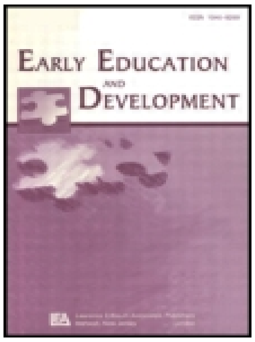

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Neuroscience in the Capital: Linking Brain Research and Federal Early Childhood Programs and Policies

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Research Findings: Each year the federal government disburses billions of dollars to support young children, with a particular focus on assisting families facing hardships. Policies for children revolve around several fundamental themes, including the promotion of physical health and high-quality environments, intellectual and language skills, emotional well-being, and interpersonal relationships, which are also areas of focus in the increasingly interdisciplinary neuroscience and child development research communities. *Practice or Policy:* Through intentional and skillful dialogue, the field of brain and cognitive research can collaborate with the early education and care and policy communities to create meaningful changes rooted in the science of human development. Research on the relationships between social and environmental variables and child outcomes should work in concert with a coordinated approach to creating and presenting policy recommendations.

Each year the federal government disburses billions of dollars to support young children, with a particular focus on assisting families facing hardships. Because of the immense scope of the government's work, it is critical that its programs and policies be founded on evidence and scientifically sound arguments. Neuroscience in particular has an ever-growing body of knowledge related to children's development in a number of domains—from movement to language, attention, problem solving, and even ethics—that is relevant to ongoing child policy conversations, especially targeting the unique period of neural growth from prenatal development through age 8.

Policies for children revolve around several fundamental themes, including the promotion of physical health and high-quality environments, intellectual and language skills, emotional well-being, and interpersonal relationships (Huston, 2002). It is no coincidence that these are also areas of focus in the global neuroscience and child development research communities, as they form the foundation for development and well-being through the life course. Individual biology combines with environmental influences to weave trillions of microscopic connections in an individual's brain. Neuroscience and government both seek to better understand how to shape the environment to optimize opportunities for development. The federal government is responsible for multibillion-dollar early education programs (including Head Start; the Child Care and Development Fund; and the Maternal, Infant and Early Childhood Home Visitation Program) as well as extensive research, analysis, and outreach related to children's development, all of which provide tremendous opportunities for collaboration.

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Following an overview of salient neuroscience research findings focused on early neural development, this article highlights several avenues through which the government currently interfaces with neuroscience in the context of early childhood health and education, in addition to presenting opportunities to use communication and coordination to leverage findings from brain research to improve federal early childhood programs and policies.

KEY NEUROSCIENCE RESEARCH FINDINGS

Researchers have gained considerable ground in linking children's physical and social environments and their developing brains and behaviors. Effects of the environment originate at the molecular level with microscopic interactions between single neurons and can grow to influence complex systems throughout the nervous system. The neuroscience findings described here are all areas of ongoing research that are inherently connected to the early education and development community.

The brain's innate *plasticity,* or ability to establish and modify patterns of thinking and behavior, is most malleable in the first several years of life, though neuroplasticity extends for years after (National Scientific Council on the Developing Child, 2007). Learning takes place throughout life, yet the brain is most sensitive to experiences early on, both positive and negative. Babies are born with more neurons than they will have as adults, and the neural pruning that takes place during the infant and toddler years is a critical mechanism for development. Different systems will mature at different times, with the sensory pathways—such as hearing and sight—typically established during the first 12 months of life, whereas language development continues through childhood, and the development of higher cognitive function continues into adolescence (Shonkoff & Phillips, 2000). The early years represent the most unique and valuable opportunity to support children's environment and promote healthy development proactively.

Neuroscientists have analyzed how the physical and social environment shapes development in many domains, and animal models have generated valuable insights into the molecular underpinnings of brain plasticity beyond what is currently possible to study in humans. For example, researchers have examined enriching rat environments with visual, motor, somatosensory, and cognitive stimuli to provide more novelty and complexity and assess the emergent neurological and behavioral changes (Nithianantharajah & Hannan, 2006). When motor activity is enhanced, for example, researchers have documented an increased proliferation of cells in the hippocampal region of the rat brain involved in learning, as well as an increase in the number and survival of certain cells in the cortex and increased levels of brain-derived neurotrophic factor, which is critical for neuronal signaling. Enrichments in developing animals' environments are in some ways analogous to the quality of home and community settings that influence young children.

