子どもは英語の形態をいつどのように獲得するのか

—英語と他言語の比較を通じて—

How and When Do Children Acquire the Rules of English Morphology?: Comparing the Data From English With Other Languages

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概要

本研究の目的は発達神経科学の理論的枠組みを概観し，英語の形態論を含む言語発達に関する有用な知見を得ることである。本研究では，音声（音韻論）の処理機構がその後に生起する表記（正字法）の処理機構よりも支配的であるとする幼児研究及び言語比較研究の知見が考慮される。言語は，脳の発達により人間が（視覚的または聴覚的に）知覚を表象する結果として得られ，また，それは環境に反応することにより形成される。しかしながら，言語はまた，話され，そして読み書きされる（形態論的表象の習得）ことで学ばれる社会的規則でもある。私たちは，話しことばと読み書き能力を通じて，人間社会と関わる２つの異なる認知的な形態論的表象の規則を学ばなければならない。それらは（1）誰もが人生初期に獲得可能な音韻論的表象と，（2）教育によって達成される正字法（綴り方）的表象の２つである。

キーワード：発達神経科学，英語形態論，話しことばと読み書き能力，音韻論的表象と正字法的表象

Abstract

The aim of the study is to review the theoretical framework of developmental neuroscience that gives us a helpful view of language development including English morphology. The study considered the phonologically dominant process over the subsequent orthographical process in infant studies and cross-linguistic studies. Language is an outcome of human brain development that allows us to represent perceptions (e.g., vision, audition), which is build by our responding to the environment. However, language is also a social rule that should be learned through speech and literacy (a learning of morphology). Speech and literacy constrain us to manage the rules of morphology through two different forms of cognition connected to human society: (1) the phonological representation, which everybody can acquire in his or her early cultural life, and (2) the orthographical representation, which should normally be attained through education.

Keywords: developmental neuroscience, English morphology, speech and literacy, phonological and orthographical representations

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1. Introduction

Language is an outcome of human brain development that allows us to represent perceptions (e.g., vision, audition) in order to be able to respond to the environment. However, language is also a social rule that should be learned through speech and literacy (a learning of morphology). Speech and literacy constrain us to manage the rules of morphology through two different forms of cognition connected to human society: (1) the phonological representation, which everybody can acquire in his or her early cultural life, and (2) the orthographical representation, which should normally be attained through education.

Phonological achievement is crucial for children's language learning in that speech is a social basis for human communication including literacy; i.e., without phonology and phonological protocols nobody can read or spell. In this respect, it is logical for an infant brain to develop phonological cognition first, and to learn to read and write later. However, it is notable that language that develops as per these two social rules (i.e., phonology followed by orthography) would yield a significant amount of developmental variability (e.g., genetic, environmental, and cultural) that is largely observed in the early stages of development from birth up to and including to childhood. According to Bear et al. (2015), more than 10% of the world's population is illiterate. Therefore, clarification of the causality of this variation in terms of educational neuroscience—i.e., facilitating children's learning through knowledge of brain development—will contribute to the better educational intervention for children's language development.

In this short essay, first, I will briefly review the theoretical framework of development that gives us a helpful view of the interaction between language and environmental factors (Mareschal et al., 2007; Thomas, & Laurillard, 2013). Second, I will consider the phonologically dominant process of language acquisition over the subsequent orthographical process in infant studies (Graven & Browne, 2008), with regard to how English infants represent phonemes and differentiate phonological discrimination in the native language (Eimas et al., 1973; Houston et al., 2000; Kuhl, 2007). Third, I will compare inconsistent orthographical data (English) with consistent orthographical data (Italian) (Angelelli, et al., 2014; Marinelli et al., 2015; Paulesu et al. 2001) to consider cultural variation across languages (Italian vs. English) in early literacy learning. Finally, I will summarize the review and identify how and when children acquire the rules of English morphology.

