# Science Does Not Speak for Itself: Translating Child Development Research for the Public and Its Policymakers

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Science has an important role to play in advising policymakers on crafting effective responses to social problems that affect the development of children. This article describes lessons learned from a multiyear, working collaboration among neuroscientists, developmental psychologists, pediatricians, economists, and communications researchers who are engaged in the iterative construction of a core story of development, using simplifying models (i.e., metaphors) such as ''brain architecture,'' ''toxic stress,'' and ''serve and return'' to explain complex scientific concepts to nonscientists. The aim of this article is to stimulate more systematic, empirical approaches to the task of knowledge transfer and to underscore the need to view the translation of science into policy and practice as an important academic endeavor in its own right.

The vitality and sustainability of a society depend on the extent to which it equalizes opportunities early in life for all children to achieve their full potential and engage in responsible and productive citizenship. Central to the achievement of this vision is the ability to leverage credible knowledge to facilitate productive learning, adaptive behavior, and sound physical and mental health.

There is a widespread assumption that science has a role to play in advising policymakers on

crafting responses to complex social problems, including those affecting children (Gregory & Miller, 1998a; Huston, 2008; Lubchenko, 1998; Shonkoff, 2000). There are also many countervailing forces that impede the fulfillment of that role. The reluctance of scholars to engage in public communications has diverse drivers, including differences in opinion about when the science is ready for translation, challenges associated with conveying discrepant findings, concern over maintaining appropriate boundaries between scholarship and advocacy, and a desire to avoid charges from peers of publicity-seeking (Greene, 2001; Gregory & Miller, 1998b). These legitimate concerns are reinforced by the dissatisfaction some feel with the role of popular media in conveying scientific information accurately (Fuller, 2007). As one observer commented, ''Scientists exchange horror stories about the press the way laymen discuss their operation scars'' (Goodell, 1977, cited in Gregory & Miller, 1998b).

While each of these translation challenges warrants thoughtful investigation, this article describes a 7-year effort spearheaded by the National Scientific Council on the Developing Child and the FrameWorks Institute to use communications research to faithfully translate complex scientific concepts for policymakers and the citizens who elect them. The goal of the article is to demonstrate that science can be served credibly and the public

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can be better informed without serious distortions of complex concepts even as they are shortened and translated into lay terms. The intention of sharing the lessons learned from this experience is to stimulate a stronger focus within the academic child development community on the need for a more systematic approach to the task of knowledge transfer, particularly in light of the critical importance of evidence-based decision making to informing and improving contemporary child policy.

During the ''Decade of the Brain'' declared by the National Institutes of Health in the 1990s, multiple examples of the complex relationship between scientists and media were reflected in the often sensationalized coverage of ''new'' research on brain development, much of which was not new but clearly captured the public's imagination (Fuller, 2007). Although the increased attention focused on the early years was largely positive, the substantive content of the science was often misinterpreted or misrepresented. One example was the overgeneralization of research on critical periods that fueled the erroneous conclusion that human brain development is effectively solidified by the age of 3 years, despite the fact that critical (vs. sensitive) periods in the maturation of the human brain are the exception rather than the rule (Bruer, 1999; Knudsen, 2004). In other circumstances, misunderstanding by policymakers led to misguided responses, such as the distribution of classical music tapes to parents of newborns based on limited findings (in adults, not children) that listening to a Mozart sonata may enhance performance on a standardized developmental test (Jones & Zigler, 2002) Alternatively, credible research findings that were not framed in a clear and uniform message sometimes contributed more heat than light to important public debates. The controversy over the link between nonparental infant care and later aggressive behavior, and the disagreement among researchers over alternative interpretations of the study findings, is one example that is well known to the child development community (Eisenberg, 1997; National Institutes of Health, 1997).

Numerous approaches have been organized to address these problems. The Association for the Advancement of Science offers programs that train scientists to understand the process of journalism and sponsors fellowships to help them be better prepared to influence media (American Association for the Advancement of Science, 2009a, 2009b). The Hechinger Institute on Education and the Media focuses on helping journalists become better science interpreters, and the Aldo Leopold Leadership Program at Stanford University advises scientists on how to explain their work to public audiences, with special attention to policymakers and the press. The salience of this issue for the Society for Research in Child Development is manifested in its Office for Policy and Communications, Policy Fellowship Program, and publication of Social Policy Reports to bring relevant research to bear on policies affecting children.

This article describes a 7-year effort to address these challenges through a somewhat different strategy—to engage a multidisciplinary group of experts in an ongoing process designed to explain the science of early childhood development and its underlying neurobiology to key policymaking audiences in the United States. The methods used to address the explicit challenges of knowledge translation are rooted in the disciplines of psychological anthropology, cognitive linguistics, and political psychology to inform choices in the presentation of scientific findings (D'Andrade, 1995; Iyengar, 1987, 1991; Lakoff, 1996; Quinn, 2005; Strauss & Quinn, 1997). This approach has been applied to early childhood development (Davey, 2009) as well as other content areas (Bales, 2008; Gilliam & Bales, 2001). Although the article includes findings from a series of systematic investigations, it is intended to be viewed as an expository essay, not a conventional scientific paper. As such, it describes the development of an evolving partnership among a group of neuroscientists, developmental psychologists, pediatricians, economists, and communications researchers by summarizing findings that have been disseminated largely through the working papers of two nonprofit organizations, and beginning to approach the complex task of measuring impacts. The purpose of this article is to share insights and lessons learned from 7 years of collaborative work. The ultimate goal is to stimulate new thinking and encourage the use of a variety of innovative methods and strategies in the service of building a rigorous scholarship of knowledge synthesis, translation, and transfer from research to policy and practice.

## The Evolution of Promising Cross-Disciplinary Collaborations

With the publication of a National Research Council (NRC) and Institute of Medicine (IOM) report in late 2000 entitled, ''From Neurons to Neighborhoods: The Science of Early Childhood Development'' the opportunity arose for a vigorous,

science-based, public effort to close the gap between what we know and what we do to advance the healthy development of young children. To this end, the authors of the report stated in their concluding section, ''based on the evidence gleaned from a rich and rapidly growing science base, we feel an urgent need to call for a new national dialog focused on rethinking the meaning of both shared responsibility for children and strategic investment in their future'' (Shonkoff & Phillips, 2000).

