Chapter

Emergent Reading and Brain Development

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Abstract

Emergent reading emphasizes the developmental continuum aspect of learning to read and advocates the importance of reading-related behaviors occurring before school. Brain imaging evidence has suggested high plasticity of young children's brains, and emergent reading experience can shape the brain development supporting fluent reading. The brain imaging evidence elucidates our understanding of the importance of emergent reading from a neurobiological point of view. Future studies are needed to understand how emergent reading experience can become protective factor for children at risk for reading impairments. Future studies need to design early interventions to improve emergent reading experience which is a crucial period.

Keywords: emergent reading, brain responses, neural basis, development, shared book reading, developmental dyslexia

1. Introduction

Reading is a complex process involving multiple regions in the brain communicating with each other to facilitate effective reading. Learning to read can play an important role in academic success. There is a reciprocal relationship between language and reading learning where improvements in one can lead to an increased understanding of the other [1, 2]. This chapter focuses on the concept of emergent reading and brain imaging evidence related to reading acquisition and aims to elucidate our understanding of emergent reading experience and its relationship with brain development.

2. Emergent reading

2.1 What is emergent reading?

The term "emergent reading" is derived from "emergent literacy" and is used to advocate that the development of reading starts early in a child's life instead of school years. The emergent literacy includes both reading and writing components. The concept "emergent reading" emphasizes the developmental continuum aspect in learning to read, rather than an all-or-none phenomenon that begins only when a child starts school, suggesting there is a boundary between reading and pre-reading. For example, over the years, educators focused on identifying what skills a child needs to understand before he/she can learn to read through a formal reading curriculum. In contrast, an emergent reading perspective views reading-related behaviors occurring before school as essential aspects of reading. Besides, an emergent reading perspective views that language and reading develop concurrently and interdependently from an early age when children were exposed to social interactions in which reading is a component, and no formal instruction was involved.

Emergent reading consists of the skills, knowledge, and attitudes that are presumed to be developmental precursors to conventional forms of reading [1, 3] and the environments supporting these developments (e.g., home literacy environment, shared book reading, etc.).

2.2 Components of emergent reading

Based on the literature, the main components of emergent reading include vocabulary knowledge, decontextualized language skills, conventions of print, knowledge of letters, linguistic awareness, and phoneme-grapheme correspondence.

Vocabulary knowledge is important in emergent reading. Reading requires decoding of visual inputs into meaning. In the earliest stages, a child decodes a word letter by letter, links each letter into its corresponding sound, and combines all the letter-sounds to a single word. For example, in the beginning, a child decodes a word "cat" by sounding out /k/ … /æ/ … /t/. The next stage is to extract the meaning of the word, which is important since it motivates the child. If a child knows individual letters but does not know the meaning, he/she is unlikely enjoying the reading process since the child has no semantic representation through which a child decodes the phonological information. Research studies have shown that semantic and syntactic abilities play important roles in acquiring reading skills when the child is reading for meaning [4, 5]. A recent study investigated the relationship between semantic knowledge and word reading in 27 6-year-old children [4]. General semantic knowledge was assessed using standardized tasks in which children defined words and made judgments about the relationships between words. They have provided strong evidence that variation in semantic knowledge is associated with variation in word-reading performance.

Decontextualized language skills refer to the language used in story narratives and other written forms of communications to convey novel information to readers [3]. **Conventions of print** in English include the left-to-right and top-to-bottom direction of print, the sequence in which the print progresses from front to back across pages, the difference between pictures and print on a page, and the meaning of elements of punctuation. Knowing these conventions helps a child learn to read [3]. Decontextualized language skills in children are related to conventional reading skills including decoding, understanding story narratives, and print production [6].

Knowledge of letters is critical to learning the sounds associated with the letters. However, only teaching letter names may only increase surface letter knowledge and may not improve the abilities to learn to read [7]. Linguistic awareness involves the ability to take language as a cognitive object and to understand how language is constructed and to use language as a way of communication. Linguistic awareness develops over time, and a child may be aware of some rules (e.g., that words are formed from phonemes) without being aware of other rules (e.g., two words rhyme). Many studies have suggested that children good at detecting syllables and rhymes are better readers [8].

