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Efficacy of the Early HeartSmarts® Program in Promoting Social, Emotional and Cognitive Development

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Raymond Trevor Bradley, Ph.D.[1], Mike Atkinson[2],
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Abstract:

Developed by the Institute of HeartMath (IHM), the Early HeartSmarts (EHS) program is designed to train teachers to guide and support young children (3-6 years old) in learning emotional self-regulation and key age-appropriate socioemotional competencies, with the goal of facilitating their emotional, social and cognitive development. This work reports the results of an evaluation study conducted to assess the efficacy of the EHS program in a pilot implementation carried out during the 2006–2007 academic year in schools of the Salt Lake City School District. The study was conducted using a quasi-experimental longitudinal field research design with three measurement moments (baseline and pre- and post-intervention panels) using *The Creative Curriculum* Assessment (TCCA) instrument, a teacher-scored, 50-item instrument measuring student growth in four areas of development — social/emotional, physical, cognitive and language development. Children in nineteen preschool classrooms were divided into intervention and control group samples (N = 66 and 309, respectively; mean age = 3.6 years), in which classes in the former were specifically selected to target children of lower socioeconomic and ethnic minority family backgrounds. Overall, there is compelling evidence of the efficacy of the EHS program in increasing total psychosocial development and also in each of the four development areas measured by the TCCA: the results of a series of ANCOVAs found a strong, consistent pattern of significant differences on the development measures favoring preschool children who received the EHS program over those in the control group who did not.

Recent advances in neuroscience are highlighting connections between emotion, social functioning and decision making that have the potential to revolutionize our understanding of the role of affect in education. In particular, the neurobiological evidence suggests that the aspects of cognition that we recruit most heavily in schools, namely learning, attention, memory, decision making and social functioning, are both profoundly affected by and subsumed within the processes of emotion … .

— Mary Helen Immordino-Yang & Antonio Damasio

"We Feel, Therefore We Learn: The Relevance of Affective and Social Neuroscience to Education." Mind, Brain and Education, 2007, 1(1): 3.

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Introduction

In their review of recent advances in neuroscience, Immordino-Yang and Damasio (2007: 3) conclude that the "processes of emotion" have a profound effect on the very elements of cognition targeted in education — "learning, attention, memory, decision making and social functioning".[1] This accords with research in psychophysiology which shows that learning effective emotion regulation techniques can significantly enhance attention, memory recall, comprehension, reasoning ability, creativity and task performance in adults and children (see the research review in McCraty et al., 2006). Moreover, Allan Schore's (1994) landmark multidisciplinary synthesis of the enormous body of research on the neurobiology of early childhood development shows that learning how to process and self-regulate emotional experience is the earliest, most fundamental socioemotional skill, one which not only facilitates neurological growth but also determines the potential for subsequent psychosocial development.[2]

Yet as fundamental as emotion is to *all* aspects of psychosocial development, our K–12 educational system remains woefully deficient in teaching children effective strategies for understanding and regulating their feelings and emotions. In general, there is a predominant focus on teaching children purely "academic" skills without providing adequate education in the socioemotional foundations underlying the development of the very cognitive capacities required for academic performance. This is exacerbated by the problem that a disturbing number of children begin school lacking the basic socioemotional skills needed to learn and get along with others within a school setting. As Boyd and her colleagues point out:

> Knowing the ABCs is not enough. To be prepared for school, children also must be excited and curious about learning and confident that they can succeed (motivational qualities). They must be able to understand the feelings of others, control their own feelings and behaviors and get along with their peers and teachers (socioemotional skills). Indeed, kindergarten teachers rate these motivational and socioemotional skills as more important to school success than being able to hold a pencil or read. They want children to be ready for learning — able to cooperate, follow directions, demonstrate self-control and "pay attention" (Boyd et al., 2005: 2).

In preschoolers and school-age children, problems in socioemotional development typically manifest themselves as challenging, socially disruptive patterns of behavior that, without intervention, can evolve into persistent antisocial behavior, such as physical aggression and bullying and ultimately adolescent delinquency (Powell et al., 2003; Wilson et al., 2001). For the teachers and classmates, these disruptive behaviors are a major challenge to educational success because children with socioemotional problems deflect valuable time, energy and attention from the entire classroom learning experience (Raver and Knitze, 2002).

As of 2002, estimates of national prevalence rates of young children with psychosocial problems were between 10% and 21% (Powell et al., 2003). According to Boyd et al. (2005: 1), kindergarten teachers report that about 20% of children entering kindergarten lack the requisite social and emotional skills to be "ready" for school. Moreover, rates of young children whose behavior displays aggression, delinquency, or hyperactivity were estimated to be as high as 25% (Raver & Knitze, 2002). And children living in poverty, which disproportionately affects ethnic minorities, are at an increased risk for socioemotional, behavioral and learning problems (Raver & Knitze, 2002). Indeed, as many as 30% of elementary children from low-income families and about the same proportion of preschoolers in Head Start programs do not have the necessary socioemotional skills for school (Boyd et al., 2005). In short, for young children at

[1] This confirmation of the importance of emotion — specifically the ability to love oneself — in enabling development of autonomy and intelligence in children, was something that the great psychologist Jean Piaget understood more than sixty years ago (Piaget, 1981).

[2] See Bradley (2001: 803-812) for a more detailed summary of the neuropsychosocial developmental processes Schore (1994) describes.

the beginning of their education, the deficiency in socioemotional skills is often an insurmountable handicap:

> They enter kindergarten unable to learn because they cannot pay attention, remember information on purpose, or function socially in a school environment. The result is growing numbers of children who are hard to manage in the classroom. These children cannot get along with each other, follow directions, or delay gratification. They show belligerence and aggression in the classroom and on the playground (Boyd et al., 2005: 2).

To rectify this problem of young children with missing or less than adequate socioemotional skills, the Institute of HeartMath (IHM) has developed an intervention program specifically targeted to equip children aged three to six with the foundational socioemotional skills for school. Called Early HeartSmarts (EHS; Institute of HeartMath, 2008), the program was designed to train teachers to guide and support young children in learning several key age-appropriate emotional and social competencies, with the goal of facilitating the children's emotional, social and cognitive development. Based on almost two decades of research on the psychophysiology of emotions and heart–brain communication (McCraty et al., 2005; McCraty et al., 2006; Tiller, McCraty, & Atkinson, 1996), the EHS program is the latest in a series of programs[3] IHM has developed to teach schoolchildren emotional self-regulation techniques (Arguelles, McCraty, & Rees, 2003). Research has shown HeartMath's programs to be effective in improving emotional stability and psychosocial functioning and in increasing academic performance (Arguelles et al., 2003; Bradley et al., 2007; McCraty, 2005; McCraty et al., 1999).

This monograph reports the results of an evaluation study conducted to assess the efficacy of the EHS program in a pilot implemented in 19 preschool classes in the Salt Lake City, Utah School District. The study was conducted using a quasi-experimental longitudinal field research design with three measurement moments — baseline and pre- and post-intervention panels using *The Creative Curriculum Assessment* instrument (TCCA; described below), a teacher-scored instrument measuring student growth on four development dimensions (social/emotional, physical, cognitive and language development). Students in all 19 preschool classes were divided into intervention and control group samples (N = 66 and 309, respectively), in which classes in the former were specifically selected to target children of lower socioeconomic and ethnic minority family backgrounds.

Overall, there is compelling evidence of the efficacy of the EHS program in enhancing the growth of preschool children across all four development dimensions measured by the TCCA: the results of the study show a strong, consistent pattern of significant differences on the development measures, favoring children who received the EHS program over those in the control group who did not.

Overview

In what follows, we begin with a brief summary of the development of emotional regulation in early childhood. At this age, the socio-psychobiological processes are foundational for brain and psychosocial development, and they have lifelong consequences. We move on to a review of the psychophysiology of emotional regulation, highlighting the key role of the heart in emotional experience and also in influencing all aspects of cognitive function and behavior. An overview of the Early HeartSmarts program follows, describing the program's goals and its core socioemotional competencies and the emotion self-regulation tools that are taught to preschool children by their teachers. Next, we present the evaluation study of the EHS program itself, detailing the research methodology, data analysis and results, findings, limitations, and primary conclusions along with their implications for educational policy.

[3] These programs are: the Early HeartSmarts program for children 3–6 years old; the HeartSmarts program for children 8–11 years old; and the TestEdge program for upper elementary, middle and high school students. In addition, there is a program designed for teachers, called The Resilient Educator. HeartMath also has designed programs for higher education and adult learners.

Emotional Regulation in Early Childhood[4]

In his groundbreaking interdisciplinary synthesis, *Affect Regulation and the Origin of Self: The Neurobiology of Development*, Allan Schore (1994)[5] details the enormously complex, multilevel processes involved in transforming the newborn infant from total psychobiological dependency to an active, psychosocially stable, dialogical self by eighteen months of age. Emotional self-regulation begins in infancy in the mother–infant dyad whereby the infant begins to learn through interactions with the mother how to self-regulate the experience of intense, otherwise overwhelming emotions — both positive and negative:

> The attachment mechanism, the dyadic regulation of emotion, … psychobiologically modulates positive states, such as excitement and joy, but also negative states, such as fear and aggression (Schore, 2003: 275).

While this neuropsychosocial transformation requires the presence of a certain biogenetic organization and potential, the infant's ontogenesis can *only* be triggered and sustained by socioemotional exchanges with the mother involving interactions organized along two dimensions. The first, an *affective* dimension, involves the mother's stimulation and arousal of her infant's positive emotions. The second is *regulation*, a control dimension by which the mother regulates the infant's psychobiological states by adjusting and modulating her child's affective responses. When optimally organized as a self-regulating, co-evolving dyadic system, charged primarily with positive emotions, the interactional exchange stimulates and shapes the development of the infant's brain, and also encodes the basic neurological templates for psychosocial function that are operative for life:

> The child's first relationship, the one with the mother, acts as a template for the imprinting of circuits in the child's emotion-processing right brain, thereby permanently shaping the individual's adaptive or maladaptive capacities to enter into all later emotional relationships (Schore, 1997: 30).[6]

By the end of the first year "…internal working models of attachment are first encoded. These … are … mental representations that enable the individual to form expectations and evaluate the interactions that regulate his attachment system."[7] Abstracted from the socioaffective dialogue with the mother, these mental representations enable the infant to image the expectation of mutuality and reciprocity in social contact: of being matched by and being able to match the affective state of the partner, as well as "participating in the state of the other"(Beebe & Lachman, 1988). This process continues through childhood, where the skills of emotional awareness (including empathy for self and others) and impulse- and self-control are learned through relationships with parents, siblings, teachers and peers. And it extends into adulthood as these skills are refined in relationships with loved ones, friends, coworkers and others.[8]

However, when the dyadic organization of socioaffective interaction is less than optimal (that is, when the infant is exposed to prolonged periods of heightened negative affect), during this critical period of (approximately) the first twelve months, the growth and organization of the infant's developing frontal cortex can be affected with enduring pathological consequences. This results in structurally defective neurobiological organization, which, in turn, produces disturbances in attachment formation. These functional impairments of the neu-

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[4] This section draws heavily from Bradley (2001).

[5] See also Schore (2003) for his important sequel, *Affect Dysregulation and Disorders of the Self.*

[6] The right hemisphere (emotion and nonverbal information) of the infant's brain is dominant for the first three years of life, after which functional asymmetry shifts to the left hemisphere (language and intellect). See Chiron et al. (1997).

[7] There is evidence from a longitudinal study of communication in 36 mother–infant dyads that socio-emotional regulation at three months predicts cognitive development (symbolic competence and general and verbal IQ) at two years. See Feldman et al. (1996); Feldman & Greenbaum (1997).

[8] It is of interest to note that there is also strong evidence that a parallel process of affect regulation is operative in social groups and organizations: relations charged with positive affect must be regulated by a hierarchical order of relations of social control in order for the emergence of collective stability and functional effectiveness (Bradley, 1987, 2004; Bradley & Pribram, 1998).

ral circuitries result in a persisting susceptibility to further patterns of pathophysiological growth.

In short, when the infant's capacity for emotional self-regulation is lacking or the skills are dysfunctional, "*affect dysregulation*," as Schore (2003) aptly labels it, is the result. Excluding congenital causes, this inability to appropriately self-regulate feelings and emotions, such as impulsive and aggressive behavior and to engage in pro-social relationships has its origins in sustained emotional abuse and/or neglect by the child's primary caregiver/s (Schore, 1994, 2003). Such development is associated with later-forming psychiatric disorders and difficulty in establishing stable social bonds (Schore, 2003), resulting in serious long-term consequences and costs — not only for the unfortunate individual, but also for society.[9]

Psychophysiology of Emotional Regulation[10]

The dominant influence of emotions on cognitive development and function is clearly depicted in a figure from Immordino-Yang and Damasio's (2007) review of recent work in the neurobiology of emotions (see Figure 1). This important conclusion is in accord with the body of evidence generated from extensive studies on the psychophysiology of emotions conducted by IHM and others over the last two decades (see McCraty et al., 2006). Moreover, from an applied perspective, IHM's research has shown that specific positive emotion-focused tools and techniques — the foundation of the EHS program — facilitate emotional self-regulation by teaching individuals the ability to make an intentional shift to a specific psychophysiological state (termed *psychophysiological coherence*, described below), which has been shown to be associated with optimal psychosocial growth, learning and performance. The basis of this ability to make such a shift lies in the fundamental role the heart plays in the emotional system.