However, though rat and human nervous systems have some mammalian features in common, it is not always possible to convert findings from animal models to useful insights into the human population. Neuroscience is beginning to link animal studies of specific genetic regions to environmental factors and to gradually explore parallel linkages in humans (see Hyman, 2009; McGowan et al., 2009). In translating this research to humans, the challenge facing scientists is to identify suitable analogs from rats to humans, both for the neuronal circuitry and genetic coding involved and for the complex objects and activities the make the rat and human worlds quite distinct, and, eventually, to determine how to overcome the limitations of such analogs.

In addition to the physical components of the environment, a number of intangible factors can penetrate and influence the developing nervous system. Stress appears in three types: positive, tolerable, and toxic (Shonkoff, Boyce, & McEwen, 2009). Of these, toxic stress, especially during the sensitive early years, can fundamentally alter a young child's behavior and brain architecture. Toxic stress in children can poison the social environment through abuse, neglect, or extended exposure to violence, which may be related to deep poverty, parental substance abuse, or severe illness (National Scientific Council on the Developing Child, 2007). Children who were victims of parental abuse during the first decade of life, for example, have been shown to make incorrect judgments about facial expressions and overinterpret neutral signals as threatening (Pollak & Kistler, 2002).

Now more than ever, neuroscience encompasses genetic research techniques and is connecting to the burgeoning field of *epigenetics,* the study of changes in an organism's genetic expression beyond what is coded by DNA, including influences from the external environment (see Miller, 2010, for a review). The hypothalamic–pituitary–adrenal axis (HPA), which processes the body's stress reaction and cortisol production, can alter its responsiveness through development. Maternal care, which for rats entails varying degrees of licking, grooming, and arched-back nursing, has been shown to influence HPA function through epigenetic regulation of glucocorticoid receptors in the nervous system (Weaver et al., 2004). More recent research has seen these findings reflected in the brains of human suicide victims who suffered childhood trauma (McGowan et al., 2009) and in cortisol production among foster children during caregiver separation (Dozier, Peloso, Lewis, Laurenceau, & Levine, 2008). Steven Hyman, a neurobiologist and former director of the National Institute of Mental Health, reported that ''severe adversity during childhood has been linked to markedly increased responsiveness of the autonomic nervous system and the HPA axis to stress, depression and suicide attempts'' (Hyman, 2009, p. 242).

The quality of early social interactions and the childhood environment influence the experience-dependent shaping of high-level brain circuits (Knudsen, Heckman, Cameron, & Shonkoff, 2006). Language and executive function—which encompasses impulse control, working memory, and cognitive flexibility—are two important ways that environmental influences become manifest in thinking and behavior. In fact, executive functions have been shown to correspond more strongly with school readiness than intelligence quotient or entry-level reading or math skills (Diamond, Barnett, Thomas, & Munro, 2007). Studies have begun to link language and executive function with socioeconomic status and cognitive style (see Hart & Risley, 2003, for a discussion of language development relative to socioeconomic status). Increased socioeconomic status has been associated with an ''increasing tendency to resist impulses and delay gratification,'' which can have important consequences in family and educational settings (Farah et al., 2006, p. 167). Rising in tandem with this cognitive research is an increasing focus on the progression of children's social-emotional skills and the affective components of learning, and those in the early education community have seen a related increase in discussion of autism spectrum disorders and developmental screenings in child care settings.

These examples of key scientific insights in human development form the foundation for discussion and cross-disciplinary applications of neuroscience in policy and practice. Researchers continue to investigate how the human environment influences brain architecture, cognition, and behavior, and this ever-growing body of findings has armed science communicators with data and policy recommendations to share beyond the research community.