2. A Theoretical Framework

There is a long-standing nature-nurture debate between nativist and empirisists about how we should view the development of language cognition (Behme, & Deacon, 2008). Nativists hypothesized that language is innate and that we have a universal grammar to allow us to recognize speech or orthography in a domain specific device of the brain (e.g., Pinker, 1999), whilst empiricists claim that language is a cultural artifact and babies should learn language purely through experience. However, neither of the two claims had a convincing explanation for the complex development of language in the brain (e.g., opaque relationship between individual differences and environmental factors such as socioeconomic status).

Knowland and Donlan (2013) emphasized the importance of exploring why a substantial degree of variability in language skill is seen during infancy and early childhood (0–5 years). They contended that we should "consider the progressive maturation of the language system at the neural level, and the gradual building of language behavior over developmental time" (p. 135). This is a notable question considering that everyone can learn speech successfully in the early years of life. In addition, Thomas and Laurillard (2013), applying

computational modeling to the quantitative variation of language development, proposed a third solution in the name of "neuroconstructivism," which "builds on the Piagetian view that development corresponds to the progressive elaboration in the complexity of mental representations via experience-dependent processes" (p. 60).

The core principle of neuroconstructivism is, briefly, twofold: (1) everything emerges (emergentism), and (2) everything is context-dependent (partial representation). Emergentism gives an essential theoretical underpinning that development progresses from complex variability to specific specialization, whilst context-dependency underscores a philosophy that nothing in the world is independent (Mareschal et al., 2007). The implication of partial representations (i.e., no complete representation alone) is important in that information processing, such as phonological and orthographical processing, functions only for the complementarity of the other information within a minimal range of competitive and cooperative environment (cultural diversity) and timing (cerebral plasticity).

This neuroconstructivist view has a unique new idea that the nativist approach does not ever have, and therefore allows us to see language and education in a broader and more practical way. It suggests that there is no such device as universal grammar (or innate competence) in our brain but that there are probably partial representations available as phonological, orthographical, or syntactical constraints, which emerge in the neural network complementarily at the level from genes to social behaviours (Thomas & Laurillard, 2013; Mareschal et al., 2007).

3. Phonological Development in Infant Studies

The auditory neural system in the fetus starts to interplay with the in utero environment (e.g., hydrophonic perception) and develops the capacity to hear, discern, and then respond to complex speech immediately after delivery (Graven & Browne, 2008). Graven and Browne claimed that, unlike the visual system that starts to develop after birth, the auditory system requires outside auditory stimulation that is meaningful for human cochlea during the last 10 to 12 weeks of fetal life. This highlights an earlier inception of auditory development than visual development, which necessitates fetal and infant interaction with environmental factors (e.g., ambient language including motherese). In addition, auditory cortical development starts earlier than visual cortical development, which engenders an early phonological representation and the subsequent morphological (visual) representation (Bear et al., 2015).

In their first year of life, infants seem to hardly understand any language despite having the ability to distinguish any two phonemes on the basis of acoustic cues (e.g., Eimas et al., 1971; Werker & Tees, 1984). However, the perception of speech sounds undergoes remarkable changes during the first year of life (Mareshal et al, 2007). Research has shown that hearing develops rapidly during that year, presumably constrained by partially innate and partially environmental factors (partial representations). It has led to an empirical consensus that by the time an infant gratifies parents with babblings, they already know which sounds belong to their own language (native phonetic contrast), although researchers are yet to agree to on what alters infant speech perception (from universal specific) in this initial period; the debate is perhaps because of the difficulty of designing experiments to measure infant's discrimination ability of different sounds.

Eimas et al. (1971) used a transducer to measure infants' sucking responses to obtain data on auditory discrimination abilities. They found that 1- and 4-month-old infants were able to discriminate acoustic pair (/b/ and /p/) that adults assume as cultural categorical perception between the voiced and voiceless stop

consonants. Eimas and colleagues then postulated that it was accomplished by an innate “biological makeup” at this early age, because infants could sort acoustic variations as adults do with limited exposure (p. 306). Another paradigm was created by Houston et al. (2000), who used a head-turn preference task to different sounds and demonstrated that English 9-month-olds showed a cross-language segmentation as Dutch adults normally do. The variability of the result was explained by the similar rhythmic structure of both language (Dutch vs. English), which suggested the relatively strong impact of environment (culture) on different languages with similar phonemes and morphemes.