Linguistic awareness involves the ability to take language as a cognitive object and to possess information about the syntax. Most research on linguistic awareness has focused on phonological skills (e.g., phoneme isolation, phoneme deletion, etc.).

The relation appears to be reciprocal. Better phonological skills led to quicker learning to read [9–12], while learning to read improves phonological skills [13, 14].

Phoneme-grapheme correspondence represents the links between phonemes and alphabet letters. A child requires to understand both how individual letter sounds and how combined letters sound. This ability has been related to higher levels of reading achievement [10, 15].

Children learn these main components of emergent reading before formal schooling. These components are the building blocks that a child needs to learn to read. Becoming a fluent reader requires all these components, which can be divided into two interdependent sets of skills and processes. They are the process of decoding and comprehension. The process of decoding needs children's knowledge of rules for translating letters to sounds and sounds to words, while the process of comprehension needs children to find meanings for the words. Both are essential processes for reading. Difficulties in either process can lead to reading impairments.

2.3 Environments supporting emergent reading

Home literacy environment has been suggested to positively correlate to preschooler's language abilities [16, 17]. Home literacy environment characterizes the literacy-related interactions and resources at home, including shared book reading between parents and children (e.g., frequency, duration) and exposure to literacy materials (e.g., how many books at home, types of books). The American Academy of Pediatrics (AAP) advocates reading aloud to children every day, beginning from birth [18]. The AAP early literacy policy released in June 2014 urges pediatricians and policymakers to ensure that books are available to all families, particularly those with low income [18]. High et al. recommends that parents focus on the following activity: read together, rhyme and play with words, set consistent routines, reward with praise, and develop a strong relationship with the child [18]. Shared reading between parents and children can strengthen bonding and improve language skills and vocabulary knowledge. Dialogic reading, known as a shared picture book reading intervention for preschoolers, has been suggested to boost the preschooler's language abilities [19–21]. Moreover, the new understanding of brain development through neuroimaging studies has also suggested that the first 1000 days are the crucial developmental stage for later cognitive development.

Children's daycare and preschool environments are important for children's emergent reading experience [3]. Studies have identified that aspects of the curriculum, the environment, teach-child interactions, and teaching practices within the classroom are related to the cognitive ability and achievement of children [22]. When controlling for home literacy environment, children's daycare and preschool environments still predict children's cognitive and academic achievement scores.

2.4 Socioeconomic status

School readiness refers to a mismatch between what many children bring to their first school experience and what schools expect of them if they are to succeed and is strongly linked to family income [3]. Socioeconomic status (SES) is one of the strongest predictors of performance differences in children at the beginning of first grade [23]. Differences in SES could lead to differences in emergent reading experiences (e.g., language exposure at home, family stress, cognitive stimulation) that likely shape the early development of brain regions that are crucial for becoming a skilled reader [24, 25]. Children from low SES are at risk for DD and are also more likely to be slow in learning to read [26]. Moreover, Matthew effects in reading demonstrated that a child is a disadvantaged organism because of the low SES and genotype provided by the child's parents [27]. Many students with low SES entering school are significantly behind their more advantaged peers with high SES, and the academic performance gap widens over the course of elementary school [28, 29]. Children from families with different SES exposure to different experiences that support the development of emergent reading skills. Mothers from lower SES groups engaged in fewer teaching behaviors during shared reading than mothers from middle-class groups [30, 31].

2.5 Interventions to enhance emergent reading experiences

Various interventions targeting one or more components of emergent reading have been developed including dialogic reading, little books, phonological sensitivity training, and whole language instruction.

Dialogic reading is a program of shared picture book reading intervention for preschoolers, and it can substantially improve a child's language skills in preschool [19, 32–34]. Dialogic reading is different from the conventional shared reading during which the adult reads and the child listens. During dialogic reading, the child learns to become a storyteller, while the adult acts as an active listener, asking questions and prompting the child to increase the sophistication of descriptions of the material in the picture book.