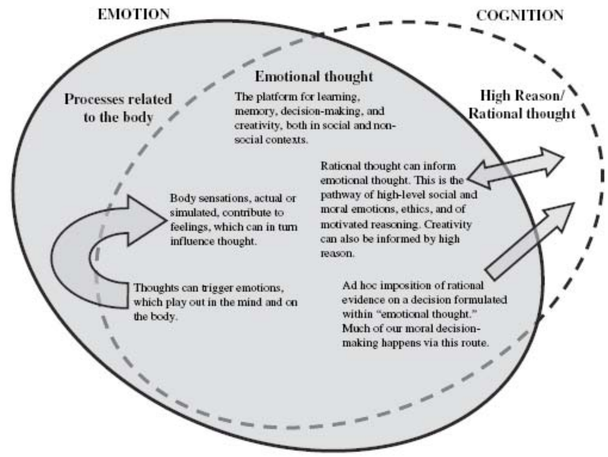

Figure 1. A Model of the Influence of Emotion on Cognition

This figure, from a recent important article by Immordino-Yang and Damasio, highlights the enormous influence of emotion on virtually all aspects of cognition — especially those aspects that are specifically targeted by education. In their words: "The evolutionary shadow cast by emotion over cognition influences the modern mind. In the diagram, the solid ellipse represents emotion; the dashed ellipse represents cognition. The extensive overlap between the two ellipses represents the domain of emotional thought. Emotional thought can be conscious or nonconscious and is the means by which bodily sensations come into our conscious awareness. High reason is a small section of the diagram and requires consciousness" (from: Immordino-Yang & Damasio, © 2007, Figure 1, page 8; reproduced with permission).

Role of the Heart in Emotional Experience

While emotion generation was once believed to be a process confined to the brain alone, the evidence is now clear that afferent (flowing to the brain) neurological and hormonal information originating from many of the body's organs and systems is intimately involved in determining our emotional experience (Pribram and Melges, 1969; Pribram, 1991). Moreover, recent research provides evidence that among these diverse bodily inputs, signals from the heart may play a uniquely important role (McCraty et al., 2006; McCraty & Tomasino, 2006).

As a primary and consistent generator of rhythmic information patterns in the human body, and

[9] Almost 2.3 million juveniles were arrested in 2002; more than 134,000 juveniles were confined in residential facilities in 1999; close to 12,000 juveniles were incarcerated in adult jails or state prisons in 2000; and for adults, as of the end of 2003, as many as 6.9 million (3.2% of all US adults) were on probation, parole, or in prison or jail (Boyd et al., 2005: 5).

[10] This section draws heavily on Bradley et al. (2007, Chapter III) and McCraty et al. (2006).

possessing a far more extensive communication system with the brain than do other major organs (Cameron, 2002), the heart exerts a unique and far-reaching influence on the brain and the entire body (McCraty et al., 2006). Far more than a simple pump, the heart also functions as a hormonal gland, a sensory organ and an information encoding and processing center, with an extensive intrinsic nervous system sufficiently sophisticated to qualify as a “heart brain” (Armour, 2003). Its neural circuitry effectively enables it to learn, remember and make functional decisions independent of the cranial brain (Armour & Ardell 1994; Armour, 2003).With every beat, the heart transmits to the brain and throughout the body complex patterns of neurological, hormonal, pressure and electromagnetic information. Furthermore, as shown below, neurological signals from the heart not only affect the autonomic regulatory centers in the brainstem, but they also cascade up into higher brain centers involved in emotional and cognitive processing, including the thalamus, amygdala and cortex. In these ways, information originating from the heart operates as a continuous and dominant influence in the processes that ultimately determine our perceptual and emotional experience (McCraty et al., 2006; McCraty & Tomasino, 2006).

Emotions Are Reflected in the Heart’s Rhythms

Research reveals that pertinent information is contained and transmitted not only in the amplitude (strength or amount) of these cardiac signals, but also in their *rhythm* and *pattern*. The rhythmic beat of a healthy heart at rest varies dynamically from moment to moment as it adapts to internal and external influences on the body. The term *heart-rate variability* (HRV) is used to refer to these naturally occurring beat-to-beat changes in heart rate, which reflect heart–brain interactions and autonomic nervous system dynamics. Recent research has revealed that heart-rate-variability patterns, *or heart rhythms*, are directly responsive to changes in emotional states, as shown in the real-time examples in Figure 2 (McCraty et al. 1995; Tiller et al., 1996).

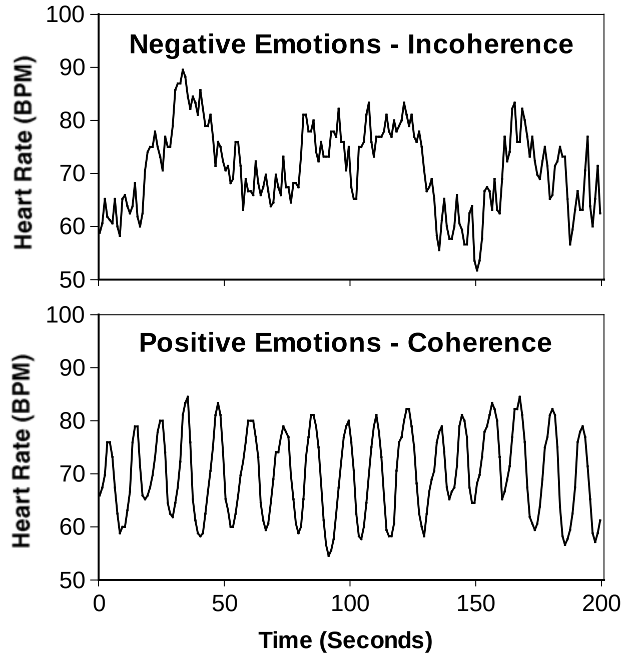

Figure 2. Heart-rhythm patterns reflect different emotional states

These heart rate tachograms show examples of the heart-rate variability trace (heart-rhythm pattern) recorded in real time from individuals experiencing different emotions. Negative emotions, such as anxiety, anger and frustration, typically give rise to an erratic, irregular heart-rhythm pattern (incoherence). Conversely, positive emotions, such as appreciation, care and compassion, produce a highly ordered, stable heart-rhythm pattern of smooth, repeating waves (coherence). (From McCraty et al., 2006. © Institute of HeartMath)

During the experience of stress and negative emotions such as anger, frustration and anxiety, heart rhythms become more erratic and disordered — *incoherent* (Figure 2). This is indicative of desynchronization in the reciprocal action between the parasympathetic and sympathetic branches of the autonomic nervous system (ANS) as well as inhibited function in higher brain centers (Lane et al., 2001). The generation of this erratic pattern of heart and nervous system activity impedes the efficient flow of information throughout the psychophysiological systems and interferes with the brain’s ability to properly synchronize neural activity (Ratey, 2001). Such desynchronization impedes brain processes necessary for functions such as attention, memory recall, abstract reasoning, problem-solving and creativity. Thus, when students come to school with high levels of anxiety, frustration, or anger, the “inner noise” produced by such emotional incoherence impairs the very cognitive resources needed for learning, memory and effective academic performance (Arguelles et al., 2003; Bradley et al., 2007; McCraty, 2005).

Conversely, sustained positive emotions, such as appreciation, love and compassion, are associated with highly ordered or *coherent* heart-rhythm patterns. This reflects greater synchronization between the two branches of the ANS and increased physiological efficiency. When the heart transmits such an ordered and harmonious signal to the higher brain centers (Figure 3), cognitive and emotion regulation abilities are facilitated, typically producing emotional stability and enhanced attention, memory recall, comprehension, reasoning ability, creativity and task performance (McCraty et al., 2006). *This is a particularly important point in understanding the operative mechanism of the HeartMath techniques taught in the EHS program*.

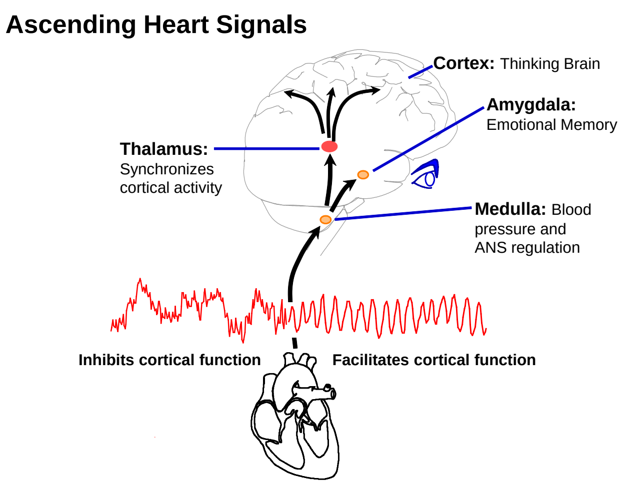

Figure 3. Heart activity affects brain function

This diagram illustrates afferent (ascending) pathways by which neurological signals generated by the heart are transmitted to key centers in the brain. These heart signals not only impact autonomic regulatory centers in the brain (e.g., the medulla), but also cascade up to higher brain centers involved in emotional and cognitive processing, including the thalamus, amygdala and cortex. Through these pathways, heart activity exerts a continuous impact on numerous aspects of brain function. As shown, when patterns of heart activity are erratic and disordered, such as during emotional stress, the corresponding patterns of neurological signals traveling from the heart to the brain produce an *inhibition* of higher cognitive and emotional functions. In contrast, the more ordered and stable pattern of the heart's input to the brain during positive emotions has the opposite effect — serving to *facilitate* cognitive function and reinforcing positive feelings and emotional stability. (From McCraty et al., 2006. © Institute of HeartMath)

Psychophysiological Coherence — A State of Optimal Function

Studies conducted by IHM have identified a distinct mode of physiological functioning — termed *psychophysiological coherence* — associated with the experience of positive emotions (McCraty et al., 2006). Correlates of psychophysiological coherence include a smooth, sine wavelike pattern in the heart rhythms (heart-rhythm coherence); decreased sympathetic nervous system activation and increased parasympathetic activity; increased heart–brain synchronization (the brain's alpha rhythms become more synchronized to the heartbeat); increased vascular resonance; and entrainment between diverse physiological oscillatory systems.

These physiological changes result in a highly efficient state in which the body, brain and nervous system function with increased synchronization and harmony. Thus, increased psychophysiological coherence has been found to directly correlate with improvements in cognitive function and task performance. This state is also associated with greater emotional stability, a reduction in the perception of stress and negative emotions, and an increase in the experience of sustained positive emotions (McCraty et al., 2006).

One of the correlates of the psychophysiological coherence state, with important implications for emotion regulation and development, is the associated shift in autonomic balance towards increased parasympathetic nervous system activity. There is a body of research on infants, children and adolescents linking impaired vagally mediated parasympathetic cardiac control to psychosocial dysfunction — poor emotion regulation, decreased reactivity to various stimuli, anxiety disorders and antisocial behavior (Mezzacappa et al., 1997; Porges et al., 1994). In contrast, increased vagal tone (associated with high parasympathetic activity) has been associated with increased physiological and behavioral flexibility, responsiveness to the environment, stress resiliency and emotion regulation ability (Porges, 1992; Porges et al., 1994). Evidence suggests that high vagal tone also enhances attentional capacity, an aspect of cognition central to learning (Richards, 1987; Suess et al., 1994). The implications are that psychophysiological states, such as coherence, that naturally enhance parasympathetic activity should play an important positive role in children's development of effective emotion regulation, healthy social behavior and optimal cognitive function (Schore, 2003).

Intentional Generation of Psychophysiological Coherence

One of the most important findings of IHM's research is that the psychophysiological coherence state can be *intentionally generated*. This body-wide shift in psychophysiological functioning can be achieved by using an emotion-driven process which has been incorporated into a system of easy-to-use tools and techniques developed by the Institute of HeartMath (Childre & Martin, 1999; Childre & Rozman, 2005). Briefly, these techniques couple an intentional shift in attention to the physical area of the heart with the self-activation of a positive emotional state. Research has shown that this process rapidly initiates a distinct shift to increased coherence in the heart's rhythms (see Figure 4). This, in turn, produces a change in the pattern of afferent cardiac signals sent to the brain, which serves to *reinforce* the self-generated positive emotional shift, making it easier to sustain. Often this shift is also associated with enhancements in perception and cognition that enable more effective reasoning, decision making and action when one is confronted with stressful or challenging situations. With regular practice, these physiological, emotional and cognitive patterns become increasingly familiar to the brain, ultimately establishing a new set-point by which the system then strives to maintain these new, healthy patterns. The occurrence of such a repatterning process is supported by studies conducted across diverse populations showing that people who regularly practice coherence-building techniques experience enduring improvements, affecting many aspects of their lives, including health, emotional well-being, attitudes, behaviors and relationships (for reviews see McCraty, Atkinson, & Tomasino, 2001; McCraty et al., 2006).