In 2001, a working group was convened under the auspices of the MacArthur Research Network on Early Experience and Brain Development to consider what impact leading scientists could have in advancing that call for a new public discussion on the findings of the NRC/IOM report and its policy implications. The composition of the working group reflected three complementary interests: (a) neuroscientists who were invested in accurate public understanding of the rapidly emerging science of brain development, (b) members of the IOM/NRC Committee who were invested in maximizing the impact of their report, and (c) experts in the study and practice of communications who were invested in enhanced public understanding of what scientists have learned about the process of early childhood development. The initiative was designed to respond to a perceived need for more consistent messages that remained true to the science as well as a disciplined strategy within the broad child development community to reach a range of audiences that hold markedly diverse personal values and political views about how to raise healthy children (Fuller, 2007). In 2003, the vision of the working group was transformed into the establishment of the National Scientific Council on the Developing Child (http://developingchild. harvard.edu/initiatives/council/).

The scientists and scholars who chose to participate in this new venture were motivated by their shared concerns about preserving the integrity and credibility of the scientific community, protecting its reliability as a source of knowledge-based guidance for effective policy and practice, and mastering the challenge of transcending the cultural barriers that separate the worlds of science, policy, and practice (Shonkoff, 2000). They were also committed to incorporating communications expertise into their public presentations and written work, as well as enhancing their access to decision makers in the policy world. The first objective was addressed by establishing a partnership with the FrameWorks Institute, a Washington-based think tank that

studies the cultural models that people bring to their understanding of science (Kempton et al., 1995). The second objective was addressed by establishing a partnership with the National Conference of State Legislatures (NCSL) and later with the National Governors Association Center for Best Practices (NGA), which essentially short-circuited the need for media translation to these influential bodies in U.S. state-level policy. Recognizing that policymakers hold many of the same cultural models about science as the general public (Gonzalez, 1984) and that government leaders are rarely presented with information from influential constituents that conflicts with these models (State Legislative Leaders Foundation, 1995), the Council proceeded to develop communications practices grounded in an understanding of the mental models and predictable biases that influence how policymakers and the general public think about issues and respond to data (Kempton et al., 1995; Walker, 2009).

Since its inception, the overarching mission of the National Scientific Council has been driven by three core strategies: (a) convening an active cadre of leading researchers in neuroscience and early childhood development to discuss current scientific findings and evaluate which aspects of the science are sufficiently credible to convey to those who make decisions about the allocation of public resources, (b) working with communications researchers to identify conceptual frames that advance understanding of the science of early childhood development and increase support for evidence-based policies to promote child health and well-being, and (c) transmitting accessible and accurate information about early childhood development to policymakers so that developmental science can be used to inform sound policy decisions. In order to accomplish these public education objectives, the members of the Council understood the need for expertise in formulating effective communication strategies to reach their target audiences. Thus, an enduring partnership was created with communications scholars and practitioners associated with the FrameWorks Institute, which has a mission to advance the communications capacity of the nonprofit sector through systematic study designed to frame public discourse more effectively (FrameWorks Institute, 2009; http:// www.frameworksinstitute.org).

In 2006, the National Forum on Early Childhood Program Evaluation was created to undertake the analysis, synthesis, translation, and dissemination of findings from intervention studies. Building on the Council's translation of basic developmental

concepts (e.g., notions of sensitive periods and decreasing neuroplasticity over time) to explain *why* investments in vulnerable young children can generate strong returns to society, the Forum was designed to answer the *what*, *when*, and *for whom* questions about effective programs. This task has been addressed through the analysis and translation of intervention studies from the prenatal period through age 5, focusing on key mediators of development as well as issues related to benefit–cost ratios and other societal goals. To this end, the Forum attempts to answer complex program evaluation questions (e.g., whether programs like Head Start ''work'') in the context of data whose interpretation is often the focus of intense disagreement among multiple constituencies (e.g., Besharov, 2005; Yoshikawa, 2005). In an effort to maximize opportunities for productive engagement with state-level policymakers, the Council and Forum, now incorporated within the recently established Center on the Developing Child at Harvard University (http://www.developingchild.harvard.edu), have leveraged a close working relationship with NCSL and NGA to enhance the leadership capabilities of policymakers by increasing their knowledge of the science of early childhood development and building their capacity to facilitate knowledge-based dialog that transcends political and ideological differences.

## Development of an Innovative Approach to Science Communications

Extensive research has demonstrated that people use mental shortcuts to make sense of the world, and that the presentation of new information provides cues to help connect that information to stored repositories of cultural models and schemas (Gigerenzer et al., 1999; Holland & Quinn, 1987). This process is known across multiple disciplines as ''framing'' (Gilliam & Bales, 2001). The FrameWorks Institute further defines framing as referring to ''the way a story is told—its selective use of particular symbols, metaphors, and messengers, for example—and to the way these cues, in turn, trigger the shared and durable cultural models that people use to make sense of their world'' (Bales & Gilliam, 2004). Frame elements (i.e., cues) in communications serve as powerful directives to the processing and interpretation of information in a wide range of domains, including the way individuals think about causes and potential solutions for major societal problems (Iyengar, 1987, 1991). Entman

(2007) identified four functions performed by fully developed frames—problem definition, causal analysis, moral judgment, and remedy promotion.

Strategic Frame Analysis, as developed by the FrameWorks Institute, integrates essential constructs from the cognitive and social sciences into the study and practice of communications. It relies upon an iterative, multimethod, empirical process to: (a) identify cultural models that people use consistently to reason about a particular issue, (b) compare and contrast these models to the content of expert thinking on that issue, and (c) develop and empirically test powerful frame cues (such as values and metaphors) for their ability to align lay judgments and solutions more closely with expert thinking (Bales & Gilliam, 2004, 2009; Gilliam & Bales, 2001).

