Comment [MSOffice1]:** The other Waxman & Booth 2001 was never actually cited after all, so we don't have the 2001a vs. b problem.

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**Table 1****Illustrative data (% correct) from studies comparing phoneme counting, simple word reading and nonword reading in different languages in Kindergarten or early Grade 1**

Language	% phonemes counted correctly	% familiar real words read correctly <sup>8</sup>	% simple nonwords read correctly <sup>8</sup>
Greek	98 <sup>1</sup>	98	97
Turkish	94 <sup>2</sup>	-	-
Italian	97 <sup>3</sup>	95	92
German	81 <sup>4</sup>	98	98
Norwegian	83 <sup>5</sup>	92	93
French	73 <sup>6</sup>	79	88
English	70 <sup>7</sup>	34	41

Note. 1 = Harris & Giannoulis, 1999; 2 = Durgunoglu & Oney, 1999; 3 = Cossu et al., 1988; 4 = Høien et al., 1995; 5 =

Wimmer et al., 1991; 6 = Demont & Gombert, 1996; 7 = Liberman et al., 1974; 8 = Seymour, Aro & Erskine, 2003

(familiar real words = content and function words, nonwords = monosyllabic items only).

**Figures**

Figure 1. A schematic presentation of introductory phrases from Waxman & Markow (1995) and an example of a single stimulus set







	Familiarization Phase				Test Phase	
	Trial 1	Trial 2	Trial 3	Trial 4		
<u>Animal Set:</u>						
	yellow duck	green raccoon	blue dog	orange lion	red cat	red apple
<u>Noun</u>	This one is. a(n) X	This one is a(n) X	See what I have?	This one is a(n)X	See what I have?	
<u>Adjective</u>	This one is X-ish	This one is X-ish	See what I have?	This one is X-ish	See what I have?	
<u>No Word</u>	Look at this.	Look at this.	See what I have?	Look at this.	See what I have?	

Figure 2. A schematic presentation of introductory phrases from Waxman & Booth (2001) and an example of a single stimulus set















	Familiarization		Contrast	Test			
	Trial 1	Trial 2		Category	Property		
<u>Purple Animal Set:</u>	 bear	 lion	 elephant	 dog	 red apple	 purple horse vs.  purple chair	 purple horse vs.  blue horse
Noun	These are blickets. This one is a blicket & This one is a blicket	These are blickets. This one is a blicket & This one is a blicket	Uh-oh, this one is not a blicket!	Can you give me the blicket?	Can you give me the blicket?		
Adjective	These are blickish. This one is blickish & This one is a blickish	These are blickish. This one is blickish & This one is a blickish	Uh-oh, this one is not blickish!	Can you give me the blickish one?	Can you give me the blickish one?		
No Word	Look at these. Look at this one & Look at this one	Look at these. Look at this one & Look at this one	Uh-oh, look at this one!	Can you give one?	Can you give me one?		

Figure 3. A schematic presentation of introductory phrases from Waxman, Lidz, Braun, & Lavin (in press) and example of a single stimulus set.

Familiarization				Contrast		Test	
 <p>Man waving balloon (4 consecutive exemplars)</p>				 <p>Man playing toy saxophone</p>	 <p>Man waving balloon</p>	 <p>Man waving balloon</p>	 <p>Man tapping balloon</p>
<p><u>Verb</u>: "Look, the man is <i>larping</i> a balloon!"</p> <p><u>Noun</u>: "Look, the man is waving a <i>larp</i>!"</p> <p><u>No Word</u>: "Look at this!"</p>				<p><u>Verb</u>: Uh-oh! He's not <i>larping</i> that.</p> <p><u>Noun</u>: Uh-oh! That's not a <i>larp</i>!</p> <p><u>No Word</u>: Uh-oh! Look at that.</p>	<p><u>Verb</u>: Yay! He is <i>larping</i> that.</p> <p><u>Noun</u>: Yay! That is a <i>larp</i>!</p> <p><u>No Word</u>: Yay! Look at this.</p>	<p><u>Verb</u>: "Now look, they're different! (Baseline) "Which one is he <i>larping</i>?" (Response)</p> <p><u>Noun</u>: "Now look, they're different! (Baseline) "Which one is a <i>larp</i>?" (Response)</p> <p><u>No Word</u>: "Now look, they're different! (Baseline) "What do you see now?" (Response)</p>	