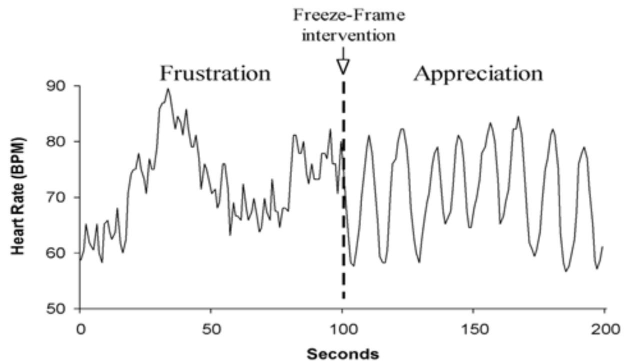

Figure 4. Shift to Coherence

The real-time heart-rate-variability (heart rhythm) pattern is shown for an individual making an intentional shift from a self-induced state of frustration to a genuine feeling of appreciation by using a HeartMath positive emotion refocusing technique ("Freeze-Frame intervention," at the dotted line). Note the immediate shift from an erratic, disordered (incoherent) heart-rhythm pattern associated with frustration and emotional stress to a smooth, harmonious, sine wavelike (coherent) pattern as the individual uses the positive emotion refocusing technique to self-generate a feeling of appreciation. (From Bradley et al., Chapter III, 2007, © Institute of HeartMath)

In educational settings, programs incorporating the HeartMath tools and techniques have been introduced at the elementary, middle school, high school, college and graduate levels and have been demonstrated to improve emotional stability, psychosocial functioning, learning and academic performance (Arguelles, et al., 2003; Bradley et al., 2007; McCraty, 2005; McCraty et al., 1999). In one study, conducted in collaboration with the Miami Heart Research Institute, HeartMath tools were taught to a group of at-risk, minority middle school students in a classroom-based program called HeartSmarts (McCraty et al., 1999). While many of the students initially demonstrated anxiety, lack of motivation and risky behavior or were at risk for school dropout, after learning and practicing the HeartMath tools, the group exhibited significant improvements in 17 of the 19 areas of psychosocial functioning assessed — including stress and anger management, risky behavior, work management and focus and relationships with teachers, family and peers. Furthermore, when prompted with an acute emotional stressor in a controlled laboratory experiment using electrophysiological measures of HRV, the HeartMath-trained students exhibited increased stress resiliency in relation to a control group: real-time HRV data indicated that the students were able to favorably modulate their autonomic response to stress, as evidenced by increases in HRV and heart-rhythm coherence during the stress recovery phase (McCraty et al., 1999).

At the high school level, a recent large-scale national study (Bradley et al., 2007), funded by the U.S. Department of Education, evaluated the efficacy of HeartMath's TestEdge program, which teaches students emotional management skills to reduce stress and test anxiety. The primary investigation, designed as a multi-methods, quasi-experimental, longitudinal field study with intervention and control schools, involved 980 tenth grade students from two California high schools. After participation in the semester-long program, there was a significant reduction in test anxiety in the intervention group, which was evident across the entire spectrum of academic ability. This was accompanied by significant improvements in a range of socioemotional measures, including negative affect, interactional difficulty, stress management ability and positive class experience. A significant improvement in performance on two California standardized tests — the California High School Exit Exam and the California Standards Test — was also measured in several student subgroups (examples shown in Figure 5). Of particular import are the results from an electrophysiological sub-study, conducted to provide an objective measure of students' stress management ability in a simulated stressful testing situation. These data confirmed that students had acquired the ability to self-activate the coherence state by using the HeartMath tools, and also that they were able to effectively apply this skill while preparing to taking a challenging test (Figure 6).

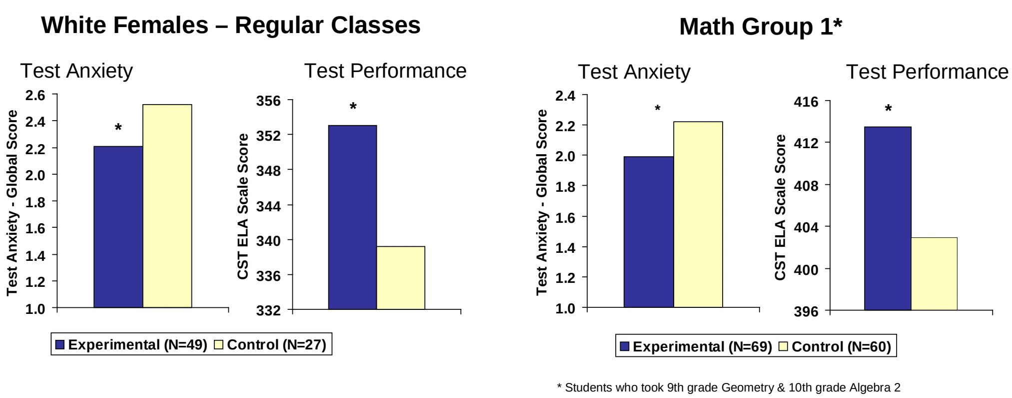

Figure 5. Changes in Test Anxiety and Test Performance in Matched-Group Comparisons

ANCOVA results from the TestEdge study for two sub-samples from the intervention and control schools matched on: 1) sociodemographic factors (White Females in average academic level classes), and 2) 9th grade Math test performance (Math Group 1), respectively. For these matched-group comparisons, significant reductions in test anxiety in conjunction with significant improvements in test performance (California Standards Test – English-Language Arts) were observed in the experimental group as compared to the control group. *$p < 0.05$. (From Bradley et al., 2007, © Institute of HeartMath)

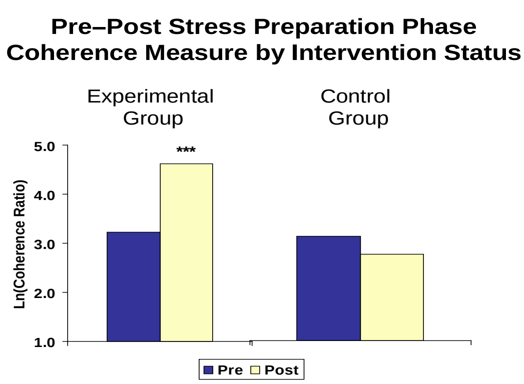

Figure 6. Heart-Rhythm Coherence While Preparing for a Stressful Test

These data are from the electrophysiological component of the TestEdge study – a controlled experiment involving a random stratified sample of students from the intervention and control schools (N = 50 and 48, respectively). In this experiment, students were administered the Stroop (color-word conflict) stress test while heart-rate variability was continuously recorded. These graphs quantify heart-rhythm coherence – the key marker of the psychophysiological coherence state – during the stress preparation phase of the protocol. Data are shown from recordings collected before and after the TestEdge intervention. The experimental group demonstrated a significant increase in heart-rhythm coherence in the post-intervention recording, when they used one of the TestEdge tools to prepare for the stressful test, as compared to the control group, who used their own stress preparation techniques. ***$p < 0.001$. (From Bradley et al., 2007, © Institute of HeartMath)

Early HeartSmarts Program

IHM's educational programs, which are based on this research foundation, are designed to teach a set of easy-to-use positive emotion refocusing and restructuring techniques that enable teachers and students to self-regulate stress, test anxiety and other emotional impediments to learning and performance. The basis of the effectiveness of the techniques is that they enable the individual to self-activate the psychophysiological coherence state. As noted above, research has shown that psychophysiological coherence is characterized by increased synchronization in nervous system activity, increased emotional stability and improved cognitive and task performance.

Building on the success of the Resilient Educator, TestEdge and HeartSmarts programs, IHM designed the Early HeartSmarts program to facilitate emotional awareness and the psychosocial growth of young children, 3-6 years of age. Thus, the primary objective of the EHS program is to give young children knowledge and skills to develop key social and emotional competencies known to facilitate their psychosocial development (see Table 1 and Appendix 1). To achieve this goal, the EHS program was designed to train teachers to guide and support young children in learning several key emotional and social competencies:

- How to recognize and better understand basic emotional states
- How to self-regulate emotions
- Ways to strengthen the expression of positive feeling
- Ways to improve peer relations
- Skills for developing problem-solving

Key among these competencies are two simple emotion shifting tools — Shift and Shine and Heart Warmer. These tools were specifically adapted from the HeartMath system of emotional management tools to facilitate young children's learning of emotional self-regulation skills. Before its evaluation in this pilot study, the EHS program content was reviewed by preschool teachers, administrators and early childhood experts. An overview of the EHS program in terms of the core competencies, skills and emotional self-regulation techniques taught is presented in Table 1; Appendix 1 presents a list of the EHS program's materials.

Research Design and Method

The pilot study evolved informally as a research opportunity resulting from discussions between IHM's Education Division's staff, and officials, staff and teachers in the Salt Lake City School District. Upon learning of HeartMath's newly developed EHS program, there was much interest and enthusiasm to participate in a study to evaluate the efficacy of the program.

Dr. Patrick Galvin (Head of Research, Salt Lake City Schools) was already conducting a longitudinal, three-panel study of the development over an academic year of all preschool children in the nineteen preschools in the school district. Dr. Galvin's study administered *The Creative Curriculum Developmental Continuum Assessment System* (hereafter abbreviated as *The Creative Curriculum Assessment*, or TCCA; see Table 2), a 50-item observational protocol completed on each student by his or her teacher, at the beginning, middle and end of the school year (Dodge, Colker, & Heroman, 2001). Under Dr. Galvin's direction, the TCCA was administered during the 2006–2007 school year.

Ms. Donna J. Anderson, an Early Childhood Specialist and a licensed HeartMath Resilient Educator trainer, who had been training Salt Lake City teachers in HeartMath's emotional regulation programs for a decade or more, approached Dr. Galvin with the idea of supplementing his research with an Early HeartSmarts intervention conducted in classes in all nineteen schools. The concept was that Dr. Galvin's study would provide an opportunity to evaluate the efficacy of the EHS program. However, it was necessary that her plan be significantly scaled down due to a series of administrative, budgetary and logistical issues. Nevertheless, Ms. Anderson selected four schools in lower socioeconomic neighborhoods with large ethnic minority enrollments (one of which was a kindergarten class not included in this study), in which there were a number of experienced teachers who had received periodic training in basic HeartMath emotional management tools and heart-rhythm coherence feedback technology[11] over a ten-year period. Ms. Anderson then selected three teachers in the three schools from the intervention group in this study whom she judged to be both competent in teaching the HeartMath material and also effective in working with children of ethnic minority, lower socioeconomic backgrounds.

Table 1. Synopsis of the Early HeartSmarts Program

The core of the Early HeartSmarts program is teaching young children key social and emotional competencies known to facilitate their psychosocial growth and development:

- How to recognize and better understand basic emotional states
- How to regulate emotions
- Ways to strengthen the expression of positive feeling
- Ways to improve peer relations
- Skills for developing problem-solving

How the Program Is Organized

Each of these skills builds successively through the main sections of the program:

1. **Connecting the Physical and Emotional Aspects of the Heart**
   Beginning with a model of a heart, children begin exploring the functions of the heart. The playing of different heartbeat sounds and the use of a stethoscope make this experience more real. Children move from the physical heart to the emotional heart through conversation led by the Bear Heart puppet.

2. **Recognizing and Understanding Emotions**
   Children learn to recognize and better understand five basic emotions (happy, sad, angry, afraid and peaceful) through a series of photo emotion cards. To help with emotional self-regulation, two simple techniques are taught by Bear Heart. The ***Shift and Shine***™ technique strengthens children's experience of positive feelings like love and care while ***Heart Warmer***™ helps with impulse control and managing upsetting emotions.

3. **Expressing Love and Care to Family and Friends**
   Playing Heart Ball and participating in a mini-unit around *The Kissing Hand* book supports the expression and experience of positive emotions. Dramatization further supports the developmental skill of learning to communicate what one is feeling.

4. **Learning Problem-Solving Skills**
   Using photo cards that portray typical age-related issues and a large instructional poster, children learn problem-solving and socialization skills with their peers. An album of songs is woven throughout the program to support the learning of key ideas and skills.

5. **Emotional Self-Regulation Techniques**
   This segment of the program includes instructions for the Shift and Shine™ and Heart Warmer™ techniques, which are taught to help children develop skills for greater emotional self-control:

Shift and Shine™ Technique

- Begin by shifting your attention to the area around your heart. It helps to put your hand over your heart to begin with.
- Now pretend to breathe in and out of your heart area. Take three slow breaths.
- Think of someone or something that makes you feel happy. Feel that warm, happy feeling in your heart and then send or shine that love to someone special.
- *Afterwards, ask the child if he or she sent that feeling to someone or something special. Then ask: How did it make you feel in your heart?*

Heart Warmer™ Technique

- Begin by putting your attention on the area around your heart. It helps to put your hand over your heart to begin with. *Model by putting hand over your heart.*
- Now pretend to breathe in and out of your heart area. Take three slow breaths.
- Imagine that your body feels nice from sitting in warm sunshine. Breathe in a feeling of warm sunshine.

[11] The emWave PC® (formerly Freeze-Framer®) technology is a computer-based heart-rhythm coherence feedback system designed to facilitate acquisition and internalization of the emotional self-regulation skills taught in HeartMath programs. The use of this technology in educational settings to facilitate social, emotional and academic learning is discussed in McCraty (2005).

In more formal terms, the study followed the logic of a quasi-experimental longitudinal field research design involving baseline, pre-intervention and post-intervention panels of data collection. For each measurement moment, *The Creative Curriculum Assessment* (TCCA; described below) was administered to teachers, who evaluated and scored each child on 50 measurement items. The hypothesis was that, relative to the control group, children in the intervention group would exhibit an increased level of development along the four TCCA development dimensions of psychosocial growth — Social and Emotional, Physical, Cognitive and Language Development — over the school year study period. An important secondary purpose was to use the results of the evaluation to inform any changes suggested by the data to improve the program's implementation and effectiveness.

There were a total of 19 schools in the study. The preschool class in each school participated in Dr. Galvin's three-panel administration of the TCCA. Three classes from three different schools (taught by the HeartMath-trained teachers Ms. Anderson selected) constituted the intervention group to which the EHS program was administered; the total student count for these three classes was 66 preschoolers. Sixteen preschool classes from the remaining sixteen schools constituted the control group, which had a total student count of 309.[12]

The timeline of the assessment administration and EHS intervention was as follows:

Fall Term, 2006

- Time 1 measurement, October: First TCCA administration at the beginning of the academic year — baseline measures.