The process of Strategic Frame Analysis typically begins with a series of recorded interviews with content experts, often supplemented by a comprehensive literature review. The product of this initial phase is a draft ''core story'' that captures the main principles that experts believe are important for informed citizens and policymakers to understand if they are to successfully apply science to the solution of societal concerns (Manuel & Davey, 2009). When possible, additional ethnographic techniques are used to analyze expert discourse (Kendall-Taylor & Mikulak, 2009), and interactions between content experts and communications researchers continue as they draft materials together for public dissemination. In this way, the communications researchers are engaged over time in learning the body of work that scientists wish to translate. While the communication that ultimately results from this translation process typically employs different language from that used by the content experts, the communications approach is held strictly accountable for assuring accurate representation of the core scientific principles. Stated simply, the imperative of scientific rigor and accuracy is always paramount.

Individual, semistructured interviews are then conducted with a sample of 20–50 engaged citizens (i.e., people who are registered to vote, attentive to news, and volunteer in their communities) varied by gender, education, parent status, and other characteristics relevant to the particular topic. These ''cultural models'' interviews are recorded, transcribed, and analyzed using methods adapted from the fields of cognitive anthropology and cognitive linguistics (Quinn, 2005). To validate and extend the individual interview findings, small groups of 8–12 comparably engaged citizens are then

recruited by local marketing firms and compensated to participate in 2-hr, guided, group dialogues that are recorded and transcribed for analysis. These peer discourse sessions are used to reconfirm the dominant cultural models that people bring to a particular topic, expose groups to alternative ways of framing an issue, and facilitate observed negotiations among the participants when they are exposed to various frames.

At the next step in the process, gaps or ''cognitive holes'' are identified that focus attention on critical areas of difference between lay and expert thinking. These areas are considered prime candidates for the development and deployment of ''simplifying models,'' which are defined as frame elements that reduce the complexity of a social or scientific concept to the form of a simple, concrete analogy or metaphor. An effective simplifying model enhances understanding of a complicated concept by helping people organize information into a clear picture in their heads, including facts and ideas that were learned previously but not organized in a coherent way (Kempton et al., 1995). Using linguistic analysis techniques (Lakoff, 1996; Lakoff & Johnson, 1980), FrameWorks researchers generate a series of candidate simplifying models in multiple metaphor categories. These models are tested empirically using a multimethod approach composed of on-the-street interviews, small group discussions, and quantitative experiments with a nationally representative sample. The culmination of this process is the identification of specific metaphorical models that can be shown to facilitate enhanced understanding of scientific concepts and their implications for informed policy responses.

The empirical process described above is grounded in the assumption that public officials reflect the values and beliefs of their constituents (Gonzalez, 1984). Thus, policymakers are viewed as forming opinions about science in much the way that ordinary people do—using heuristics to make sense of the information provided by media and colleagues within a cultural context. Huston (2008) noted the influence of both common sense and expert opinion on how policymakers reason about science-related issues, and it is that domain of widely shared cultural models that Strategic Frame Analysis is designed to capture in its interviews with legislators and voters who share their political culture. Thus, although the negotiation of public policy provides a distinctive forum for shaping perspectives, there is little to indicate that patterns of thinking about complex social issues are different among policymakers compared to the general public. Moreover, FrameWorks investigators have found legislators to be highly reliant on verbal discourse, images in public media, folk wisdom, common sense, and the views of their colleagues who have little expertise in science (Aubrun et al., 2005; Bostrom, 2005, 2006a,b).

The extensive database that has shaped the core story of development generated through this process is available on the FrameWorks Web site (http://www.frameworksinstitute.org). This includes information on recruitment and analysis procedures involving multiple samples reflecting significant diversity in terms of age, geographic location, political ideology, race, and ethnicity from the following sources: (a) 40 cultural models interviews with civically engaged voters in Arizona, Kentucky, Rhode Island, and Wisconsin (Aubrun & Grady, 2002); (b) two peer discourse sessions each in Arizona, California, Kansas, Massachusetts, New Jersey, and Virginia (Bostrom, 2002); (c) 40 telephone interviews to investigate simplifying models with respondents in California, Colorado, New York, and Washington State (Aubrun & Grady, 2003a); (d) a combination of in-person and telephone interviews and written surveys to confirm simplifying models, completed by 400 participants nationwide (Aubrun & Grady, 2003b); (e) in-person interviews with 72 participants nationwide to confirm simplifying models (Brown et al., 2006); (f) in-person interviews with 20 state legislators or staff in Connecticut, Maine, New Hampshire, and Rhode Island (Aubrun et al., 2005); (g) two peer discourse sessions with voters and two with policymakers in Arizona (Bostrom, 2005); (h) secondary analysis of interviews with 17 legislators in Ohio (Aubrun et al., 2006); (i) peer discourse sessions with 8 legislators in Kansas (Bostrom, 2006a); and (j) peer discourse sessions with 7 legislators in South Carolina (Bostrom, 2006b). The purpose of this work was to identify broad cultural constructs that inform public thinking across groups. Before proceeding further in this article, it is important to underscore that these data are presented as the cumulative results of a systematic approach to the pragmatic challenge of teaching nonscientists about what science has learned about child development, and not as the products of conventional, peer-reviewed research. With this caveat in mind, these findings should be viewed as practical information to guide efforts to translate science into policy and practice, as well as hypothesis-generating data to inform the kind of experimental studies that are needed to build a robust science of knowledge translation.

The core story of development currently being communicated by the Council, including the creation of three key simplifying models, is described in the next section.

## Specific Challenges in Translating Child Development Research

The task of translating the science of early childhood development presents three challenges. The first is to determine what needs translating. The second is to identify obstacles to public understanding. The third is to develop and verify the impact of specific frame elements that improve public thinking. The processes used to address these issues and the outcomes associated with each level of investigation are described next.