However, from the perspective of phonological neuroscience, whether infants around the age of 1 should undergo a reversible effect when they lose the ability to discriminate between nonnative phonetic contrast (e.g., Japanese /l/ and /r/), or there is an interaction between brain and environment when they gain the discrimination ability on native contrast was elusive and controversial (Kuhl, 2007); i.e., whilst nativists assume the discrimination ability (nonnative contrast) as an innate competence such as the universal grammar (e.g., Pinker, 1999), Werker and Tees (1984) assume that the discriminatory effect of infants (in the head-turn paradigm) on native contrast was a declining effect, postulating that infant phonetic discrimination is initially language universal (general), but later limited (specialized) to their native language.

On the basis of a series of behavioural-and-electrophysiological paradigm studies that validated the early establishment of phonological representations in the infant brain, Kuhl (2007) hypothesized that the earliest phonological learning is not innate but requires social interaction (see also Behme and Deacon [2008] for review). Kuhl demonstrated that 6 months of natural listening experience is sufficient to alter these early representations, and, moreover, she contended that the period would also underpin the higher level of later morphological success by those infants (e.g., vocabulary learning, reading, etc.). Importantly, this hypothesis predicted infant statistical learning (Saffran et al., 1996) assuming that social interaction is necessary for the infant brain to learn because infants “are sensitive to the distributional frequencies of the sounds they hear in ambient language, and this alters perception” (Kuhl, 2007, p. 112).

4. Morphological Development in Cross-linguistic Studies

So far we have reviewed how and when phonological representations in infant brain and behaviour are affected by environmental factors, as well as by cerebral development. Next, let us consider how orthographical development in childhood emerges in a manner that parallels with phonological development, by comparing data in English orthography with data in Italian orthography.

Most human languages are written down with a set of conventions called orthography. Children at the early stage of being literate have little orthographical knowledge of morphology since it is a social artifact. Therefore, morphological development in children owes much to literacy achievement (e.g., fluency and accuracy) in families or communities. Angelelli et al. (2014) reported that about 60% of less familiar words are derived by affixation or compounds (e.g., “fireman”) in alphabetic scripts, such as in English or Italian, which suggests that both English and Italian school children need to read and spell a considerable number of morphologically complex words (Nagy and Anderson, 1984).

With regard to Italian, an increasing number of studies have found that there is a main effect of morphology on comprehensive fluency and accuracy in reading; morphological representations are of great help for the developmental cognition of semantic and grammatical structure, providing a significant tool to accelerate the higher order cognitive process for vocabulary acquisition. Traficante et al. (2011), for example,

Table 1 The Dimensions of Syllabic Complexity and Orthographic depth

		Orthographic depth				
		shallow				deep
syllabic structure	simple	Finish	Greek Italian Spanish	Portuguese	French	
	complex		German Norwegian Icelandic	Dutch Swedish	Danish	English

Seymour, Aro, & Erskine (2003)

revealed that both typically developing Italian children (2–7th grade) and dyslexic children at the same age could read aloud morphologically high-structured pseudowords (e.g., "donn-ista" [woman-ist]) faster than the pseudowords without such structures (e.g., "den-nosto"[meaningless]). Traficante and colleagues further emphasized the position of morphemic units (e.g., roots or suffixes) in terms of eye movement, as well as their differential qualitative (regularity) effect on children's overall literacy development (e.g., orthography-to-semantics mapping provided by the units).

Seymour, Aro, and Erskine's (2003) multiple cross-linguistic studies found that consistent orthography-phonology mappings in orthographies are associated with shorter times in acquiring the ability to read, which, from a perspective of partial representation, seems to imply that the causality of the morphological acceleration effect either or can be traced back to phonological representation. According to Seymour and colleagues, Italian belongs to a family of shallow orthographies with consistent phoneme-to-grapheme correspondences along with Spanish and Finnish. In these languages, morphological knowledge is relatively unnecessary for assigning the correct pronunciation or spelling. English and French, however, are classified as having deep orthographies, which in effect require morphological knowledge in order to be able to pronounce and spell correctly (see Table 1).