Winter Term, 2007

- Time 2 measurement, early January: Second TCCA administration — pre-intervention measures.
- Intervention initiated late January: A one-day Early HeartSmarts intervention training for teachers followed by delivery of the EHS program by teachers to their students throughout the rest of the school year.

Spring Term, 2007

- Time 3 measurement, end of April: Third TCCA administration — post-intervention measures.

The Intervention

In January 2007, two members of HeartMath's Education Division conducted a one-day training for teachers selected to introduce the EHS program into their preschool classes. The training consisted of HeartMath's Resilient Educator Program plus an orientation to the specific components of the Early HeartSmarts Program. The goal of the training was to provide the teachers with a working familiarity with the scientific foundation of the HeartMath System as well as the EHS concepts, tools, techniques and materials prior to their beginning classroom instruction.

Teachers then delivered the EHS program to their students throughout the rest of the school year — through the end of May, 2007. In the program, students learned:

- Rudimentary concepts about the heart and its connection to emotions
- How to recognize five basic emotions (happy, sad, angry, afraid, peaceful)
- How to practice ways to generate positive emotions
- The Shift and Shine and Heart Warmer techniques — two simple tools for emotional self-regulation and greater self-control
- Simple problem-solving strategies and social skills for relating to their peers.

[12] However, 194 of these control group children were in classes in which their teachers had been previously exposed to a HeartMath Resilient Educator program taught by Ms. Anderson, while the remaining 155 children were in classes with teachers who had no prior exposure to a HeartMath program. Because this raises the question of a prior exposure effect, which could dilute any observed differences between the intervention and control groups, we subdivided the control group into these two groups of children in a special analysis (presented after the main results, below) in order to investigate whether there was any evidence of a HeartMath exposure effect.

Instrumentation

The study used the TCCA as the instrument to measure the impact of the Early HeartSmarts program on preschool children's growth and development across four primary areas — social/emotional development, physical development, cognitive development and language development (see Table 2). The instrument has been psychometrically validated as an "adequate" assessment instrument and is widely used in schools throughout the United States (Lambert, undated). It was adopted by the Salt Lake City School District as a standardized means of systematically assessing the psychosocial development of all preschool students in the nineteen schools in the district.

Table 2 shows the dimensions, components and measurement items in the TCCA which teachers use in making their observations of each child's development. There are four dimensions, covering the Social/Emotional, Physical, Cognitive and Language areas of a child's development, each of which is divided into subcategories and then measurement items on which the teacher evaluates and scores each child. Altogether there are 50 measurement items — 13 in Social/Emotional Development, 8 in Physical Development, 16 in Cognitive Development and 13 in Language Development. For each item, the teachers assessed and scored each child's development in terms of a four-point competency/proficiency rating scale: 0 = Forerunners; 1 = Step I; 2 = Step II; 3 = Step III.[13] Over the course of the study, teachers made three ratings on each measurement item, as depicted in the study timeline above: the first in the Fall of 2006, at the beginning of the school year; the second at the beginning of the Winter term, 2007; and the third following the EHS intervention at the end of the Spring term, 2007.

Table 2. ***The Creative Curriculum Assessment*: Primary Dimensions, Subcomponents and Measurement Items**

The Creative Curriculum® Goals and Objectives at a Glance

SOCIAL/EMOTIONAL DEVELOPMENT	PHYSICAL DEVELOPMENT	COGNITIVE DEVELOPMENT	LANGUAGE DEVELOPMENT
Sense of Self 1. Shows ability to adjust to new situations 2. Demonstrates appropriate trust in adults 3. Recognizes own feelings and manages them appropriately 4. Stands up for rights **Responsibility for Self and Others** 5. Demonstrates self-direction and independence 6. Takes responsibility for own well-being 7. Respects and cares for classroom environment and materials 8. Follows classroom routines 9. Follows classroom rules **Prosocial Behavior** 10. Plays well with other children 11. Recognizes the feelings of others and responds appropriately 12. Shares and respects the rights of others 13. Uses thinking skills to resolve conflicts	**Gross Motor** 14. Demonstrates basic locomotor skills (running, jumping, hopping, galloping) 15. Shows balance while moving 16. Climbs up and down 17. Pedals and steers a tricycle (or other wheeled vehicle) 18. Demonstrates throwing, kicking, and catching skills **Fine Motor** 19. Controls small muscles in hands 20. Coordinates eye-hand movement 21. Uses tools for writing and drawing	**Learning and Problem Solving** 22. Observes objects and events with curiosity 23. Approaches problems flexibly 24. Shows persistence in approaching tasks 25. Explores cause and effect 26. Applies knowledge or experience to a new context **Logical Thinking** 27. Classifies objects 28. Compares/measures 29. Arranges objects in a series 30. Recognizes patterns and can repeat them 31. Shows awareness of time concepts and sequence 32. Shows awareness of position in space 33. Uses one-to-one correspondence 34. Uses numbers and counting **Representation and Symbolic Thinking** 35. Takes on pretend roles and situations 36. Makes believe with objects 37. Makes and interprets representations	**Listening and Speaking** 38. Hears and discriminates the sounds of language 39. Expresses self using words and expanded sentences 40. Understands and follows oral directions 41. Answers questions 42. Asks questions 43. Actively participates in conversations **Reading and Writing** 44. Enjoys and values reading 45. Demonstrates understanding of print concepts 46. Demonstrates knowledge of the alphabet 47. Uses emerging reading skills to make meaning from print 48. Comprehends and interprets meaning from books and other texts 49. Understands the purpose of writing 50. Writes letters and words

[13] "Teachers make ratings of each child three times during the school year: fall, winter and spring. Teachers are encouraged to maintain portfolios of student work along with anecdotal records, accumulating multiple sources of evidence that can inform the ratings. The process of completing the ratings requires the teacher to identify the developmental level of a specific child on a specific item according to a four-point scale. Each item is phrased in terms of specific behaviors and functional areas, and each of the four levels on the accompanying rating scale is anchored to descriptions of specific examples of these behaviors. The four levels have been identified as Forerunner, Step I, Step II and Step III. The Forerunner level represents behaviors that may indicate a developmental delay or that a child has not previously been exposed to that skill. Still, this level represents strengths of the child upon which both future development and instructional strategies can build. Step III represents complete mastery of a particular goal while Steps I and II indicate the phases of development through which a child will pass on the way to mastery. The Continuum is therefore organized to facilitate, for teachers and families, an understanding of both child development and the progress of specific classrooms and children" (Lambert, undated, pages 3-4).

Study Results

After the database of each teacher's sets of baseline, pre-intervention and post-intervention ratings were uploaded into a SPSS program, the data were reviewed and cleaned in preparation for statistical analysis. Following a description of the sample characteristics and the results of an analysis of measurement reliability and validity, the analysis strategy begins with a descriptive analysis of the results at baseline (Time 1), pre-intervention (Time 2) and post-intervention (Time 3), both for the whole sample and also broken down by intervention status. We then move on to a within-groups analysis of the pre- to post-intervention effects by intervention status, followed by an analysis of the between-groups intervention effects. In addition to the analysis by intervention status, the latter also includes a breakdown by sociodemographic factors and a matched-group analysis, controlling for classroom size and total development score. Because, as noted above, some of the teachers in the control group had received trainings in HeartMath techniques over a number of years before the study, we conducted an analysis to check for evidence of a prior exposure artifact which may have diluted the main results. Finally, because the student scores are based solely on a single rating for each item by their teacher, we conducted an analysis of the variation of teachers' ratings in the two groups to check for evidence of scoring bias in the intervention group.

Sample Characteristics

Table 3 shows the breakdown of the study population in terms of sociodemographic characteristics. Aggregated across the three intervention and sixteen control schools, there were a total of 375 children in the study's sample population. Of these, 66 (17.6%) were in the intervention group and 309 (82.4%) were in the control group. The two samples were comparable on both age and gender, with a mean age of 3.6 years each and with a nearly even division on gender (48% male and 52% female for the intervention group and 49% and 51% female for the control group). However, there is evidence of some difference in family socioeconomic status, in that while almost two-thirds (64%) of the intervention group received a free lunch, only half (48%) of the children in the control group did so.[14] Also there are notable differences in ethnic composition; there was a greater proportion of Hispanic children in the intervention group (65% versus 51%) and a much lower proportion of White children (8% versus 33%, respectively). Finally, there was a greater range in class size in the control group (11–28 children versus 18–26, respectively), and the mean class size was slightly smaller in the intervention group (19.31 versus 22.00).

Table 3. Sociodemographic Characteristics (Time 1) of the Whole Sample, Intervention Group and Control Group

	All Students (N=375)	Intervention Group (N=66)	Control Group (N=309)
Mean Age ± SD, yrs (Range 2.8 - 4.7)	3.6 ± 0.32	3.6 ± 0.31	3.6 ± 0.33
Gender, % male	49	48	49
Free Lunch, %	51	64	48
Ethnicity			
Asian	2%	2%	2%
Black	3%	2%	4%
Hispanic	54%	65%	51%
Indian	1%	0%	1%
Polynesian	5%	9%	4%
White	29%	8%	33%
Other	3%	3%	3%
NA	4%	12%	3%
# of Classes	19	3	16
Class size, mean (range)	19.7 (11-28)	19.3 (18-26)	22.0 (11-28)

Measurement Integrity

Before proceeding to an analysis of the intervention results, we conducted a validity and reliability analysis to evaluate the measurement integrity of items and scales constructed from the TCCA.

For each development dimension, a child's scores on the items involved are aggregated to construct a scale score for that dimension. We constructed the Total Development scale by aggregating a child's scores across all 50 items. All students were scored on each of the 50 items using the four-point rating scale on which a student was evaluated by his or her teacher. Since the lowest point value on the rating scale was zero, the maximum score for any item was 3 points, which, when aggregated over the 50 items, yields a total

[14] Student participation in the free lunch program was used as an indicator of low family socio-economic status.

possible development scale score of 150 points (see Appendix 2 for descriptive statistics).

Using the whole sample, we conducted an item analysis and a validity and reliability of measurement analysis of the instrumentation — development scales, subcomponents and individual items (see Appendix 3). Starting with the item analysis, the range of the point-bi-serial order correlation (pbs *r*) over the 50 items across the three measurement moments was 0.26 to 0.82. Since there were no items with a zero or negative pbs *r*, all items met the minimum criteria for technically acceptable measurement; these results suggest that there was an adequate level of discrimination between high- and low-performing children on the assessment. The standard error of measurement (SEM) for the total development score was $\pm$ 1.05, $\pm$ 1.29 and $\pm$ 1.20 points for Time 1, Time 2 and Time 3, respectively, and ranged from $\pm$ 0.15 to 0.44 for the four development dimensions over all three measurement moments — all SEMs are well within psychometrically acceptable limits.

Turning next to the results of the validity and reliability of measurement (see Appendix 3), for the total development score, the Time 1, Time 2 and Time 3 Cronbach's alpha (α) reliability coefficients are all high (0.97, 0.98 and 0.98, respectively), indicating a high degree of internal consistency in the teachers' scoring. With the exception of somewhat lower alpha coefficients for Physical Development (0.80, 0.86 and 0.86) — still psychometrically acceptable for an assessment of this length and type — the relatively high alpha coefficients on the other three development dimensions (ranging from 0.92 to 0.95), also indicate a high level of measurement consistency. While slightly lower alpha coefficients are observed for the subcomponents within each of the four development dimensions (ranging from 0.71 to 0.93), they are, with one exception, all above the technically acceptable level ($\alpha \geq 0.75$).

We also conducted a factor analysis with varimax rotation (results not shown) to evaluate the factor loadings and confirm correct classification of the items in accordance with their nominal assignment. While there were some exceptions, in broad terms, the factors identified and item classifications are consistent with TCCA's categorization of items (see Lambert, undated). In short, the results of these analyses indicate that both the baseline, pre-intervention and post-intervention measures appear to be internally consistent and that the five development scales and ten subcomponent constructs appear to have psychometric integrity as measurement devices.

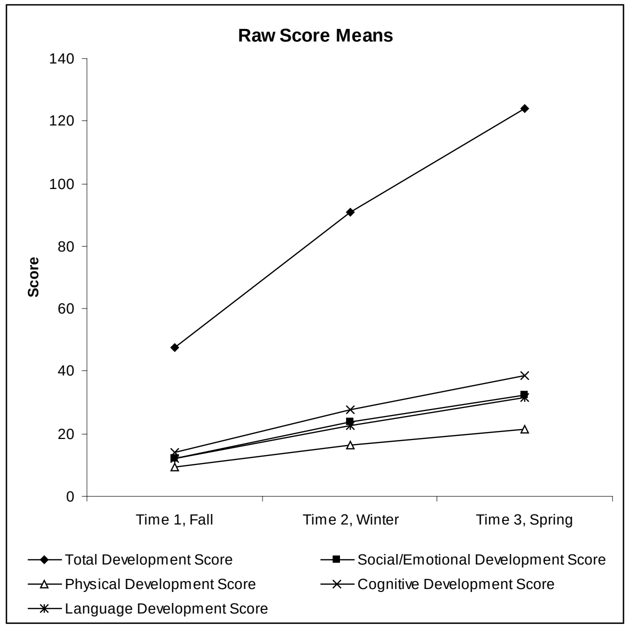

Figure 7. Line Graph of Five Development Scales (mean score) for Entire Sample Population by Measurement Moment

The results of these measurement procedures are shown in aggregate form in the line graph in Figure 7, which plots the sample population's mean total development score and four development dimension scores across the three moments of measurement.[15] Clearly evident is the upward trend in development on all five measures over the three points in time. Thus, the mean Total Development score rose from 47.71 at baseline, to 90.71 at the pre-intervention moment, to 124.15 at the post-intervention measurement moment — a Time 1 to Time 3 increase of 160.22%. In descending order of

[15] Basic descriptive statistics — mean, standard deviation (SD), standard error of measurement (SEM), etc. — for the total sample's performance on the TCCA across the three moments of measurement (T1, T2 and T3) are provided in Appendix 1.

the magnitude of change, the improvement in the mean score on each development dimension was from 13.90 to 38.79 for Cognitive Development (an increase of 179.06%), 12.26 to 32.39 for Social/ Emotional Development (164.19%), 12.26 to 31.42 for Language Development (156.28%) and 9.29 to 21.56 for Physical Development (132.08%).