## Determining What Needs to Be Translated

Despite its considerable interest in science, the public's attention span is typically short. Polsby and Wildavsky (1988) underscored this challenge in their observation that "most (voters) are not interested in most public issues most of the time." Over the course of the past several years, FrameWorks investigators noted the additional challenge that information is best communicated to state legislators through an oral culture (Aubrun et al., 2005). Consequently, the Council and its communication partners concluded that it was essential to articulate a finite set of principles that characterize the essence of early childhood development and to embed these principles in a compelling narrative of how child development works, using scientific knowledge to help the public approach related policy concerns. This led to the concept of crafting a core story of development.

The first task in developing a core story required the participating scientists to discriminate between what is essential to understanding the process of development and what is more peripheral. This necessary discipline helped to prevent the compilation of a laundry list of disconnected information and was driven by the recognition that impact required consistent messaging. At the same time, the story that resulted was viewed as a common context for communicating individual research findings, not a restrictive formula to which all communications needed to adhere. Thus, participating scientists were encouraged to adapt different aspects of the resulting story as they perceived them to fit both their content and audience. In this way, the core story provided a valuable mechanism for linking a wide variety of dissemination activities involving a diversity of individual research interests. Thus, although different audiences may have heard about research on such varied topics as early language development, self-regulation, and gene–environment interaction, the central aim of the Council was to help policymakers and the public understand these diverse findings in the context of a unified and coherent story of how young children (and their brains) develop, including such critical issues as what develops, how it develops, what might undermine development, and what promotes it. Indeed, all of these story elements were found by the communications researchers to be missing components in the public's understanding and amenable to science communications, using frame elements.

Finally, the task of continually refining the core story provided the communications researchers with an indispensable tool to use as they approached their iterative investigative process. For example, comparing the core story established by content experts with the public's "folk" understanding of child development revealed important gaps in how nonscientists reason about this issue. These gaps (multiple examples of which are described next) presented promising opportunities for pursuing subsequent lines of investigation to design and test frame elements to determine how intentional framing could fill the holes. Stated simply, given the primary objective to bridge the gap between how experts explain issues and how the public understands them, it was essential to begin the research process by crafting a clear and coherent core story of the science of child development. It is important to note that this process proceeds indefinitely, as investigators continue to challenge, refine, and expand parts of the story as the frontiers of science continue to advance.

The method used for building and continually refining the core story has been highly interactive. At the beginning, through discussions and the production of working papers, the members of the Council added to and refined the foundational knowledge base presented in *From Neurons to Neighborhoods* (Shonkoff & Phillips, 2000). Grounded in basic concepts that had achieved consensus through many decades of developmental and behavioral research, this knowledge base was then expanded through the enhanced integration of new findings from the rapidly advancing neurosciences. Using an extension of the rigorous review process employed in the writing of IOM and NRC

reports, the Council was able to articulate over the course of several years an increasingly textured, compelling, and scientifically credible story of development. Concurrently, FrameWorks researchers participated in Council meetings, contributed to working papers, reviewed scientific findings, and conducted the investigations described in this article, all of which provided a rich opportunity to discover a common pattern of principles reflected in all of these products. As new scientific findings continue to be incorporated regularly into the ongoing communications research process, the basic architecture of the core story is conserved and the integrity of its essential principles is protected by not shifting its essential messages based on the findings of single, individual studies. At the same time, important additions to the core story are harvested continually, driven by ongoing interactions among scientists and communications researchers. The communications research agenda, in turn, evolves over time, as new issues (e.g., gene–environment interaction, executive function, resilience) are slated for further investigation because of a growing consensus about their salience and as the frontiers of investigation generate new insights that are deemed by the scientists to be ''ready'' for public consideration. In the sections that follow, we explain how this evolving story addresses both conceptual and perceptual problems in the cultural models people hold about child development and what frame elements have been incorporated to directly address these problems.

At the time of this writing, the core story of development that has emerged from this iterative process is grounded in the following key concepts (Center on the Developing Child, 2007; National Scientific Council on the Developing Child, 2007b):

1. Child development is a foundation for community development and economic development, as capable children become the foundation of a prosperous and sustainable society.
2. Brain architecture is constructed through an ongoing process that begins before birth and continues into adulthood. As it emerges, the quality of that architecture establishes either a sturdy or a fragile foundation for all the capabilities and behavior that follow.
3. Skill begets skill as brains are built in a hierarchical fashion, from the bottom up. Increasingly complex circuits and skills build on simpler circuits and skills over time.
4. The interaction of genes and experience shapes the circuitry of the developing brain. Young children serve up frequent invitations to engage with adults, who are either responsive or unresponsive to their needs. This ''serve and return'' process (what developmental researchers call contingent reciprocity) is fundamental to the wiring of the brain, especially in the early years.
5. Cognitive, emotional, and social capacities are inextricably intertwined and learning, behavior, and both physical and mental health are highly interrelated over the life course. You cannot address one domain without affecting the others.
6. Although manageable levels of stress are normative and growth promoting, toxic stress in the early years (e.g., from severe poverty, serious parental mental health impairment such as maternal depression, child maltreatment, and/or family violence) can damage developing brain architecture and lead to problems in learning and behavior, as well as increased susceptibility to physical and mental illness.
7. Brain plasticity and the ability to change behavior decrease over time. Consequently, getting it right early leads to better outcomes and is less costly, to society and to individuals, than trying to fix it later. We can pay now or we will pay more later for society's failure to promote healthy development in the earliest years of life.
8. Effectiveness factors make the difference between early childhood intervention programs that work and those that do not work to support children's healthy development. These factors can be measured and can inform wise investments in effective policies and programs.

## Identifying Obstacles to Public Understanding

Concurrent with the development of the core story, communications investigators have conducted extensive, descriptive research to elucidate the underlying patterns of thinking that nonscientists use to make sense of early childhood development. This investigation has yielded a number of findings that were addressed specifically in the composition of the core story.