Little books are small, easy-to-read books that contain simple words, simple illustrations, and repetitive text. Studies have shown that giving free little books to children from family with low and middle incomes facilitates better emergent reading experience and supports better reading outcomes [35–37].

Phonological sensitivity training is to teach children phonological sensitivity, which is one of the strongest predictors of later reading achievement. Interventions on phonological sensitivity training have been shown to be effective in beginning readers [38–40].

Whole language instruction focuses on the reading components including language units (e.g., words), semantic units (e.g., concepts), and contextual units (e.g., narrative) [41, 42]. Whole language approach advocates that there are strong parallel between the reading acquisition and oral language acquisition and believes that reading acquisition would occur as easily and naturally as language acquisition if the meaning and purpose of the text were emphasized. However, there is ongoing debate on whether whole language emphasis is effective approach [43]. More research is necessary to resolve this debate. Whole language is currently controversial approach to teach reading.

3. Behavior and brain connection

If cognitive behaviors are the immediate results of our brain states, then the most effective way of uncovering a cognitive behavior is to understand the brain states that would lead to it. Brain states are determined by the organization of synaptic connections between neurons that generate various patterns of activations. Thus, brain imaging can provide insights into the neural basis that would lead to the certain cognitive behavior.

When a child learns to read, he/she is more likely to show reading-related activity in the region of occipitotemporal cortex [44–47]. Two decades ago, brain research has suggested that the socioeconomic status (SES) modulates brain-behavior relationships in reading [25]. Specifically, as SES levels decreased, the relationship between the phonological language skill and functional magnetic resonance imaging (fMRI) data was stronger, whereas as SES levels increased, these brain-behavior relationships were attenuated [25]. Thus, a child's background and life experiences, as determined by SES, can systematically influence the relationship between emergent reading skills and reading-related brain activity. To better understand the importance of emergent reading experience, brain imaging evidence will be used to demonstrate the underlying neural basis supporting the developmental continuum aspect of learning to read.

4. Brain imaging evidence

Recent advances in neuroimaging techniques make it possible to identify the brain-based factors that facilitate successful reading outcomes. Importantly, brain imaging may provide innovative solutions to improve education curriculums and lead to improvements in reading results in young children.

Over the last decades, neuroimaging studies focused on identifying brain markers that are the cause of dyslexia (see reviews: [48, 49]). Although researchers are far from concluding that the brain markers causing dyslexia, we have learned about the neural basis of reading acquisition. For instance, a left-lateralized brain network, including temporoparietal and occipitotemporal cortices, is critical to facilitate skilled reading [50, 51] (see **Figure 1**). High white matter integrity in accurate fasciculus (AF) predicts better reading outcomes in children at risk for dyslexia [52]. AF is a tract connecting Broca's area and Wernicke's area, related to reading ability [53–55] (see **Figure 1**). If neuroimaging measures can identify children at risk for reading difficulties before they even start to learn to read in school, early emergent reading interventions can be applied to help them overcome the risk of developing reading difficulties in school years. Only a limited number of studies have specifically investigated the relationship between emergent reading environments and neuroimaging data.

Hutton et al. used StimQ-P questionnaire [56] to quantify the cognitive simulation at home and identified that functional magnetic resonance imaging (fMRI) data during a storying comprehension task presented stronger activity for those children with higher StimQ-P Reading scores [57]. They reported that higher StimQ Reading scores were associated with stronger activation in occipital cortices, including lateral occipital gyrus and precuneus, which can be attributed to mental imagery evoked during story listening [58]. Their study sample includes nineteen 3- to 5-year-old children from a longitudinal study of healthy brain development. In preschool children listening to stories, greater home reading exposure was positively related to activation of left posterior occipital fusiform, lateral occipital, posterior inferior temporal, posterior middle temporal, posterior cingulate, and angular gyri and left precuneus (household income is controlled). Their finding suggests that

