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Commentary Open Access

Potential Effects of a Technology Pervasive World on Young Children's Brain Development

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Abstract

This commentary reviews changes in the social and play environments of infants and young children related to the pervasiveness of technology-augmented toys and other devices. The author discusses how early brain development, as well as cognitive, social, and emotional development may be affected by this environmental change and suggests that study of this phenomenon be a focus of child development specialists.

Keywords: Technology; Child development; Play

Commentary

It is now a common occurrence to see very young children attending to pictures on an electronic device while their parents enjoy a restaurant dinner, to observe them intently focused on electronic tablet images during a long airplane trip, or see them quietly amused by a video at daycare or preschool. Those of us from earlier generations who remember our frantic efforts to engage our young children in interesting activities when dining out, traveling, or just stressed out with caregiving may envy the ease with which such activities can be done today in our technology pervasive world. Even diapering can go more smoothly if an infant holds the parent's or other caregiver's cell phone! While there are certainly occasions when such devices can calm young children and ease stressful situations, there are many questions regarding what the long term and pervasive consequences of their use may be on young children's brain development and ultimately on their social, emotional, cognitive, and even physical development.

Although the American Academy of Pediatrics [1] has made policy statements regarding the amount of time that children of various ages should be involved with technology-augmented devices, and the National Association for the Education of Young Children [2] has given guidelines for careful use, the opinions from these organizations do not seem to be having much influence on parental and other caregiver use of such devices with young children. Not only are the children engaged in technology use but often adult's concentrated focus on their own phones or other electronic devices inhibits their full engagement in interactions with their children.

At the same time that these changes are occurring in parent/caregiver/child interaction, the research on how young children's brains develop is increasingly showing that the types of human and technological interactions infants and preschoolers have will greatly influence brain synaptogenesis, myelination, pruning, and thus, all other developmental areas. The sequence of brain development in infants and young children has been well charted and at birth, the neonate has about 100 billion neurons, which compose most of the neurons the individual will have throughout life. However, many neural networks are not initially established so the process of synaptogenesis (creating neuronal network connections) is of great importance during the early years. Also, the coating of nerve axons with fatty glial cells (myelination), which act to speed neural signals, and the pruning of networks that are used less often begins during this age period. Frontal lobe synaptogenesis is extensive during the age one to two year period, and by age three, the child's brain has about 1,000 trillion overall connections [3].

Synaptogenesis is especially active during the first year in the occipital lobe (vision) and in the parietal lobe of the cortex (involving motor and sensory abilities). These early areas of synaptic growth give rise to "enactive" cognitive representation, which Bruner [4] has characterized as the earliest mode of understanding. Young children's early motoric experiences encode knowledge in motor/sensory brain areas, which they then can apply to other actions in the environment. Bruner asserts that this early form of cognition is an essential pre-requisite for cognitive development of later "iconic" (pictorial images) and "symbolic" (letters, numbers, other cognitive areas) understanding. During the toddler and preschool years extensive synaptogenesis promotes increasing ability to understand iconic and symbolic levels of thought, but these are built upon the inactive level of experiences.

More recently research has shown the early activation of "mirror neurons," located in the premotor cortex, which connect portions of the parietal lobe with the occipital lobe and various other areas in the cortical regions [5]. These neurons seem to involve the transformation of visual information into understanding the actions of others by promoting the child's physical imitation of the observed behavioral acts. This process is easily observed in infant early social interaction with parents or other caregivers, but young children's understanding of the actions of objects (e.g., toys) also may involve the mirror neuron system [6]. Researchers have described this brain mapping and mirror neuron activity occurring in infants when they participate in child/parent social play interactions [7,8]. The infant brain is extremely active during such interactions, suggesting that these early brain mappings may be predictive of infant social attachment. It is presently unclear whether similar or different mappings will occur when infants interact with technology-augmented toys, phones, tablets, or robotic creatures.

If young children spend more time in technology-augmented play, this type of engagement may result in fewer interactions with parents, other caregivers, other children, and even with physical objects in the environment. Thus, brain developmental patterns and enactive cognition in such children may differ from that of children in past generations. For example, one study of a toddler who used CD-ROM technology extensively showed that the child began to "click" his parents to gain their responses to his demands [9]. It is already common for parents to report that their young children who have used various technology devices often press their finger on the TV screen or on pictures in magazines, thinking that the images can be activated that way. Thus, their motoric schemes (and cognition!) seemed to have been affected by their technology-augmented experiences. If, as Bruner suggested, enactive cognition is the first step leading to higher orders of cognition, the diminishment or reconfiguration of enactive cognition may result in other cognitive variations. Theorists such as Wilson [10] who discussed the importance of "embodied cognition" speculate that sensorimotor experiences may underlie cognitive processes at all age levels, influencing thought processes not only in early childhood but at all age levels.

In a discussion of learning through play [11] stresses the role of embodied cognition. He suggests that designers of technology-augmented play materials should include experiences that involve physical interactions and involvement of all sensory modes. Because in the future young children's play will include technology-augmented devices, attention to the design of such devices should involve play designs that encourage embodied experiences, thus promoting enactive cognition. However, it is also important that young children continue to have many "real world" experiences involving play with parents and other caregivers, play with children of various ages, outdoor as well as indoor play, and physical interactions with "real world" materials. Young children need to continue to have multiple experiences with the natural environment and the human social world as well as the technology world if human versatility and resilience are to continue to exist [12,13].

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