First, policymakers and the public struggled to see child development as a public issue. Legislators

often decried the use of public funds for what they viewed as ''babysitting'' (Bostrom, 2006a, 2006b). Voters tended to consign responsibility for early childhood development almost exclusively to the family and failed to see a public purpose beyond individual well-being (Aubrun & Grady, 2002, 2003b). Thus, in an effort to establish why early childhood development matters to society, the core story begins with the assignment of a value of prosperity and asserts the link between individual and collective achievement. Numerous scholars have asserted the role that commonly held cultural values play in affecting sociopolitical preferences (Lakoff, 1996; Rokeach, 1979; Schon & Rein, 1994). The effects of the value of prosperity, and other values identified in qualitative research, are currently being tested using experimental surveys administered by the Political Communication Laboratory and YouGov/Polimetrix at Stanford University.

The major challenge identified by the qualitative research, which we are addressing in greater depth, is the finding that most people have only a loosely organized model of human development, which results in a limited understanding of what happens ''inside'' the child. This phenomenon presents the dilemma of a ''developmental black box'' (Aubrun & Grady, 2002), which leaves the public especially vulnerable to simplistic, automatic habits of thinking and less able to assimilate new learning into a coherent framework. Consequently, many conversations about early childhood development default to those aspects of childrearing that are deeply embedded in the political culture of the United States—namely, childrearing is a uniquely private concern, self-reliance is the main goal of the successful child, and physical safety is the primary concern (Bales, 2005).

One problem with these entrenched frames is that they run counter to contemporary scientific thinking about the dynamic and interactive nature of the developmental process. For example, when the development of young children is perceived to happen largely or even exclusively within the family, the influence of the broader environment is minimized relative to the deterministic perception of children's inborn characteristics and the specific actions of the adults who care for them. When parents (particularly mothers) are viewed as the only significant influences on their children's development, then the parent's individual motivation and effort become the overwhelming considerations. This perspective obscures the impact of broader contextual variables that contribute to greater developmental vulnerability or resilience, such as

poverty and discrimination or supportive neighborhoods and other sources of social capital. Alternatively, if physical safety is the primary concern, then societal attention focuses on external, physical threats, such as exposure to violence, and not on internal, developmental processes that can be impaired by adverse experiences and environments, such as the inconsistent caregiving that results from high staff turnover rates in child-care centers.

These illustrations of ''cognitive mistakes'' recur with predictable frequency because of the sketchy science available to the lay public as it tries to make sense of the multiple, causal mechanisms that might potentially influence the process of child development (Aubrun & Grady, 2002). These misperceptions are further cued up when developmental scientists reinforce the image of the child nested in the cocoon of the family. Stated simply, the public generally views child development as some combination of genes, fate, free will, parents, and environment that is stirred up within the mystery of a proverbial ''black box.'' When asked to explain how development happens, the analogies people use relate to sponges, blank slates, precious objects to be protected, young plants to be nurtured, clay to be molded, empty vessels to be filled, and little adults, among others (Bostrom, 2002). While these are often vague and inadequate, they nevertheless have consequences for the ways people think about what is necessary for healthy child development. Furthermore, because the models they use are scientifically inaccurate in many respects, lay observers are prone to judgments about programs and policies that are grossly at odds with the science of child development, such as the effects of chronic poverty on learning, behavior, and health (Aubrun & Grady, 2003a).

Most popular default frames and current models downplay the full range of young children's competencies and important interactions, concentrating attention solely on the domain of the family and on observable (largely cognitive) development. Consequently, key considerations related to the influence of a child's physical environment, the network of community relationships, and social and emotional growth are lost in the ''black box'' and remain largely invisible to most adults (Aubrun & Grady, 2002). While there appears to be broad acceptance of the idea that something important happens in the early years, this appreciation is based on a faulty understanding of brain development as a process of passive osmosis, not on a concept of

dynamic, interactive wiring of circuitry (Aubrun & Grady, 2003a). The burden that these perceptions impose on the policymaking process is evident when this pattern of thinking serves to further reinforce the public's tendency to assign responsibility for early childhood development solely to the individual family. This makes child development less a public good that supports a prosperous society and more a private achievement of autonomous individuals. Thus, the job of the effective science communicator is to provide more accurate models that are memorable and prove to be more conducive to science-based conclusions about how healthy development might be promoted on a broader, societal scale (Knudsen et al., 2006).

### Developing and Verifying the Impact of Specific Frame Elements

In response to these identified problems in public perceptions, three areas consistent with the core story were prioritized initially for further development: (a) the need to describe what develops in concrete terms, (b) the need to make visible the process of how development happens, and (c) the need to demonstrate why development is derailed in the face of adversity. Drawing on cultural models theory (D'Andrade, 1995; Kempton et al., 1995; Strauss & Quinn, 1997), FrameWorks investigators assigned these three challenges to the simplifying models process, which is designed to reduce a complex concept or idea to an understandable, concrete analogy or metaphor that helps people integrate information into a clear and coherent picture in their heads. Because simplifying models can serve to concretize and make vivid previously hidden or ill-understood aspects of a scientific or social phenomenon, they can help solve problems in public understanding or ''plug'' specific cognitive holes in people's thinking.

Simplifying models are tested according to a number of criteria. In the first stage, understanding and comprehension are typically probed through one-on-one interviews. After exposure to a simplifying model, the subject is asked to explain it and respond to specific questions. Candidate models that are found to be misdirecting are discarded and more promising models are tested for their communicability. Using ''persistence trials,'' in which groups of subjects explain to other subjects the model presented to them orally, researchers look for the model's inherent ability to be faithfully reproduced and taught across generations of repetition as

well as to self-correct and inoculate against interpretations that are at odds with the science. Finally, in quantitative testing, brief exposures to various models are analyzed for their effects on selected policy preferences to determine whether they can bring people closer to using scientific reasoning to think about proposed solutions. This is an evolving methodology that currently is experimenting with alternative quantitative designs for testing comprehension, communicability, durability and applicability (Kendall-Taylor & Mikulak, 2009).