Baseline (Time 1) Results

Table 4 presents the results of a one-way ANOVA of differences in mean score on the five development scales at baseline measurement broken down by intervention status, gender, ethnicity and socioeconomic status. Starting with the results for intervention status, it is clear that on all five scales there are statistically significant differences between the control group and the intervention group. For instance, on the Total Development scale a 10.00 point difference in mean score favoring the control group (49.47 versus 39.46; F, 15.33; *p* <0.001) is evident. While there are no differences by gender, there are significant differences favoring White children over those with Hispanic or Other ethnic affiliation on all development scales except Physical Development. This same pattern is observed on the indicator of socioeconomic status: the non-free lunch children had significantly higher development scores than the free lunch children on all scales, except that for Physical Development.

In sum, two points emerge from these results. First they indicate that the intervention and control groups were not well matched at baseline on the five development scales. And second, that in the analysis that follows, we will need to control for the effects of ethnicity and free lunch status in the event that pre–post-intervention differences in development are observed between the intervention and control groups.

Pre–Post-Intervention Results

In our investigation of the effects of the EHS intervention, we conducted two sets of statistical analyses. The first was conducted on the intervention and control groups, separately, in order to investigate the degree of pre–post change in development within each group. The second set was conducted to identify any changes in development in the intervention group that could be attributed to the effects of the EHS intervention by comparing the differences between the two groups in pre–post changes in development.

Table 4. Baseline (Time 1) ANOVA of Development Scales by Intervention Grouping, Gender, Ethnicity, and Family Socioeconomic Status

	Intervention Group (N=66)			Control Group (N=309)						ANOVA Between Groups		
	Mean	SD	SEM	Mean	SD	SEM				Mean Sq	F	*p* <
Total Development Score	39.47	16.20	1.99	49.47	19.34	1.10				5434.40	15.33	0.001
Social/Emotional Development Score	9.62	4.45	0.55	12.83	5.32	0.30				558.30	20.83	0.001
Physical Development Score	8.33	2.19	0.27	9.49	2.93	0.17				73.00	9.23	0.01
Cognitive Development Score	11.71	5.85	0.72	14.36	7.09	0.40				382.01	8.05	0.01
Language Development Score	9.80	5.48	0.67	12.79	5.99	0.34				484.05	13.91	0.001
	Male (N=178)			Female (N=189)						ANOVA Between Groups		
	Mean	SD	SEM	Mean	SD	SEM				Mean Sq	F	*p* <
Total Development Score	47.25	19.62	1.47	48.01	18.93	1.38				52.68	0.14	ns
Social/Emotional Development Score	11.98	5.40	0.40	12.46	5.30	0.39				20.87	0.73	ns
Physical Development Score	9.31	3.01	0.23	9.29	2.72	0.20				0.08	0.01	ns
Cognitive Development Score	13.92	7.15	0.54	13.78	6.79	0.49				1.89	0.04	ns
Language Development Score	12.03	6.17	0.46	12.48	5.86	0.43				18.84	0.52	ns
	Hispanic (N=202)			White (N=108)			Other (N=65)			ANOVA Between Groups		
	Mean	SD	SEM	Mean	SD	SEM	Mean	SD	SEM	Mean Sq	F	*p* <
Total Development Score	43.34	15.87	1.12	56.70	20.95	2.02	46.34	20.66	2.56	6360.78	18.94	0.001
Social/Emotional Development Score	11.49	4.65	0.33	13.94	5.86	0.56	11.88	5.72	0.71	216.17	7.94	0.001
Physical Development Score	9.13	2.46	0.17	9.78	3.20	0.31	8.97	3.25	0.40	18.82	2.35	ns
Cognitive Development Score	12.25	5.70	0.40	17.28	7.84	0.75	13.38	7.03	0.87	898.88	20.54	0.001
Language Development Score	10.47	4.97	0.35	15.71	6.08	0.58	12.11	6.37	0.79	969.89	31.30	0.001
	Non-Free Lunch (N=184)			Free Lunch (N=191)						ANOVA Between Groups		
	Mean	SD	SEM	Mean	SD	SEM				Mean Sq	F	*p* <
Total Development Score	50.98	20.88	1.54	44.55	16.86	1.22				3879.50	10.82	0.01
Social/Emotional Development Score	12.93	5.67	0.42	11.61	4.88	0.35				163.84	5.88	0.05
Physical Development Score	9.49	3.12	0.23	9.09	2.54	0.18				15.41	1.91	ns
Cognitive Development Score	15.22	7.46	0.55	12.62	6.18	0.45				635.98	13.60	0.001
Language Development Score	13.33	6.47	0.48	11.23	5.33	0.39				413.75	11.82	0.001

Single Factor ANOVA

Within-Groups Analysis

For the intervention and control groups separately, we conducted a within-subjects repeated measures analysis to investigate the changes in the children's development in the two periods up to and then following the EHS intervention (pre-intervention: Time 1 to Time 2; and post-intervention: Time 2 to Time 3, respectively). The analysis was conducted on the five development scales. While a significant change in development was hypothesized for children exposed to the EHS intervention, the children in the control group were also expected to exhibit development, reflecting the natural growth processes in children of this preschool age group.

Both these expectations were confirmed by the results (Table 5). Across all five development scales, a significant increase in mean score (p <0.001, on all measures) was observed in both the baseline (Time 1) to pre-intervention (Time 2) and pre-intervention to post-intervention (Time 3) periods for each group. Beginning with the Total Development scale — our most robust construct, composed of 50 measurement items — the results for the intervention group show that the greatest increase in development was observed in the first period before the EHS intervention (Δ mean score: T2 − T1 = 53.15 points; Δ mean score: T3 − T2 = 38.69 points). While somewhat smaller in magnitude, the same pattern was observed for the children in the control group (Δ mean score: T2 − T1 = 40.64 points; Δ mean score: T3 − T2 = 32.42 points). Even though, as already noted, this somewhat smaller degree of change in the second period was significant in both groups, determining how much of this growth in development in the intervention group is attributable to the effects of the EHS program requires a between-groups comparison of the two groups, in which any differences in the measures of development at the baseline (Time 1) and pre-intervention (Time 2) moments are statistically controlled. We turn to this all-important question next.

Between-Groups Analysis

The primary statistical analysis technique we used to investigate pre-post changes in development was analysis of covariance (ANCOVA). An important advantage of ANCOVA is that the baseline (Time 1) and pre-intervention (Time 2) differences on the development measures between the intervention and control groups are statistically adjusted to make them comparable before the change effects are determined.

To evaluate the effects of the Early HeartSmarts intervention on the children's development, we conducted a series of ANCOVA studies in which any difference on the development measures at Time 1 and at Time 2 were controlled by treating them as covariates in the statistical model. We begin with the results by intervention status, before moving to the breakdowns by gender, ethnicity and family socioeconomic background.

Table 5. Within-Subjects Repeated Measures Analysis of Change in Development Scales (mean score) for Intervention and Control Groups

Within-Subjects Repeated Measures - Intervention Group

		Time 1		Time 2		Time 3		Time 1 vs. Time 2			Time 2 vs. Time 3		
	N	Mean	SD	Mean	SD	Mean	SD	Mean Sq	F	*p* <	Mean Sq	F	*p* <
Total Development	65	39.88	15.98	93.03	22.95	131.72	19.19	183646.54	620.87	0.001	97311.15	411.63	0.001
Social/Emotional Development	65	9.75	4.35	24.58	6.19	35.02	5.00	14296.86	413.81	0.001	7072.06	197.48	0.001
Physical Development	65	8.38	2.17	16.72	3.83	22.74	2.21	4519.45	503.43	0.001	2352.02	248.00	0.001
Cognitive Development	65	11.85	5.79	29.05	8.28	41.11	7.83	19229.60	439.16	0.001	9456.25	292.12	0.001
Language Development	65	9.89	5.47	22.68	7.12	32.86	6.88	10624.02	399.73	0.001	6742.22	333.52	0.001

Within-Subjects Repeated Measures - Control Group

		Time 1		Time 2		Time 3		Time 1 vs. Time 2			Time 2 vs. Time 3		
	N	Mean	SD	Mean	SD	Mean	SD	Mean Sq	F	*p* <	Mean Sq	F	*p* <
Total Development	301	49.57	19.23	90.21	23.38	122.63	22.12	497082.47	1920.83	0.001	316405.59	1491.65	0.001
Social/Emotional Development	301	12.88	5.25	23.62	6.91	31.88	6.55	34746.70	1199.91	0.001	20532.21	1067.94	0.001
Physical Development	301	9.51	2.92	16.13	3.37	21.32	2.85	13222.67	1389.75	0.001	8105.79	1184.94	0.001
Cognitive Development	301	14.39	7.08	27.61	8.24	38.30	7.95	52652.36	1462.75	0.001	34382.36	998.26	0.001
Language Development	301	12.80	5.98	22.84	7.18	31.12	7.00	30340.48	1525.28	0.001	20664.57	815.77	0.001

The bar chart in Figure 8 presents the ANCOVA results by intervention status for the five development scales and the ten dimension subcomponents. Clearly evident is the strong consistent pattern of significant differences on all fifteen measures of development, favoring the intervention group over the control group. On ten of the fifteen measures of development, the statistical power of the magnitude of the difference (the F statistic coefficients range from 10.40–29.98) and the level of statistical significance (p <0.001) are strong. More specifically, from the adjusted means on the five development scales, a marked difference was observed favoring the intervention group on the Total Development scale (130.96 versus 122.79, respectively; p <0.001), and on each of the social/emotional development (34.95 versus 31.90, p <0.001), physical development (22.59 versus 21.35, p <0.001), cognitive development (40.58 versus 38.41, p <0.01) and language development (33.74 versus 30.99, p <0.001) scales.

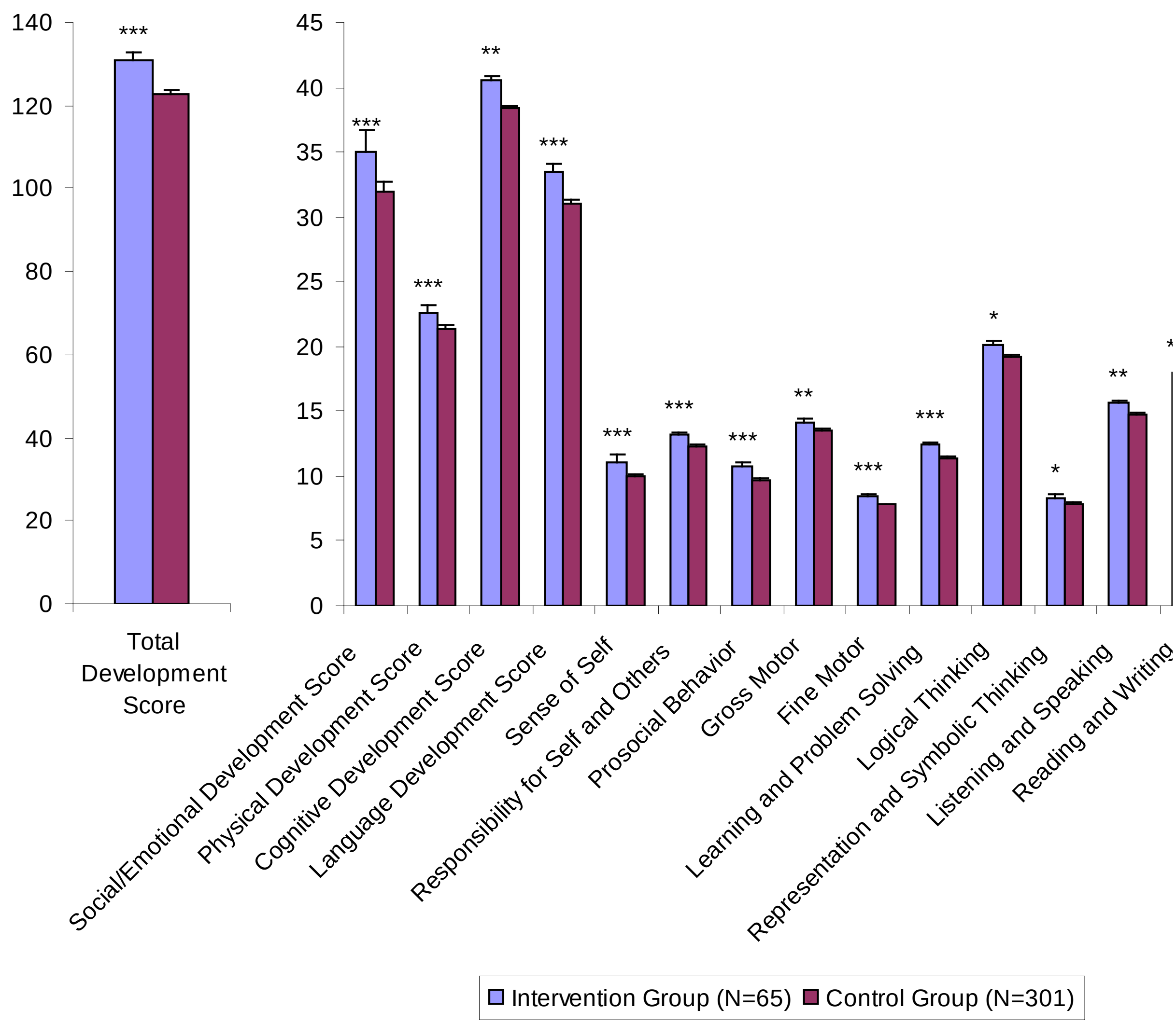

Figure 8. Bar Chart Showing Results of ANCOVA of Intervention Effects on Development Measures Comparing Intervention and Control Groups

Significance: * p < 0.05; ** p < 0.01; *** p < 0.001

Sociodemographic Effects

In order to investigate the degree to which these observed differences in development were of a general nature and not mediated by one or more intervening sociodemographic factors, a further series of ANOVA studies was conducted on the five development scales controlling for gender, ethnic status and socioeconomic (free lunch status) background. The results are presented in Figure 9 and Table 6.