Marinelli et al. (2015) quantitatively compared the spelling acquisition between Italian and English at primary school, and found greater accuracy in Italian children than English children; Italian after only 2 years of schooling demonstrated accurate spelling, whilst English children's spelling performance was poor after 5 years of schooling. The results suggested that more spelling difficulties among the English was due to English children having to learn more morphologically irregular words and complex rules to convert between phonemes and graphemes. Importantly, Marinelli and colleagues emphasized not only quantitative, but also qualitative differences between English and Italian orthographical consistencies. In other words, because of the inconsistent orthography in English, more morphological representations together with less phonological representations seemed to be needed. On the other hand, Italian children's cognition was specialized differently even at the earlier grade due to the consistent orthography that arguably allows phonological representations to be translated into writing with more ease.

Paulesu et al. (2001), with positron emission tomography (PET) scanning technique, examined Italian, English, and French dyslexics' explicit and implicit reading skills. Dyslexia is broadly defined as poor reading accuracy and fluency in learning literacy, which does not include higher order cognition such as comprehension of texts (Hulme, & Snowling, 2009). Paulesu and colleagues revealed the same reduced neural activity in a region of the left hemisphere—i.e., in the middle, inferior, and superior temporal cortex and in the middle occipital gyrus—but, interestingly, different behavioural responses to reading tasks (namely, Italian dyslexics performed better than the others despite the equally controlled impairment). The implication of

the neuroimaging technique is significant because not only did it demonstrate that the emergence of dyslexic phonology changes depending on the different orthographies across language, it also implied that, irrespective of typical and atypical development, phonological representations have a fundamental role on Italian children's orthographical processing presumably via phoneme-to-grapheme mapping due to its strong consistency.

A similar result was found by Goswami's (2000) meta-analysis study, which, in an attempt to integrate findings in phonological development, reading development, and dyslexia into a coherent framework across languages, revealed that, despite the similarity of the factors governing phonological development across languages, the differences in the speed and level of phonological progressing were associated with the acquisition of alphabetic literacy. Putting these two studies' results together, it seems that there should be a failure in the emergence of phonological representations in English dyslexic children, which would in turn yield reduced representations or impaired granularity for their orthographical and/or semantic representations, whilst Italian dyslexics may be aided by the consistent orthographies (of course we still need to consider other factors such as semantic or syntactic effects of the morphemic units themselves in both languages).

A summary of these cross-linguistic differences between English and Italian accounts for early literacy learning in terms of the role of phonological representation; that is, cognitive load (depth) pertain directly to literacy (e.g., complex mapping from phoneme to grapheme) is lower in Italian than those of English. Frost (1994) called this the orthographic depth hypothesis, which explains that in shallow orthographies, readers would tend to rely on the phonological representations, whilst in deep orthographies, readers would be culturally afforded to use lexical (semantic) representations for the sake of fluency and avoidance of the equivocality in phoneme-grapheme correspondences.

5. Conclusion

This essay reviewed the theoretical framework of developmental neuroscience that gives us a helpful view of language development, and considered the phonologically dominant process over the subsequent orthographical process in infant studies and cross-linguistic studies.

To conclude, the rules of English morphology are established over time through the interaction between brain and environment, which originates with a prenatal commitment of the auditory system progressing from fetal to infant period, forms local phonological representations through interacting with ambient speech (i.e., English) from 6-months to 12-months of age, and emerges in the competitive, cooperative, and partial (complementary), as well as social, networks. English morphological representations develop increasingly after 12-months old, aided by phonological representations. However, babies who go on to speak English may need to rely more on orthographical knowledge than speakers of other languages. In a similar fashion, English dyslexics and English children who have poor literacy are, at the earlier stage, likely to need more aid than their Italian counterparts.

Last but not least, as Knowland and Donlan (2013) mentioned, it is noteworthy to point out the importance of early intervention for infants and children in terms of the neural maturation from low-level representation (ambient speech) to the later establishment of abstract language (e.g., vocabulary learning). Future intervention should be designed from the perspective that children's language development changes from initial universal variability to later specialization through partially innate but largely social interaction with familial and educational environment.

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