### What Develops—The Circuitry and Architecture of the Brain

The first simplifying model to emerge from this process was brain architecture. Researchers reported that it focused attention on how the brain is built and strengthened, as well as how it might be weakened structurally (Aubrun & Grady, 2003b). For example, one focus group participant who was exposed to the model and then asked to explain the physiological consequences of severe stress associated with deep poverty on early brain development (i.e., elevated cortisol and its potential harm to developing neural circuits) stated, ''I think what really gets me from the study is that it could actually have a chemical or biological or some sort of impact on the child's brain. . . . Behavior is one thing, and attitude and personality is one thing, but if it can really negatively impact . . . the chemistry and the makeup of the brain—you can damage that that early—that's really serious. That's more than just having a bad personality, that's really screwing up a kid'' (Aubrun & Grady, 2003b). These kinds of findings underscore the need for science communicators to help nonscientists envision the material (i.e., concrete) factors that support development, rather than focusing primarily on mental (i.e., abstract) processes. It is for this reason that our evolving core story puts so much emphasis on the underlying neurobiology of skill development and behavior. The following is an example of the model as articulated by the Council. It is important to note that the concept of brain architecture, as it has been developed and used, is sufficiently flexible to be executed by scientists in numerous ways.

*Simplifying model #1: Brain architecture.* The early years of life matter because early experiences affect the architecture of the maturing brain. As it emerges, the quality of that architecture establishes either a sturdy or a fragile foundation for all the development and behavior that follow—and getting things right the first time is easier and more

effective than trying to fix them later. When interpersonal experiences are disruptive, neglectful, abusive, unstable, or otherwise stressful, they increase the probability of poor outcomes. When a young child experiences excessive adversity, chemicals are released in the brain that can damage its developing architecture (National Scientific Council on the Developing Child, 2007a).

### How Development Happens: From Mirroring to Serve and Return

Communications researchers initially recommended a simplifying model that used the concept of ''mirroring'' to explain the phenomenon of contingent reciprocity that characterizes the bidirectional nature of adult–child interaction in early childhood development. The idea that adults mirror a baby's actions and the baby then mirrors back the adult's responses was reported to strike people as new and instructive, and therefore was viewed by the communications researchers as a promising way to help people see why nonparental child care must involve one-on-one interactions with attentive providers (Aubrun & Grady, 2003b). When this model was presented to the Council scientists, however, they found it to be too passive and deficient in capturing the self-initiating aspect of the behavior of young children. Consequently, the communications researchers were sent back into the field to craft a model that made child–adult interaction more explicitly interactive. After two subsequent rounds of data gathering, employing both interviews and talkback chains with a total of 54 participants (Brown et al., 2006), a number of alternative candidates were tested (e.g., co-action, interplay) before a final decision was made in favor of the following model. This process of rejection and refinement of candidates for simplifying models underscores the struggle that lies at the heart of the science-communications partnership, a struggle that will be revisited later in this article.

*Simplifying model #2: Serve and return.*   Scientists now know that the interactive influences of genes and experience literally shape the architecture of the developing brain. The active ingredient in what we refer to as experience is the ''serve and return'' nature of the relationships that children have with their parents and other caregivers in their family or community. Like the process of serve and return in games such as tennis and volleyball, very young children naturally reach out for interaction through vocalizing, facial expressions, and gestures. If adults do not respond by getting in sync and engaging in responsive, complementary behaviors, the child's learning process is disrupted and there can be negative implications for later development, (National Scientific Council on the Developing Child, 2004).

### *Why Development Is Derailed: The Physiological Consequences of Toxic Stress.*

The initial round of simplifying models development suggested focusing on ''chemicals in the brain'' to capture the idea that excessive stress releases chemical substances in the blood that can weaken brain architecture or hinder its development (Aubrun & Grady, 2003b). Following this finding, an investigation of how people think about child abuse and neglect suggested that even when a developmental perspective was invoked explicitly, the lasting effects of abuse were typically viewed as something to overcome through effort, and not as physical and/or psychic ''damage'' to the developing child. This was labeled the ''baby bootstrap'' problem, as it so closely aligned with the U.S. cultural model of self-reliance and rugged individualism (Bales, 2004). Put another way, this model was suspected to be too weak to overcome the dominant frame of individual effort. Based on that initial recommendation, the Council supported a refinement and expansion of this simplifying model of stress-related chemicals in the brain. Consequently, in order to help people understand the deleterious effects of unremitting adversity and the buffering effects of caring adults, the model was amended to differentiate among ''positive, tolerable, and toxic stress.'' Initial investigations of the effects of this simplifying model on policy preferences have found that it yields substantial benefits to a wide array of child development policies (Manuel, 2009). Interestingly, the development of this particular model was accomplished in collaborative discussion among FrameWorks researchers, members of the National Scientific Council, and consulting journalists. Thus, although it is imperative that simplifying models address very specific cognitive holes and be tested empirically for their ability to do so (O'Neil, 2007), many of the best simplifying models may very well emerge initially from scientists themselves, as well as from journalists who are tasked with explaining complex processes to the general public. Once again, this process of cross-disciplinary conferral and empirical testing appears to yield the best communications outcomes. The following is a sample execution of the current model in use by the Council.

*Simplifying model #3: Types of stress.* Scientists talk about distinguishing among three kinds of stress experience, characterized by differing intensity and duration of elevations in heart rate, blood pressure, and a range of stress hormones (such as cortisol) that can damage organ systems when they are activated for prolonged periods of time. *Positive stress*, such as a physiological response to the first day in a new preschool setting, is normative and short-lived. *Tolerable stress,* which is associated with potentially serious threats such as significant family illness or a natural disaster, could be damaging to young children but they are buffered from long-term, adverse effects by the presence of supportive relationships, like a strong family when a loved one dies. In contrast, *toxic stress* lasts longer, lacks consistent supportive relationships, and can cause damage to the developing brain and other organ systems that leads to lifelong problems in learning, behavior, and both physical and mental health. Toxic stress in early childhood can be precipitated by extreme poverty, physical abuse, chronic neglect, or severe maternal depression or parental substance abuse, among other risk factors (National Scientific Council on the Developing Child, 2005; Shonkoff et al., 2009).