NEUROSCIENCE AND POLICY

Legislators on Capitol Hill have taken notice of the rise of the brain sciences. In May 2010, the bipartisan Congressional Neuroscience Caucus was approved, chaired by Representative Earl Blumenauer, a Democrat from Oregon's 3rd Congressional district, and Representative Cathy McMorris Rodgers, a Republican from Washington's 5th Congressional district. Congressional caucuses are groups of senators and representatives who convene around a central theme to discuss objectives and build consensus. The mission of the Congressional Neuroscience Caucus includes building awareness of the intrinsic role brain research plays in understanding human society, communicating the findings and benefits of this research, and determining avenues to inform federal policy, with a focus on health and neurological disorders (Blumenauer, 2011). Although the Congressional Neuroscience Caucus is still fairly new, it aims to sponsor briefings on neuroscience research, collaborate with advocacy organizations to build awareness, reach out to others on Capitol Hill, and develop and promote legislation to support the field of neuroscience.

Smaller scale initiatives in states have been progressing parallel to those at the federal level. From 2005 to 2006 in Washington state, legislators sought input from researchers and business professionals on evidence-based changes to early childhood policies that ultimately led to House Bill 2964, which consolidated disparate funding streams and programs to create the Department of Early Learning. State Representative Ruth Kagi, a long-time member of Washington's House of Representatives and one of the bill's sponsors, sought out neuroscience expertise on early neural development—such as language acquisition and the biological effects of prenatal drug use—and helped involve scientists in the dialogue around the bill (Center on the Developing Child, 2006). Researchers presented findings on early development to legislative committees, and in Seattle the National Conference of State Legislatures sponsored an event titled ''Breakthroughs in Early Learning: Advances in Science, Economics, and State Policy'' several months before the final bill came to a vote.

On March 28, 2006, Washington Governor Christine Gregoire signed the bill, streamlining existing structures into a ''more cohesive and integrated voluntary early learning system'' to promote ''better employment and early learning outcomes for families and all children'' (Washington H.B. 2964, 2006, p. 2). Evidence of the impact of substance abuse on the child's growing brain, both prenatally and in childhood, has provided support for the integration of parental engagement activities into early care and education programs (Shonkoff & Phillips, 2000). In Representative Kagi's words, ''Science, and the research around what works, helped us decide where we should be investing our money'' (National Research Council and Institute of Medicine, 2010, p. 2). The policy change focused on birth through age 6, including the transition to kindergarten. Although the restructuring of the state's early care system alone may not have immediately impacted children's outcomes, the process of engaging researchers with policymakers raised awareness of the neuroscience issues specific to early life and helped promote meaningful changes to the system.

Research focusing on early childhood neural and cognitive development has also stirred policy changes abroad. Intervention studies, which have been launched in numerous countries, provide compelling examples of the reach of experimental studies to advocate for children. Present-day longitudinal studies documenting the effect of environmental deprivation on child development trace their roots back several decades. Howard Skeels, who longitudinally tracked orphans cared for by institutionalized women in Iowa beginning in the 1930s, and J. M. Hunt, who assessed infants' outcomes in Iranian orphanages in the 1970s, were two pioneers in the field (see Hunt, Mohandessi, Ghodssi, & Akiyama, 1976).

In a more recent example, a team of neuroscientists, psychiatrists, social workers, pediatricians, and others from multiple universities collaborated on the Bucharest Early Intervention Project (BEIP), which was launched in 2001 to examine the biological, cognitive, and emotional effects of early institutionalization in Romania (Nelson et al., 2007). Prior to the study, Romania did not have a system of high-quality foster care, so the researchers recruited guardians who were patient, sensitive, responsive, and consistent to accept foster children. One randomly selected group of 68 children between 6 and 30 months old was moved from the orphanage into foster care while a matched group did not receive the intervention. The group who moved to foster care saw cognitive and physical gains related to the age at which they were transferred; outcomes were worst for children who stayed in an institution until a later age, even when the length of time they were subsequently placed in foster care was controlled.

The institutionalization of children has been a major political issue in Romania, and the BEIP had important implications for law and policy related to children raised in institutions. The BEIP team worked with the United States ambassador to Romania and the Romanian government to help pass a law that forbid institutionalization for most children under the age of 2 and also helped create more government-sponsored foster care. Further neuroscience-focused intervention studies have the potential to illuminate details about how the timing and duration of interventions can improve outcomes for disadvantaged children (Shonkoff & Phillips, 2000).