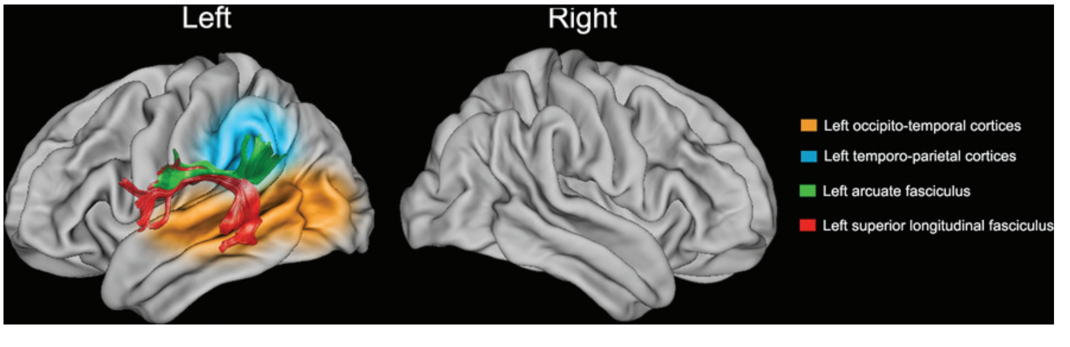

Figure 1.
Brain regions and white matter tracts related to reading on a 3D rendered brain. Red: accurate fasciculus (AF), green: superior longitudinal fasciculus (SLF).

brain-based markers exist as a result of parent-child reading in early childhood. Thus, emergent reading shall be promoted and may help shape the developing brain and better prepare a child for formal reading instructions in school.

Developmental dyslexia (DD) has strong genetic basis [59], and family history of DD can increase a child's chance to develop reading difficulties by 34–56% [60–62]. In order to identify children at risk for DD, familial risk can be used as a good indicator. One group led by Dr. Nadine Gaab in Boston Children's Hospital has done pioneer work in this research field [48, 52, 63–70]. For the first time, they examined the relationship between home literacy environment (HLE) and the neural basis of phonological processing in beginning readers with family history of DD (n = 29, first-degree relative who has reading difficulties) and without family history of DD (n = 21) [67]. This study aimed to identify brain mechanism of how HLE affects reading development in beginning readers. SES was controlled in this study in order to isolate the effects only by HLE. In reading-related brain regions (e.g., left inferior/middle frontal and right fusiform gyri), stronger correlations between HLE composite scores and brain activations were present in children without familial risk than those with familial risk. In the nonreading-related brain region (e.g., right precentral gyrus), stronger correlations existed in children with familial risk than those without familial risk. These findings suggest that genetic predisposition for DD alters contributions of HLE to brain activation. Specifically, typically developing children can benefit more from better HLE than children with familial risk for DD. Therefore, enhanced HLE is especially important for children with familial risk for DD to have the same impact as for typically developing children.

Shared parent-child reading is one of the important factors in emergent reading. A recent study demonstrated increased activation and functional connectivity in children who are more deeply engaged during shared reading in 22 mother-daughter pairs [71]. The same group also associated shared reading quality scores with brain activation, and they found a positive correlation between shared reading quality scores with activation in left-hemispheric regions supporting expressive and complex language, social-emotional integration, and working memory in 22 healthy, 4-year-old girls from low SES [72]. Their findings suggest that the use of shared parent-child reading is crucial for emergent reading experience, but the quality of this experience has also a strong impact on brain development. Especially for those at-risk families, improvements of the quality of shared reading can promote healthy brain development and better prepare a child for future success in school.

Morken et al. [73] used a longitudinal study design to examine the differences of cortical connectivity in the brain during reading tasks between children with dyslexia and children with typical reading development through dynamic causal modeling (DCM) [74]. They included five regions (inferior frontal gyrus, precentral gyrus, superior temporal gyrus, inferior parietal lobule, and occipitotemporal cortex) in their effective brain connectivity model [74]. They found that effective connectivity between the inferior frontal gyrus and the occipitotemporal cortex during reading tasks changes during reading acquisition. In addition, the group readers with dyslexia presented different developmental trajectory than the control group. The control group actually seemed to downregulate or stabilize connection strength over time, whereas the dyslexia group started out at a level well below the control group, followed by an increase in connectivity from 6 to 8 years and then a downregulation from 8 to 12 years. The general downregulation of connectivity in the control group might reflect that they need these connections to establish reading skills initially, and then, the connections are no longer needed after later automaticity is established. The dyslexia group showed late development of some connections in occipitotemporal cortices. However, they seem to show overcompensation around age 8, followed by normalization before age 12. Importantly, the dyslexia group was clearly lagging behind in the development of the brain networks at the age of 8 (emergent reading stage), suggesting emergent reading stage is critical.