Beginning with the results (adjusted means) for the Total Development scale (Figure 9), it is evident that with the exception of the result for the Ethnicity-Other category, a consistent pattern of significant differences is observed favoring the intervention over the control group: for Males (128.10 versus 121.35, $p < 0.05$), Females (133.876 versus 124.42, $p < 0.001$, Hispanic (129.60 versus 121.22, $p < 0.001$), White (130.62 versus 121.87, $p < 0.05$), Free Lunch (131.61 versus 125.29, $p < 0.01$) and Non-Free Lunch (130.09 versus 120.33, $p < 0.01$). This pattern of results signals a notably greater level of development for children with these characteristics who were exposed to the EHS program than those who were not.

Table 6. ANCOVA of Intervention Effects on Development Scales Comparing Intervention and Control Groups by Gender, Ethnicity and Socioeconomic Status

Spring Post Study Between Group Effects

	Intervention Group					Control Group							
Dependent Variable	N	Adj Mean	SEM	Lower 95% CI	Upper 95% CI	N	Adj Mean	SEM	Lower 95% CI	Upper 95% CI	Mean Sq	F	*p* <
All Students													
Total Development Score	65	130.96	1.72	127.57	134.35	301	122.79	0.77	121.27	124.31	3200.92	18.13	0.001
Social/Emotional Development Score	65	34.95	0.54	33.89	36.02	301	31.90	0.24	31.42	32.38	446.46	25.69	0.001
Physical Development Score	65	22.59	0.27	22.07	23.12	301	21.35	0.12	21.12	21.59	77.74	17.60	0.001
Cognitive Development Score	65	40.58	0.68	39.25	41.92	301	38.41	0.31	37.81	39.02	235.35	8.33	0.01
Language Development Score	65	33.47	0.58	32.34	34.61	301	30.99	0.26	30.48	31.51	303.67	14.99	0.001
Males													
Total Development	31	128.10	2.45	123.28	132.93	144	121.35	1.09	119.21	123.50	1021.06	6.14	0.05
Social/Emotional Development	31	33.91	0.81	32.31	35.51	144	31.20	0.36	30.49	31.91	162.34	8.99	0.01
Physical Development	31	22.56	0.37	21.82	23.30	144	21.14	0.17	20.81	21.48	47.82	11.58	0.001
Cognitive Development	31	39.17	0.97	37.26	41.09	144	38.25	0.44	37.39	39.11	19.93	0.74	ns
Language Development	31	32.83	0.73	31.39	34.28	144	30.68	0.33	30.03	31.34	109.70	7.03	0.01
Females													
Total Development	32	133.87	2.51	128.91	138.83	152	124.42	1.11	122.22	126.61	2121.62	11.49	0.001
Social/Emotional Development	32	35.70	0.76	34.20	37.21	152	32.54	0.34	31.86	33.21	241.88	13.97	0.001
Physical Development	32	22.69	0.40	21.91	23.47	152	21.53	0.18	21.18	21.88	33.52	7.03	0.01
Cognitive Development	32	42.12	0.95	40.24	43.99	152	38.76	0.43	37.92	39.60	278.85	10.20	0.01
Language Development	32	34.39	0.91	32.59	36.19	152	31.38	0.41	30.58	32.18	215.84	8.84	0.01
Ethnicity - Hispanic													
Total Development	43	129.60	2.18	125.30	133.89	157	121.22	1.10	119.04	123.40	2111.33	11.33	0.001
Social/Emotional Development	43	34.95	0.68	33.61	36.29	157	31.79	0.35	31.10	32.47	302.41	16.55	0.001
Physical Development	43	22.58	0.33	21.92	23.24	157	21.39	0.17	21.05	21.73	45.07	9.83	0.01
Cognitive Development	43	40.07	0.83	38.42	41.71	157	37.94	0.43	37.09	38.78	142.24	5.05	0.05
Language Development	43	32.60	0.78	31.07	34.13	157	29.94	0.39	29.17	30.72	215.16	9.01	0.01
Ethnicity - Other													
Total Development	5	136.10	6.09	124.02	148.19	102	125.98	1.32	123.36	128.59	465.45	2.63	ns
Social/Emotional Development	5	36.08	1.82	32.47	39.68	102	31.88	0.40	31.09	32.67	81.82	5.07	0.05
Physical Development	5	21.94	1.01	19.93	23.94	102	21.24	0.22	20.80	21.67	2.22	0.45	ns
Cognitive Development	5	43.04	2.39	38.31	47.78	102	39.85	0.52	38.82	40.88	46.83	1.70	ns
Language Development	5	36.32	1.86	32.62	40.02	102	32.95	0.41	32.14	33.75	51.93	3.12	ns
Ethnicity - White													
Total Development	17	130.62	3.06	124.49	136.74	42	121.87	1.87	118.12	125.62	768.54	5.55	0.05
Social/Emotional Development	17	34.38	1.04	32.29	36.47	42	32.46	0.63	31.20	33.73	35.75	2.27	ns
Physical Development	17	22.85	0.47	21.92	23.79	42	21.49	0.29	20.91	22.07	20.67	5.99	0.05
Cognitive Development	17	40.19	1.32	37.54	42.84	42	37.09	0.81	35.47	38.71	97.69	3.74	ns
Language Development	17	33.44	0.94	31.56	35.32	42	30.73	0.58	29.56	31.89	78.06	5.75	0.05
Free Lunch													
Total Development	42	131.61	1.89	127.88	135.34	148	125.29	0.98	123.37	127.22	1168.07	8.48	0.01
Social/Emotional Development	42	36.04	0.59	34.87	37.21	148	32.88	0.31	32.28	33.49	292.52	21.51	0.001
Physical Development	42	22.94	0.27	22.40	23.48	148	21.85	0.14	21.57	22.13	37.29	12.28	0.001
Cognitive Development	42	41.03	0.80	39.45	42.61	148	38.97	0.42	38.15	39.79	127.44	5.05	0.05
Language Development	42	32.92	0.71	31.51	34.33	148	31.22	0.37	30.49	31.95	87.57	4.35	0.05
Non Free Lunch													
Total Development	23	130.09	3.10	123.98	136.20	153	120.33	1.15	118.06	122.59	1686.58	8.51	0.01
Social/Emotional Development	23	33.57	0.98	31.64	35.50	153	30.86	0.37	30.14	31.58	132.80	6.59	0.05
Physical Development	23	22.24	0.52	21.22	23.26	153	20.83	0.19	20.45	21.22	36.53	6.41	0.05
Cognitive Development	23	39.88	1.17	37.57	42.18	153	37.86	0.44	36.99	38.72	74.61	2.58	ns
Language Development	23	34.13	0.95	32.25	36.01	153	30.82	0.36	30.12	31.53	197.88	10.37	0.01

ANCOVA - covariates Fall and Winter baseline scores

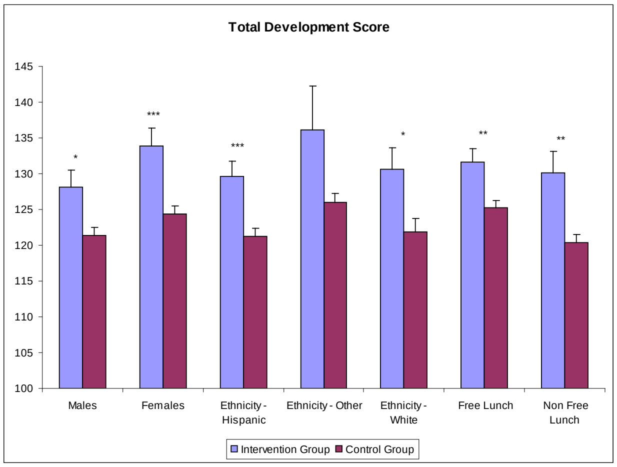

Figure 9. Bar Chart of ANCOVA Results Comparing Pre–Post Change in Total Development Mean Scores by Intervention Status and by Sociodemographic Grouping

Significance: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 6 presents the ANCOVA results for the four development dimension scales. For Females, Hispanics and Free Lunch students, there is a pattern of a significantly greater increase in development in the intervention group compared to the control group, on all four scales — viz, Social/Emotional Development, Physical Development, Cognitive Development and Language Development. With the exception of the Cognitive Development scale, this same pattern is observed for Males and Non-Free Lunch students. While for White students there is evidence of a significantly greater increase in development of the intervention group over the control group on two dimensions (Physical Development and Language Development), this is evident only on one dimension (Social/Emotional Development) for students in the Other Ethnicity category.

Matched-Groups Analysis

We also conducted another ANCOVA study to investigate the degree to which the observed differences between the two groups of children were not confounded by an underlying difference in class size. To conduct the study we constructed a matched-group comparison by selecting classes from the control group sample that were close to or within the class size range (18–24 children) of the three classes in the intervention group. There were four classes in the control group (total N = 90) with a class size of between 17–26 children, and we selected these for the matched-group comparison.

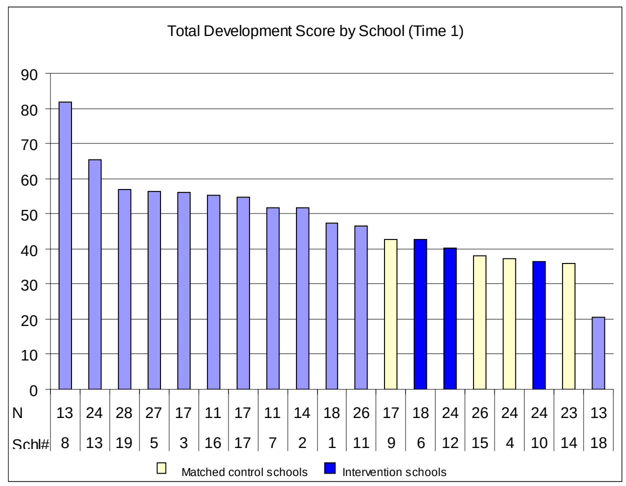

Figure 10. Baseline (Time 1) Mean Total Development Score by School Class and Showing Class Size (N)

As shown in Figure 10, the seven classes included for the matched-group comparison — three intervention classes (#s 6, 10 and 12) and four control classes (#s 4, 9, 14 and 15) — were also within the same range on mean baseline total development score (35.78–42.71). This enabled us

Table 7. Matched-Groups ANCOVA of Intervention Effects on Development by Intervention Status, with Time 1 and Time 2 Used as Covariates

Post Study (Spring) Mached Sample Comparision (Intervention Schools vs Matched Schools 4, 9 & 14)

	Intervention Group					Control Group							
Dependent Variable	N	Adj Mean	SEM	Lower 95% CI	Upper 95% CI	N	Adj Mean	SEM	Lower 95% CI	Upper 95% CI	Mean Sq	F	*p* <
Total Development	65	123.68	1.73	120.27	127.10	89	115.93	1.45	113.07	118.79	1782.54	10.60	0.001
Social/Emotional Development	65	33.14	0.60	31.96	34.32	89	29.53	0.50	28.54	30.52	392.45	19.32	0.001
Physical Development	65	21.86	0.27	21.32	22.40	89	20.74	0.23	20.29	21.20	40.58	9.11	0.01
Cognitive Development	65	38.06	0.64	36.79	39.34	89	36.47	0.54	35.40	37.54	77.53	3.26	ns
Language Development	65	31.43	0.60	30.24	32.62	89	28.60	0.51	27.59	29.60	262.83	12.09	0.001

ANCOVA - covariates Fall and Winter baseline scores

to simultaneously control for the effects of differences between the intervention and control group on both class size and total development, providing for a somewhat more rigorous matched-groups analysis.

As in the ANCOVA studies just presented, in order to control for any differences in development between the two groups in the pre-intervention period, development scores at Time 1 and Time 2 were deployed as covariates in the statistical model. Table 7 presents the results.

A strong significant difference in the pre–post increase in the mean total development score is observed for the intervention group over the matched-group sample from the control group (123.68 versus 115.93, respectively; F = 10.60, *p* <0.001). A similar difference is also evident for three of the four development dimensions: Social/Emotional Development (33.14 versus 29.53; F = 19.32, *p* <0.001); Physical Development (21.86 versus 20.74; F = 9.11, *p* <0.01) and Language Development (31.43 versus 28.60; F = 12.09, *p* <0.001). In short, when baseline differences in class size and total development are controlled, there is still compelling evidence of greater development in the children who received the EHS program than in those who did not.