GOVERNMENT-SUPPORTED EARLY CHILDHOOD STUDIES

Longitudinal studies like the BEIP provide some of the richest data on early childhood development. Over the past several decades the federal government has funded and coordinated a number of large-scale longitudinal studies focusing on children's cognitive development, educational programs, environments, and other factors that affect their growth. Although many of these studies are still under way, others have provided immense data sets for researchers to explore relevance to programs and policies, such as Head Start and Early Head Start, child care subsidies, and home visiting programs for new mothers.

Multiyear, multisite studies of early childhood development have been coordinated by different agencies. For example, the U.S. Department of Education's Institute of Education Sciences administered the Early Childhood Longitudinal Study birth cohort, a nationally representative sample of 14,000 children born in the year 2001 that includes children from diverse socioeconomic and ethnic backgrounds. The Study of Early Child Care and Youth Development at the National Institute of Child Health and Human Development (NICHD) began collecting data from more than 1,000 children in 1991. The study investigated connections between type of child care; number of hours spent in care; and other factors related to health, language, social, and cognitive outcomes at elementary school entry—aspects that touch on programs across federal agencies (NICHD, 2006).

Over time, these federally funded longitudinal studies have begun incorporating more neuroscience variables into the study design to more directly assess biological dimensions of children's development. The National Children's Study (NCS) at the NICHD is the largest example. In 2010, the NCS began recruiting children and mothers to participate in observational assessments from before birth until age 21. The NCS is congressionally mandated to ''incorporate behavioral, emotional, educational, and contextual consequences to enable a complete assessment of the physical, chemical, biological and psychosocial environmental influences on children's well-being . . . which may include the consideration of prenatal exposures'' (Children's Health Act of 2000, p. 1131). indicating a clear focus on brain science. The NCS aims to ''be one of the richest research efforts geared towards studying children's health and development and will form the basis of child health guidance, interventions, and policy for generations to come'' (NCS, 2010).

The NICHD plays a unique role by not only funding external research but also supporting its own scientists in areas ranging from genetics to children's nutrition, behavior, developmental disabilities, pharmacology, and reproductive sciences (NICHD, 2010). In many cases, these same scientists along with colleagues from other agencies contribute to federal interagency working groups and summits that reflect the applied side of the research topics and are useful for developing consistent messages for government agencies to disseminate to their communities. Such applications can include public health announcements, the publication of guidelines and best practices for families and early education professionals, and online evidence-based resources.

The National Science Foundation's Directorate for Social, Behavioral and Economic Sciences assesses recent advances in genomics, neuroscience, computing, imaging, and other areas in light of their policy and economic implications for federal agencies. In the report *Social, Behavioral and Economic Research in the Federal Context,* the authors highlighted emerging neuroscience research on a number of topics in early childhood development, including brain changes accompanying interventions for dyslexic children (National Science and Technology Council, 2009). The National Science Foundation has provided funding for translational research connecting anatomical changes in the brain with educational interventions, including learning disabilities and dyslexia in children.

Since 2000, the U.S. Environmental Protection Agency (EPA) has conducted meta-analyses of impacts of environmental contaminants and childhood illnesses on children up to age 18 as described in its publication *America's Children and the Environment.* Of particular relevance to the early education community is that the EPA's analysis examines links between lead exposure and disrupted cognitive development and behavior disorders: Children younger than the age of 6 are particularly vulnerable to lead exposure and its effects because of age-related risk factors such as hand-to-mouth behavior, small body mass, and a developing nervous system (U.S. Environmental Protection Agency, 2003). Because children are exposed to and are affected by environmental contaminants differently than adults, the report's findings are linked to child-focused policy recommendations, which range from helping ensure that playground equipment is not manufactured with wood treated with toxic preservatives to launching an initiative to create healthier classrooms.

ECONOMIC IMPACT

Some of the most important discussions scientists should weigh in on concern funding. Initiatives that support children, especially vulnerable populations, are necessary to build America's next generation (Shonkoff & Phillips, 2000). Children with unstable family situations, financial insecurity, and poor health conditions face undue hardships. Local, state, and federal funding is allocated to children raised in poverty to confront ''their increased risk of academic failure, unemployment, teenage parenthood, and criminal behavior as young adults,'' and over time ''these efforts have been undergirded by results from randomized experiments demonstrating enhanced outcomes associated with high-quality preschools or educational intervention in child-care settings targeting poor children'' (Pungello et al., 2010, p. 411). Scientists can not only advocate for enhanced funding to support research in this area but also inform the debate on how money for early care and education should be best spent. In the case of Washington state, for example, research pointed to the benefits of streamlined programs for young children and their families as a vehicle to support healthy development.