Younger et al. also used a longitudinal study design and found decreases in connectivity for most connections from the first (T1) to the second (T2) time point about 2–3 years apart, regardless of changes in reading skill in 59 typical developing children [75]. But they found a significant decrease in the dorsal, decoding processing pathway from fusiform gyrus (FG) to inferior parietal lobule (IPL) for the group who improved more from the first to the second time point, suggesting that the improvements in reading skills lead to a decreased reliance on the dorsal pathway (decoding processing pathway) in the brain. The high and low improving groups did not differ in behavioral performance at T1, and high improvers showed greater connectivity between FG and IPL at T1 compared to the low improvers. The dorsal pathway facilitates phonological processing, which is necessary for development of the ventral pathway supporting automatic processing of visual word forms. However, there is no sequential relationship between the two routes. They may develop simultaneously.

Yu et al. studied 28 children over three stages (pre-reading, beginning reading, and emergent reading) and found decreases in neural activation in the left inferior parietal cortex (LIPC) during an audiovisual phonological processing task [69]. Seed-based brain network analysis revealed increases in connection strength in the brain network of children with above-average gains in phonological processing but decreases in connection strength in the brain network of children with below-average gains in phonological processing measured by Comprehensive Test of Phonological Processing (CTOPP). Moreover, the connection strength between LIPC and the left posterior occipitotemporal cortex (LpOTC, BA 18) at the pre-reading stage significantly predicted reading skills at the emergent reading stage.

5. Discussion

This chapter demonstrates the view of emergent reading and brain imaging evidence supporting advocacy for emergent reading. Emergent reading emphasizes the developmental continuum aspect of learning to read and the importance of reading-related behaviors occurring before school.

Both behavioral and imaging studies on DD suggest that early reading skills are essential to the later development of reading. Most children start formal reading curriculum in kindergarten; however, at that time, many factors (genetic, SES, HLE, etc.) have already affected the future reading development. Moreover, early interventions work more effectively.

Brain regions (left inferior/middle frontal gyrus, bilateral fusiform gyri, and right anterior superior temporal gyrus) were identified to be especially sensitive to differences of early language/literacy exposure in beginning readers [67]. A richer HLE corresponded to increased brain activations during a phonological processing task [67] and increased brain activations related to high reading proficiency [76] demonstrated the underlying neural basis of reading. Among the children with a familial risk for DD, only around 50% of them will develop DD. The imaging evidence implies that a rich HLE might be one of the protective factors in reading development especially for children with a familial risk for DD. Future longitudinal studies are needed to examine how HLE contributes to the development of reading networks in the brain and its role as a protective factor in general.

Advocating emergent reading can benefit all children who are learning to read and especially those who are also at risk for DD. It is clear that aspects of HLE (e.g., shared reading) before a child entering kindergarten or preschool benefit the later reading development.

6. Conclusions

Emergent reading experience is crucial since it affects the development of reading. The formal reading curriculum usually starts in kindergarten. Before kindergarten, genetic and environmental factors have already affected the starting point for children. Research studies on DD have provided a rich body of evidence that reading acquisition is influenced by complex genetic and environmental interactions [48]. Recent studies started to focus on the importance of home literacy environment and emergent reading stage using brain imaging evidence.

7. Future directions

There are still a limited number of longitudinal imaging studies on emergent reading. In the future, research shall focus on studying which intervention approaches in emergent reading stage work the best using both behavioral and brain imaging data. In addition, how brain imaging evidence can be used in designing optimized interventions targeting emergent reading stage.

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Conflict of interest

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