Finally, to determine the strengths and weaknesses of the three simplifying models as they were being constructed, small groups of legislators in South Carolina and Kansas were asked to view and discuss a 15-min video presentation focused on key aspects of the core story. Preliminary analyses of these discussions indicated that the brain architecture model succeeded in priming the South Carolina legislators to think about the foundations of development and strategies to prevent later problems, whereas the Kansas participants talked about the need for improvements in prenatal care (Bostrom, 2006b). It was also noted that many legislators from both states quickly picked up on the distinction between tolerable and toxic stress, both in terms of their precipitants and their physiological consequences. This part of the core story appears to be effective because the differentiation among levels of stress helps legislators understand the underlying biological mechanisms and gives them a framework to think about multiple influences on child development. Perhaps most important, most legislators agreed that listening to the core story together encouraged them to engage with fellow lawmakers and talk across partisan lines with their new understanding of the science of early childhood and the developing brain.

In summary, this collaborative, story-building task began with an initial series of investigations designed to enhance the capacity of developmental scientists to explain the process of child development and its underlying neurobiology. One next step is to conduct experimental studies to test the extent to which enhanced understanding of core concepts of early childhood and early brain development influences respondents' ability to choose among competing policy options that require informed judgment and an understanding of how the process of development works. Another step in the continuing process of science identification and translation is to continue to struggle with those concepts that scientists wish or need to communicate and that communication researchers endeavor to express in ways that can be demonstrated to achieve clarity and coherence for the public and policymakers. For example, scientists often assume that the public can readily understand the applicability of animal data to human development, whereas communications researchers suspect that it may be much harder for people to see that the development of animal brains follows comparable biological processes. These kinds of questions and hypotheses are discussed routinely and prioritized for future communications research. Such issues are investigated for their impact on science thinking among ordinary citizens and, as required, assigned to the simplifying models process in order to test metaphors that can be shown to deepen the public's understanding.

Finally, while it may be tempting to consign this process to the arena of public relations or science "spin," it should be acknowledged that the goal of the communications research discussed here is not to determine which presentation people like or endorse but rather which presentation gets them closest to seeing developmental processes in the way that scientists do. Stated simply, the aim is to communicate complex scientific principles simply but accurately, using techniques of investigation from the cognitive and social sciences in order to achieve that objective (Bales, 2009).

## Assessing the Influence of the Core Story on Public Discourse and Policy Decisions

Although the translation of research findings into policy development is a matter of great interest to a growing segment of the academic child development community, the measurement of impact remains a complex and formidable challenge. Central to

this conundrum is the inherently "messy" process of policymaking, which is influenced by an array of individual advocates, content experts, policy analysts, and organized interest groups, among many others, who engage in a multidimensional process of debate, negotiation, and compromise that results in a variety of explicit actions or implicit decisions to not act. Within this context, measuring the percentage of the variance in outcomes that is explained by any single influence is a daunting task.

Notwithstanding the complexity of the challenge, the Center on the Developing Child and Frameworks Institute has begun to assess the impact of our work in two ways. First, we look for evidence that our simplifying models have been understood, remembered, and used by influential target audiences such as news media and policymakers. Second, we conduct key informant interviews to ascertain whether and to what extent our written materials and oral presentations are perceived by selected public and private sector leaders to have influenced the content of proposed policies or the enactment of specific legislation. Because of the subjective and nongeneralizable nature of these assessments, we present the following findings as highly preliminary and suggestive indications, not scientifically validated evidence, of the impacts of our efforts to date.

Over the past few years, the Center has conducted an informal examination of major media in geographic areas where the results of this communications process could have had an influence as well as reviewed selected public documents for evidence of effects. Through this process, we have found a growing number of encouraging examples of the incorporation of elements of our core story as quoted material in state and federal legislation. Moreover, although the Council has not sought to translate science for the press explicitly, it cannot ignore the impact that accurate reporting through the press has on policymakers and voters. Multiple editorials, opinion columns, and news articles from Maine and Michigan to Louisiana and South Carolina and as far away as Australia, Great Britain, Germany, and China have reproduced frame-tested translations of the science of early childhood development to make a case for increased investment in young children. Specific examples of successful outcomes include the following: (a) references to the Council's concept of "toxic stress" in federal legislation to reauthorize Head Start by the U.S. House Committee on Education and Labor (H.R. 1429, 2007), in the *New York Times* (Tarkan, 2009),

and in multiple episodes of *Unnatural Causes*, a 4-hr documentary on the root causes of socioeconomic and racial disparities in health that was broadcast by the Public Broadcasting System (Adelman, 2008); (b) references to the Council's concept of "serve and return" to describe adult-child interaction and its effect on early brain development in a *Detroit News* opinion column (Martina, 2008), a UNICEF report from the Innocenti Research Center on child-care policies across nations (Bennett, 2008), and a three-part radio series that aired across Canada (Eisen, 2009); (c) incorporation of the Center's language describing "brain architecture" as the foundation of all future learning, behavior, and health into Louisiana Senate Concurrent Resolution No. 7 (Sen. Con. Res. No. 7., 2008); and (d) attribution of a direct quote from a Council publication in the Hawaii Early Learning Act, enacted by the state legislature in July 2008 (S. 2878, 2008).

These examples are notable because they answer the charge, often leveled at science communicators, that it is impossible to engage news media in faithfully representing science. That is to say, by simplifying and shortening the science while still preserving its integrity, we have been able to help make these stories more scientifically accurate than they would have been otherwise.

Key informant interviews with policymakers and civic leaders in more than 20 states in which Council and Forum members have been engaged personally have generated considerable positive feedback from across the political spectrum about the extent to which the core story of development has "opened their eyes" to think about early childhood investments in a different way. In several circumstances, this knowledge has influenced the development of new policies and programs, as illustrated in the following examples.