Research tying child development findings to economic outcomes has focused on the High/Scope Perry Preschool Project in Michigan, the Carolina Abecedarian Project, and Chicago's Child-Parent Centers, all of which have already yielded several decades of data, albeit lacking a strong neuroscience component (see Heckman, 2007, for a review). For families with few financial resources, such interventions can provide a tremendous boost. These intervention studies have shown that an investment during early childhood in high-quality early childhood programs can more than repay itself in later years (Knudsen et al., 2006). Such programs require substantial funding in the short term, but ''effective programs for such highly vulnerable, young children are likely to generate a substantial return on investment through significant reductions in the later costs of special education, grade retention, welfare assistance, and incarceration'' (National Scientific Council on the Developing Child, 2007, p. 8). Ultimately, these investments can save taxpayer dollars.

Cost-benefit analyses and other economic implications of education and health interventions for children will be an important factor in determining when and how interventions can be implemented on a large scale.

PARTNERSHIPS WITH PROFESSIONAL ORGANIZATIONS

Government agencies frequently provide funding, coordinate formal networks of stakeholders, or develop other partnerships with nonfederal organizations to draw on a body of expertise and explore innovative ideas. The field of brain science is no exception and has contributed to robust collaborative efforts.

The Society for Neuroscience (SfN) coordinates a number of advocacy initiatives that allow scientists to engage with congressional leaders and others with a stake in policy that influences early childhood settings. The SfN Advocacy Network, for instance, was launched in June 2008 and totals more than 1,100 members nationwide. Through this channel, SfN encourages its member neuroscientists to communicate with their local government officials to share their subject matter expertise and enthusiasm. In several states, neuroscientists have given policymakers tours of their labs as ''a forum to discuss the local and national importance of neuroscience research and how research funding is a proven pathway to better health and a stronger economy'' (Society for Neuroscience, 2009, p. 38). Communications from the SfN network are bidirectional, both encouraging scientists to bring their findings to Capitol Hill and also keeping the research community aware of legislative and budgetary action. Throughout the year, SfN also promotes Brain Awareness Week, an educational outreach effort to demonstrate the importance of neuroscience research to a wide audience, including children and students.

In the area of early childhood programs and policies, the American Academy of Pediatrics is one of a number of medicine- and science-oriented professional societies that works directly with the federal government through contracts, grants, cooperative agreements, and other arrangements. The American Academy of Pediatrics collaborates with the U.S. Department of Health and Human Services (HHS) to develop evidence-based, health promotion–focused online tools for both parents and child care professionals, drawing on the knowledge of the nation's largest group of pediatricians, pediatric nurses, and other childhood health professionals. A versatile aspect of these tools is that they live in the public domain and may be accessed free of charge. Zero To Three, a nonprofit organization whose mission is to improve the lives of infants and toddlers through education and outreach, has also worked with HHS on publications, events, and technical assistance specifically related to highlighting the importance of the first 3 years of life. A recent request for proposals from the HHS Office of Head Start sought projects related to buffering children from toxic stress through parenting interventions at Early Head Start, an obvious opportunity for an external organization to serve as a bridge between the research and programmatic sides of this topic.

The role of neuroscience in education was highlighted at a 2009 SfN summit led by then-president of SfN Tom Carew titled ''The Promise of Interdisciplinary Partnerships Between Brain Sciences and Education'' (Carew, 2009). The meeting convened experts in various fields with the ''common goal of understanding the developing brain, and how it acquires, stores, and retrieves information at different stages of maturation,'' said Carew (p. 1). Those coming from a K–12 education background brought a number of important concerns at the intersection of brain science and education, such as critical periods, how to promote students' long-term retention, self-regulation, and the effect of technology in the classroom. Among the participants' conclusions was the need for engagement from distinct fields, such as psychology, cognitive science, engineering, genetics, education, and neuroscience, to generate the richest scientific foundation for policies and curricula. However, the early care and education field was ostensibly absent from the summit. Initiatives such as the 2009 summit should encompass the earliest learning and brain development and invite early childhood professionals to highlight these topics alongside their school-age teacher counterparts.