Split-Half Sample Analysis

As the final step in our primary analysis, we conducted a split-half sample analysis. In a typical application, the procedure involves randomly dividing the study sample population into two halves and then repeating the analysis separately on each half-sample. This enables a check on the statistical integrity of non-random samples and also provides some indication of the likely generalizability of results. Since both of these are issues for the EHS study, a split-half sample analysis was undertaken.

To conduct this analysis, we randomly divided the intervention and control groups into two ap-

Table 8. Results of Split-Half Sample ANCOVA on Development Dimensions and Subcomponents by Intervention Status

Random Split 1 - Post Study (Spring) Between Groups ANCOVA

	Intervention group (N=36)				Control group (N=151)							
	Adj Mean	SEM	Lower 95% CI	Upper 95% CI	Adj Mean	SEM	Lower 95% CI	Upper 95% CI	Mean Sq	F	*p* <	Sig.
Total Development Score	128.85	2.17	124.57	133.13	122.00	1.03	119.97	124.04	1254.24	7.93	0.01	0.005
Social/Emotional Development Score	34.07	0.67	32.75	35.39	31.73	0.32	31.10	32.36	146.43	9.67	0.01	0.002
Physical Development Score	22.36	0.37	21.64	23.08	21.31	0.18	20.96	21.65	30.68	6.60	0.05	0.011
Cognitive Development Score	39.66	0.88	37.93	41.39	38.11	0.42	37.28	38.94	66.11	2.49	ns	0.116
Language Development Score	33.10	0.71	31.69	34.50	30.78	0.34	30.10	31.45	147.51	8.49	0.01	0.004
Sense of Self	10.80	0.24	10.34	11.27	9.89	0.11	9.67	10.12	21.72	11.75	0.001	0.001
Responsibility for Self and Others	12.96	0.34	12.29	13.63	12.27	0.16	11.95	12.59	12.83	3.26	ns	0.073
Prosocial Behavior	10.47	0.25	9.97	10.97	9.60	0.12	9.36	9.84	20.97	9.53	0.01	0.002
Gross Motor	14.03	0.25	13.53	14.52	13.57	0.12	13.33	13.81	5.77	2.68	ns	0.103
Fine Motor	8.31	0.21	7.89	8.73	7.74	0.10	7.54	7.95	9.14	5.67	0.05	0.018
Learning and Problem Solving	12.11	0.34	11.43	12.78	11.32	0.16	11.00	11.64	17.11	4.27	0.05	0.04
Logical Thinking	19.64	0.48	18.70	20.59	19.02	0.23	18.57	19.47	10.72	1.38	ns	0.242
Representation and Symbolic Thinking	8.19	0.22	7.75	8.63	7.82	0.11	7.61	8.03	3.71	2.24	ns	0.136
Listening and Speaking	15.58	0.36	14.87	16.28	14.79	0.17	14.45	15.13	16.59	3.86	ns	0.051
Reading and Writing	17.58	0.46	16.68	18.48	16.03	0.22	15.60	16.46	67.23	9.34	0.01	0.003

ANCOVA - covariates Fall and Winter baseline scores

Random Split 2 - Post Study (Spring) Between Groups ANCOVA

	Intervention group (N=29)				Control group (N=150)							
	Adj Mean	SEM	Lower 95% CI	Upper 95% CI	Adj Mean	SEM	Lower 95% CI	Upper 95% CI	Mean Sq	F	*p* <	Sig.
Total Development Score	133.19	2.76	127.74	138.64	123.66	1.16	121.38	125.95	1920.03	9.76	0.01	0.002
Social/Emotional Development Score	36.02	0.88	34.28	37.76	32.07	0.37	31.34	32.80	325.96	16.43	0.001	0.000
Physical Development Score	22.84	0.39	22.06	23.61	21.41	0.17	21.08	21.74	46.30	11.00	0.001	0.001
Cognitive Development Score	41.62	1.06	39.52	43.71	38.74	0.45	37.85	39.64	185.02	6.07	0.05	0.015
Language Development Score	33.81	0.94	31.95	35.66	31.23	0.40	30.44	32.02	145.23	6.20	0.05	0.014
Sense of Self	11.46	0.31	10.84	12.07	9.93	0.13	9.68	10.19	46.79	19.27	0.001	0.000
Responsibility for Self and Others	13.57	0.41	12.75	14.38	12.32	0.17	11.97	12.66	33.87	7.58	0.01	0.007
Prosocial Behavior	11.14	0.31	10.53	11.75	9.79	0.13	9.53	10.06	42.09	15.74	0.001	0.000
Gross Motor	14.36	0.27	13.83	14.89	13.53	0.12	13.30	13.76	16.04	7.99	0.01	0.005
Fine Motor	8.50	0.20	8.10	8.90	7.90	0.09	7.73	8.07	8.20	7.25	0.01	0.008
Learning and Problem Solving	12.84	0.42	12.01	13.67	11.53	0.18	11.17	11.89	39.85	8.04	0.01	0.005
Logical Thinking	20.60	0.58	19.46	21.73	19.43	0.25	18.94	19.91	31.31	3.44	ns	0.065
Representation and Symbolic Thinking	8.39	0.26	7.87	8.91	7.74	0.11	7.53	7.96	9.09	5.00	0.05	0.027
Listening and Speaking	15.70	0.45	14.82	16.59	14.84	0.19	14.47	15.21	16.01	3.05	ns	0.083
Reading and Writing	18.20	0.48	17.25	19.16	16.48	0.21	16.07	16.90	68.48	10.46	0.001	0.001

ANCOVA - covariates Fall and Winter baseline scores

proximately equal subgroups each and then repeated the pre–post ANCOVA comparison on each of the two half-sample pairings, accordingly: *viz*, Random Split-Half 1: 1st Intervention Subgroup versus 1st Control Subgroup; Random Split-Half 2: 2nd Intervention Subgroup versus 2nd Control Subgroup. As an extra precaution, we not only conducted the analysis on the five development scales and but also included the ten subcomponents of the four development dimensions as well. The results for each split-half are presented in Table 8 (labeled "Random Split 1" and "Random Split 2").

Beginning with the five development scales, a comparison of the results for Random Split 1 to those for Random Split 2 shows that, with one exception (Cognitive Development scale), a pattern of significant differences favoring the intervention group on the other four development measures is evident in both ANCOVAs. This suggests that the intervention results on the Total Development scale and the Social/Emotional, Physical and Language Development scales appear to be robust, are unlikely to be the result of sample bias, and are probably generalizable to children with similar characteristics and in similar educational contexts as those in the intervention group.

However, the results for the ten subcomponents of the development dimensions suggest that the differences between the intervention and control groups are less robust than those observed above on the full samples. Comparing the ANCOVA results for Random Split 1 with those of Random Split 2 reveals that while the latter had significant differences between the intervention and control half-subgroups on eight subcomponents, this was true for only five subcomponents for the former — Sense of Self, Prosocial Behavior, Fine Motor, Learning and Problem Solving, and Reading and Writing. These five are among the eight subcomponents found significant in the ANCOVA of Random Split 2. This commonality suggests that the differences in development observed above, favoring the intervention group on this set of five subcomponents, are likely to be robust and not a result of the EHS study sample selection procedure.

Potential Sources of Spuriousness

Given the strength and consistency of these results, a further series of ANCOVA studies was conducted in an effort to rule out two potentially important sources of spuriousness. One of these concerns the possible impact of an exposure effect: that some teachers in the control group had received HeartMath's Resilient Educator training program some years before this study. There are two ways in which this artifact could have inflated the differences in favor of the intervention group. One is that this prior exposure could have predisposed them (consciously or unconsciously) to impart elements of the HeartMath system to their students, thereby potentially minimizing the expected difference with the intervention group. The converse consequence is that control group teachers with a favorable opinion of the HeartMath program could have been predisposed (consciously or unconsciously) to produce a positive study outcome by biasing ratings of their students more negatively than teachers who had no prior exposure to HeartMath.

The second potential source of spuriousness is the so-called "Hawthorne Effect," first identified by Roethlisberger and Dickerson (1939) in their study of worker productivity in General Electric's factories. This effect is produced when research subjects change their natural behavior and conspire to produce what they perceive as the outcome expected by researchers. In the case of the present study, the question for investigation is whether the intervention teachers — all selected by Ms. Anderson because she anticipated them to be effective teachers of the HeartMath material — biased their ratings of the children in their classes to generate or exaggerate results that would produce an outcome favorable to the EHS program.

Issue of Prior HeartMath Exposure

Of the 309 children in the control group, 194 were in classes in which their teachers had been previously exposed to a HeartMath Resilient Educator program; the remaining 155 children were in classes with teachers who had no prior exposure to a HeartMath program. We subdivided the control group into these two groups of children, labeling them as "Prior HM Exposure Control" and "No HM Exposure Control," respectively, and conducted three ANCOVA studies to investigate whether there was any evidence on the five development scales of a HeartMath exposure effect. The results of the three studies are presented in Table 9.

For the first study (top section in Table 9), we compared the intervention group against the No HM Exposure Control subgroup — a "pure" control group uncontaminated by a teacher's prior exposure to a HeartMath training program. A consistent pattern of significant differences is observed on all five development scales favoring the intervention group over the "pure" control group. This is as expected, given the positive results for the EHS intervention presented thus far.

For the second study (middle section, Table 9), we compared the intervention group with the control subgroup whose teachers had received HeartMath training — a direct check for evidence of a prior HeartMath exposure effect. Here again a strong pattern of significant differences (all with $p < 0.001$) on all five development scales in favor of the intervention group is observed. It appears that there is no evidence of a contamination artifact in the control group — no dilution of development differences between the children in the two groups associated with a teacher's prior exposure to a HeartMath program.

For the third study we compared the two parts of the control group against each other: that is, we compared the pure No HM Exposure subgroup against the Prior HM Exposure subgroup. Shown in the bottom section of Table 9, with the exception of a small difference in Physical Development, the results show that the two subgroups experienced virtually the same changes in development. This is compelling confirmation that the two subgroups in the control sample were essentially equivalent, and, therefore, that the use of the whole control group sample in the analyses above was justified.

Table 9. ANCOVA Comparing Intervention Group with "Prior HM Exposure Control" (Exposed Control) and "No HM Exposure Control" (Pure Control) Subgroups on Development (Time 1 and Time 2 Used as Covariates)

Intervention Schools vs Pure Control Schools

	Intervention Schools (N=66)				Pure Control Schools (N=114)						
	Mean	SEM	Lower 95% CI	Upper 95% CI	Mean	SEM	Lower 95% CI	Upper 95% CI	Mean Sq	F	*p* <
Total Development	128.08	1.68	124.78	131.39	121.77	1.24	119.32	124.22	1432.41	8.62	0.01
Social/Emotional Development	34.34	0.57	33.22	35.46	31.50	0.42	30.67	32.32	280.56	15.10	0.001
Physical Development	22.24	0.25	21.74	22.73	21.36	0.19	20.99	21.73	30.08	7.70	0.01
Cognitive Development	39.64	0.66	38.34	40.94	37.83	0.49	36.86	38.80	124.74	4.69	0.05
Language Development	32.69	0.58	31.54	33.84	30.62	0.43	29.76	31.47	159.70	7.76	0.01

ANCOVA - covariates Fall and Winter baseline scores

Intervention Schools vs Exposed Control Schools

	Intervention Schools (N=65)				Exposed Control Schools (N=187)						
	Mean	SEM	Lower 95% CI	Upper 95% CI	Mean	SEM	Lower 95% CI	Upper 95% CI	Mean Sq	F	*p* <
Total Development	135.07	1.73	131.67	138.47	123.25	0.97	121.34	125.17	5590.66	33.29	0.001
Social/Emotional Development	35.87	0.54	34.80	36.94	32.06	0.31	31.45	32.66	599.36	35.18	0.001
Physical Development	22.99	0.27	22.45	23.53	21.39	0.16	21.08	21.70	110.52	24.88	0.001
Cognitive Development	42.04	0.68	40.71	43.37	38.77	0.39	38.01	39.53	450.24	16.77	0.001
Language Development	34.12	0.56	33.03	35.22	31.05	0.32	30.43	31.68	404.60	22.07	0.001

ANCOVA - covariates Fall and Winter baseline scores

Exposed Control Schools vs Pure Control School

	Exposed Control Schools (N=187)				Pure Control School (N=114)						
	Mean	SEM	Lower 95% CI	Upper 95% CI	Mean	SEM	Lower 95% CI	Upper 95% CI	Mean Sq	F	*p* <
Total Development	121.99	0.99	120.05	123.93	123.68	1.27	121.18	126.17	194.95	1.08	ns
Social/Emotional Development	31.74	0.30	31.16	32.32	32.12	0.38	31.37	32.86	9.63	0.59	ns
Physical Development	21.07	0.16	20.76	21.38	21.73	0.20	21.33	22.14	28.60	6.37	0.05
Cognitive Development	38.28	0.40	37.50	39.06	38.33	0.51	37.33	39.34	0.22	0.01	ns
Language Development	31.09	0.34	30.42	31.75	31.19	0.43	30.33	32.04	0.71	0.03	ns

ANCOVA - covariates Fall and Winter baseline scores

Table 10. ANOVA of Standard Deviation of Teachers' Ratings Comparing Intervention and Control Groups by Measurement Moment

	Intervention Group (N=66)		Control Group (N=309)				
	Mean SD	Variance	Mean SD	Variance	*F*	*p* <	*P-value*
Baseline-Time 1	3.59	14.40	4.27	20.32	0.20	ns	0.659
Pre Study-Time 2	5.06	28.55	5.15	29.69	0.00	ns	0.965
Post Study-Time 3	4.34	20.83	4.86	26.71	0.09	ns	0.769

Issue of a "Hawthorne Effect" Ratings Bias

To investigate this question we conducted an analysis investigating the degree to which the teachers' ratings of the children in the intervention group exhibited a different pattern of variation than the teachers' ratings of the control group. We expected that if there was a "Hawthorne Effect" at work, the variation of the intervention group's scores would be more confined — reflecting a conscious or unconscious bias across all children — than a more natural pattern of variation in scores produced by teachers in the control group.