In Nebraska, a debriefing for the members of the nation's only unicameral state legislature, sponsored by the speaker, provided an overview of the core story shortly before a scheduled vote on a bill that proposed to nearly double the state's commitment to early childhood programs for children from low-income families. The subsequent passage of the legislation was approved by a vote of 42-0. The program manager for the NCSL Child Care and Early Education project observed that "Nebraska demonstrated what can be accomplished through a combination of good timing, key legislative leadership, and credible research provided at the right time" (Center on the Developing Child, 2006a).

In the state of Washington, testimony by a member of the National Scientific Council before the Senate Ways and Means Committee broke a partisan gridlock and helped generate overwhelming bipartisan support for the establishment of a cabinet-level Department of Early Learning that consolidated three agencies, oversaw the initial implementation of universal preschool, and established a ground-breaking public–private partnership to support early childhood programs. The vote in the Senate, which previously rejected the bill, was held immediately after similar testimony and passed by a margin of 47-2. A follow-up interview with a key legislative leader reported that the Council's core story of development was instrumental in securing the support of previous opponents (Center on the Developing Child, 2006b).

In Kansas, the Center's bridge-building work with the Democratic governor and her staff, the Republican speaker of the House, and other state legislators from both parties played an important role in building a science-based foundation that helped previously noncollaborative branches of state government and opposing political parties find common ground in a highly successful Governor's Summit on Early Childhood. Following the summit, comprehensive legislation that included an expanded investment in prenatal care and early childhood mental health services was passed with the support of the conservative Republican speaker of the House who said that he would not have supported such investments if he had not learned about early influences on brain development through his participation in a Legislative Working Group cosponsored by the Center and NCSL. (M. Neufeld, personal communication, June 26, 2008).

It is important to reiterate that the subjective and nonrandom nature of the examples enumerated above clearly warrant considerable caution in drawing any conclusions or generalizations about the effectiveness of the work described in this article. That said, credible impact evaluations of efforts to communicate science to policymakers are exceedingly rare, and these anecdotal data are offered to stimulate the development of more rigorous evaluation methods in the service of building a robust science of knowledge translation.

### Raising Healthy Children: Implications for Policy and Practice

The National Scientific Council on the Developing Child and the National Forum on Early Childhood

Program Evaluation, now both based at the Center on the Developing Child at Harvard University, were established to translate the science of early childhood development and intervention, and its underlying neurobiology, to inform public decision making affecting the lives of young children. As described earlier, these initiatives were built on the foundational work of the NRC/IOM Committee on Integrating the Science of Early Childhood Development, which produced *From Neurons to Neighborhoods: The Science of Early Childhood Development*, and the MacArthur Research Network on Early Experience and Brain Development, which demonstrated the transformative impact of interdisciplinary thinking and collaborative research at the intersection of neuroscience and developmental psychology. A signature feature of this collaborative effort to date has been its seamless integration of communications research, through a partnership with the FrameWorks Institute, and sophisticated understanding of state-level policymaking, through a partnership with the NCSL and the National Governors Association Center for Best Practices.

This highly integrated set of partnerships offers a model for translating developmental science for state-level policymakers that has generated promising results and invites more rigorous study. Our initial analyses of both the successes and the challenges of the past several years reveal two key lessons.

First, child development researchers can influence the thinking and actions of a politically diverse policymaking audience if they focus more on teaching about science and less on preaching about which specific policies and programs should be supported. In this spirit, we believe that much of the power of our core story of development rests on the extent to which we focus largely on well-established, science-based principles (not isolated studies) and the degree to which we describe causal mechanisms (not simply report statistical associations) in concrete terms that explain how early experience shapes brain architecture and developmental outcomes (both for good and for bad). The essence of this approach is the presentation of a coherent narrative that helps nonscientists understand the process of development, both behaviorally and in the brain, in a way that leads them to think differently about how a range of policies and practices could improve the life prospects of young children.

Second, beyond the Council's and Forum's written materials and the keynote presentations delivered by their members, whose unique effectiveness

is difficult to measure, the greatest impacts have been achieved when scientists have been able to use their communications skills to explain the science of early childhood development directly to people who have the capacity to make things happen. The ability of policymakers to pass on information gleaned from their personal interactions with scientists represents its own kind of ''talkback chain,'' proving that the translated elements of the core story actually can be viral. When these relationships have been leveraged strategically, they have contributed to better informed public dialogue and associated policy advances in multiple states representing a wide variety of contexts and diverse political ideologies.

The range and number of voices articulating the scientific and economic rationale for investments in early childhood are attracting increasing public attention across the United States and around the world. In this context, credible translation of the science of early childhood development and its underlying neurobiology, conveyed in a clear and concise story, can increase the probability that this rapidly advancing knowledge base will be well understood, repeated accurately, and applied in an informed way to the formulation and implementation of policies and practices that will make a measureable difference in the lives of young children and their families. It is also important to note that the lessons described in this report are not applicable to the early childhood years alone. Indeed, the basic principles of Strategic Frame Analysis have already been employed to enhance communications related to adolescence (Lochner & Bales, 2007) and social issues more generally (Bales & Gilliam, 2004), and the core story of early childhood development can certainly be extended into middle childhood and the adolescent period.

The partnership described in this article illustrates how the challenge of science translation can be addressed within a mutually respectful, ongoing, collaborative process in which developmental scientists, communications researchers, and policymakers can become coproducers of broadly understood yet sophisticated scientific messages that are not ''dumbed down'' yet take into account the cognitive shortcuts that nonscientists bring to the discussion of complex issues. It is also important to underscore that the systematic approach to science translation presented in this article has been embedded in a pragmatic action agenda focused on developing and refining the role of a credible knowledge broker, in contrast to that of a partisan advocate, in the policy arena.

The purpose of this expository essay is to share what we have learned with the academic child development community. The intended goal is not to presume to have all the answers but simply to offer our experiences and thoughts as a starting point for the compelling, unfinished business that remains to be done—the interrelated tasks of building a rigorous science of knowledge translation and developing an effective practice of knowledge transfer from research to policy and service delivery.

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