COMMUNICATION AND COLLABORATION

Communication between early childhood policymakers and neuroscience researchers holds great promise. Yet strategies for communication within the federal government and with external groups require different approaches. Although major federal policy decisions are at the discretion of government officials, organized and unorganized constituency pressures can penetrate and influence the policy process (National Research Council, 1982).

Within the government, conversations about the scientific evidence base for programs and policies require communication between different agencies and offices. The Office of Program and Public Liaison (OPPL) at the NICHD, for example, coordinates communication between the scientific network at the National Institutes of Health and those working on legislation and congressional reports on Capitol Hill. In some cases, legislative staff will solicit feedback on the scientific soundness of a specific proposal, which could include research on or funding for children's health and education programs.

One responsibility of the OPPL team and similar offices, besides verifying the scientific base with NICHD-based researchers, is to identify possible duplications of effort. For instance, even if a senator's proposal to construct a new autism research center in his or her state may seem practical, such legislative proposals rarely come with funding attached. Any financial resources used for the new project, therefore, could be diverted from existing efforts in the same area, potentially diluting support for successful ongoing autism-related programs. The senator and constituents would be advocating for new programs in his or her state without an accurate understanding that they would detract from necessary resources already committed elsewhere. Examining the evidence base of new programs and reducing duplicative efforts is fundamental to determining the course of action, balancing both the government's finite resources and the needs of children across the country while OPPL is one group working as a bridge across fields, broader linkages are required to establish infrastructure for deep and continued communication.

A major challenge for the communication of science findings as they apply to early childhood settings is the creation and promulgation of a consistent, evidence-based message. Policymakers are flooded with information and ideas from advocates on all sides. It is often easier for them to rely on popular media and non–research organizations to learn about science rather than the researchers who actually conduct the studies. Yet some argue that researchers have a professional responsibility for educating the public and that it is irresponsible for the scientific community to allow the media to control the broad perception of the field and its findings (Bertenthal, 2002). It is critical for researchers to intentionally and skillfully promulgate policy recommendations that are consistent with their research findings (Gruendel & Aber, 2007).

One organization dedicated to leveraging brain science for use in policy and practice is the National Scientific Council on the Developing Child, a collective of faculty from multiple universities established in 2003 that has convened to synthesize concise, factual messages tying early childhood brain development to learning outcomes. Following the publication of *From Neurons to Neighborhoods* (Shonkoff & Phillips, 2000), a cohort of neuroscience and human development experts came together to continue the momentum around the topic and established the Council. Based at the Center on the Developing Child at Harvard University, the Council has created a library of resources, including working papers, videos, and Web-based tools that dive deeply into topics including toxic stress, maternal depression, gene expression, and others (see National Scientific Council on the Developing Child, 2007). The Council's charge is to link neuroscience with programs, interventions, and nonpartisan policy recommendations—such as the instrumental efforts in brokering the policy changes in Washington state—that support vulnerable children and families.

CONCLUSION

These efforts represent the first steps in bridging neuroscience and federal policy in the context of supporting young children and their families. Representatives from many fields—including health, brain science, education, psychology, and policy—have unique and valuable voices to contribute to the evolving dialogue. Science researchers should establish contact with advocacy groups and professional societies to bring greater visibility to their work and reach out to other researchers working on similar topics to brainstorm potential applications to policy. Scientists should reach out to policymakers by writing letters, making phone calls, and setting up meetings at local or national offices. Likewise, policymakers and early childhood practitioners should communicate with one another to identify urgent research questions and develop a policy research agenda.

The field of neuroscience expands each year, along with research in child development, education science, and economics. Understanding the causal relationships between environmental variables and child outcomes over time will require not only expertise across the disciplines but a coordinated approach to creating and presenting policy recommendations. For research findings to translate into improvements in children's programs and policies, there should be an infrastructure for communication in the government, a renewed focus on collaboration, and an unwavering commitment to the positive development of children.

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