As an index of variation, we used the standard deviation (SD) of the mean score for each student on each of the fifteen primary measurement constructs — the five development scales and the ten subcomponents. We then conducted an ANOVA of the pooled mean SD for the two groups for the three moments of measurement. The results of the analysis (Table 10) show that the mean pattern of variation in the teachers' ratings between the two groups at baseline (Time 1), pre-intervention (Time 2) and post-intervention (Time 3) was similar and not significant. This suggests that there is little evidence of a systematic bias in the scoring of children by the teachers of the intervention group.

Summary

Despite baseline differences favoring the control group over the intervention group on the five development scales, the results of the ANCOVA studies have consistently shown a pattern of significant differences in development favoring children who received the EHS program over those in the control group who did not. The results are compelling in that these differences do not appear to be mediated by gender, ethnic affiliation, socioeconomic background, or classroom size, or explained by baseline differences in development between the two groups of children. Moreover, the results of a split-half sample analysis suggest that the findings for all but one of the development scales are robust and likely generalizable to children of similar characteristics and educational contexts as those in the intervention group. Finally, the investigation of potential sources of spuriousness found no evidence of a prior HeartMath exposure artifact or any evidence of a ratings bias in teacher scoring of children.

In short, on the basis of the strong, consistent pattern of positive results observed in these analyses, there is compelling evidence of the efficacy of the EHS program in enhancing the growth of the preschool population studied, both in terms of their overall development and also on each of the four areas measured by the TCCA assessment — Social/Emotional Development, Physical Development, Cognitive Development and Language Development.

Discussion

Given the research decision to target schools in lower socioeconomic areas that were also high in minority populations, the baseline differences observed on all five development scales favoring students in the control group over those in the intervention group are consistent with the findings of previous research and suggest that the measurement of development in the two samples has face validity. This is further corroborated by the higher development score on all scales (except Physical Development) of White over Hispanic students and of the non-free lunch students over students enrolled in the free lunch program; these differences, too, are as expected from previous research. Moreover, the within-group results — showing a significant increase on all five scales over time for both the intervention and control samples — are also as expected, given the natural processes of relatively rapid development of young children in the age groups in the study. In short, these findings suggest the measurement of development appears valid.

With respect to the key question of a pre–post-EHS intervention effect, we used a rigorous multivariate procedure — ANCOVA — in order to be statistically confident that any observed pre–post-intervention differences could *not* be the result of differences at baseline between the two groups. This procedure revealed a strong pattern of consistent differences favoring the intervention group students both on the five development dimension scales as well as on the ten subcomponents. This effect was also observed on the Total Development scale for each of the sociodemographic categories examined[16] (males, females, Hispanic, White, free lunch and non-free lunch), and also for females, Hispanics and free lunch students on all four development dimension scales, and for Whites on two development scales (Physical Development and Language Development).

These results, showing strong evidence of an EHS intervention effect, appear robust. Both the matched-groups analysis (in which we controlled for baseline differences in class size and total development score) and the random split-half sample analysis found essentially the same pre–post-intervention differences in development favoring the intervention group on the Total Development scale, and also on three of the four development dimension scales — Social/Emotional Development, Physical Development and Language Development. The random split-half sample results are noteworthy, in that they suggest that on these development measures the differences between the two groups are unlikely due to sample bias and are probably generalizable to children with similar characteristics and in similar educational contexts as those in the intervention group.

Finally, the investigation of two potential sources of spuriousness — the prior exposure of some teachers in the control group to HeartMath training, and the possibility of a ratings bias for a favorable EHS study outcome among teachers in the intervention group — ruled out both artifacts. The comparison of the prior HM exposure control subgroup and the pure, non-HM exposure control group with the intervention group produced the same pattern of differences, favoring the latter, over all five development scales, as observed for the full control group. And there was no evidence from the analysis of variation in teacher ratings of a ratings bias in the scoring of the students between the two groups.

Overall, the strong, consistent pattern of positive pre–post-intervention results provides compelling evidence of the efficacy of the EHS program in promoting greater development across the five primary measures — Total Development, Social/Emotional Development, Physical Development, Cognitive Development and Language Development. This is empirical validation of the effectiveness of the EHS program in improving the psychosocial development of children from culturally and socioeconomically disadvantaged family backgrounds. More than this, the results show that not only does the EHS program enable such children to overcome their developmental handicap and catch up to other children who are not so developmentally impeded, but also that the intervention even enables these children to surpass their more privileged peers in key areas of psychosocial development.

While it is likely that the positive results found here probably extend to young children in compa-

[16] This is with the exception of the "ethnicity-other" category.

rable cultural and socioeconomically disadvantaged circumstances, further research will be necessary on samples more representative of U.S. children as a whole in order to confirm the efficacy of the EHS program in promoting growth and development more broadly. Even so, what is intriguing — even remarkable — is that the results clearly show that very young children (mean age = *3.6 years*) can actually learn, retain and use the socioemotional competencies — including the emotional regulation tools — taught in the program, and thereby facilitate their own psychosocial development.

Limitations

Rather than being designed with the sole purpose of evaluating the efficacy of the EHS program, the study evolved informally as an adjunct investigation to the research already being conducted on the development of preschoolers in all schools in the Salt Lake City School District. Leaving aside any methodological issues that may apply to the pre-existing study, there were some limitations that came with the implications of this informal research strategy.

One limitation concerns the generalizability of the study's results. There are two issues: 1) the lack of randomization in sample selection and intervention/control group assignment; and 2) the degree to which the study population is broadly representative of the population of preschoolers in the US as a whole. While the lack of randomization for sample selection is not an issue, because all 19 schools in the Salt Lake City School District were included, it is a limitation of the criterion-reference procedure used to assign intervention/control group status. Even so, the results from the random split-half sample analysis suggest, in broad terms, that the primary findings appear to be generalizeable to preschool children in similar sociogeographic contexts and with similar sociodemographic characteristics. Concerning the second issue, expanding the intervention group sample to include an additional sub-sample of three or four classes from the control group would have enabled the study to evaluate the EHS program's efficacy both for the disadvantaged sample investigated and also a more mainstream sample. Assuming the results for the latter showed evidence of an intervention effect, this would have provided the empirical basis for establishing — via a random split-half analysis — the generalizability of the EHS program's efficacy to a non-disadvantaged, more mainstream population of preschool children as well.

A potentially more serious limitation was that the teachers were not "blind" to the study's goals and desired outcomes, and, therefore, could have consciously or unconsciously acted to affect the results. As noted above, this is known as a "Hawthorne Effect." Although we found little evidence of scoring bias in our analysis of the variance of the teachers' ratings, we cannot definitively rule out such an artifact.

Another potential limitation was that the control group was not completely "pure": in addition to children whose teachers had no prior exposure to HeartMath — effectively a pure control group — it included children whose teachers had prior exposure to HeartMath training programs. We turned this limitation into a research opportunity by comparing the pure and HeartMath-exposed parts of the control group both against each other and also against the intervention group, in an effort to rule out prior exposure effects and also to address the question of a "Hawthorne Effect," just described.

A final limitation is that the children's scores are all based on observation, evaluation and rating from a single source — their teacher. While we were mostly able to address the basic psychometric issues of rating consistency and measurement validity, reliability and discrimination in the item analysis we performed, future studies should be conducted using at least two experts to independently observe and rate each child's development on every measurement item.

Conclusion

Of the key socioemotional competencies in early childhood that lay the foundation for future development and the potentials for adult psychosocial growth, well-being and accomplishment, emotional self-regulation is core. And yet, as noted at the outset, a disturbing proportion of preschool children, especially from ethnic minority and low socioeconomic family backgrounds, lack the fundamental socioemotional skills needed to learn and function effectively at school. Although the EHS program was developed with the broader goal of enhancing the psychosocial development of all preschool children, it was expected that the program would have particular application in facilitating development in children from such disadvantaged family backgrounds and circumstances. In this report we have presented the results of an investigation of the EHS program's efficacy in a pilot implementation of the program, targeting schools with children in these more disadvantaged circumstances in the Salt Lake City School District.

Despite the limitations just noted, the results are noteworthy in that there is strong evidence of an intervention effect. First, across all of the statistical analyses performed, a consistent pattern of significant differences in growth on the primary development constructs — Total Development scale, Social/Emotional Development scale, Physical Development scale, Cognitive Development scale and Language Development scale, plus their ten subcomponents — is evident for the children receiving the EHS intervention relative to those in the control group who did not. The magnitude of development observed for the intervention group children is particularly striking, given that they began with a significant development handicap relative to their peers in the control group. And yet, after receiving the EHS program, they had surpassed the latter's development growth by the end of the study.

A second important finding is the strong pattern of pre–post-intervention differences on total development score between the two groups for all but one (Ethnicity-Other) of the sociodemographic categories investigated. Importantly, given the study's targeting of ethnic minority and low socioeconomic status students, the evidence shows that the EHS program was effective in boosting development of females, Hispanics and free lunch students in the intervention group on the four development dimensions — Social/Emotional, Physical, Cognitive and Language — beyond that of their peers in the control group.

A series of additional analyses found that these differences do not appear to be mediated by gender, ethnic affiliation, socioeconomic background, or classroom size, or explained by baseline differences in development between the two groups of children. Further, the evidence from a random split-half sample analysis corroborates the results from analyses of the whole intervention and control group samples, and it indicates that the findings for all but one of the five development scales (Cognitive Development) are robust and likely generalizable to children of comparable sociodemographic characteristics and in similar educational contexts as those in the intervention group. Lastly here, on these questions of alternative explanations and methodological artifacts, the investigation of potential sources of spuriousness found no evidence of a prior HeartMath exposure artifact or any evidence of a ratings bias in teacher scoring of children.

In sum, the strong, consistent pattern of positive results observed across all analyses is compelling evidence of the efficacy of the EHS program in significantly facilitating development growth in preschool children both overall, as measured by the Total Development scale, and also in each of the four dimensions of development measured by the TCCA — Social/Emotional Development, Physical Development, Cognitive Development and Language Development.

One the most important points to emphasize in this conclusion is that these results are for preschool children — very young children, 96% of whom were between 3.0 to 4.0 years old. It is both striking and remarkable that children as young as three can learn, retain and practice the self-regulation skills they were taught in the EHS program and actually facilitate an increase in their rate of psychosocial development. Given that the age range from three to six years is a period of accelerated neurological growth and psychosocial development, it is likely that the learning and sustained use of socioemotional self-regulation skills during this period could instantiate a new set-point in the young child's nervous system for an optimal pattern of psychophysiological function, and thereby significantly boost the development trajectory of future psychosocial growth.

Establishing this key set-point *early* in the child's life, when neural connectivity is still highly malleable, and then sustaining it throughout the educational process with programs building on these fundamental skills, can set the child on a life course of health, well-being, achievement and social responsibility. Correspondingly, the integration of programs designed to foster socioemotional competence into educational curricula — beginning at preschool — should help prevent manifestation of much of the psychosocial dysfunction and pathology that not only robs individuals of a fulfilling life but also result in an enormous cost to society.

Authors' Roles

The authors had the following roles in the Early HeartSmarts (EHS) study:

Dr. Raymond Bradley and Dana Tomasino are independent research consultants to the Institute of HeartMath. Their involvement in the EHS study began in 2009, after the data were collected. Dr. Bradley designed and directed the statistical and psychometric analysis of the data, analyzed and interpreted the results and, with Dana Tomasino, wrote this report.

Mike Atkinson, Research Manager at the Institute of HeartMath, processed all the data, conducted the statistical analysis and also prepared the tables and figures.

Dr. Robert Rees, Director of Education at the Institute of HeartMath, worked with Ms. Donna Anderson to initiate the EHS study and also contributed to the report.

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Donna Anderson, former preschool specialist with the Salt Lake City School District, who contributed to the design of the Early HeartSmarts program, its implementation and the EHS study, along with helping to train the preschool teachers in HeartMath skills and concepts.

Dr. Patrick Galvin, formerly Head of Research with the Salt Lake City School District, for initiating the study of preschool development in the district and for his support in enabling the EHS study.

The teachers in the study — especially those who taught the classes included in the intervention group.

We also thank **Jeffrey Goelitz**, Education Division, Institute of HeartMath, for coordinating all aspects of the study with the Salt Lake City School District.

Appendix 1: Early HeartSmarts Materials

Teacher's Guide: the instructor manual provides all the essential information to successfully implement the program. Each of the thirteen lessons is organized with purpose and materials, quick steps, scripted lessons, recommended books, parent connection, music lyrics and support activities. Song lyrics are featured in the last section for easy access.

Introductory DVD: a short, narrated PowerPoint presentation that introduces core concepts, skills and materials

Music CD: besides heartbeat sounds, there are six beautifully sung songs and an instrumental version of "Little Wheel Turning in My Heart."

Anatomical Model Heart: the squishy, anatomically correct heart serves as a physical model for conversation about the functions of the heart.

Bear Heart Puppet: the puppet plays a crucial role as facilitator and teacher in the program. Use a normal, pleasant voice when speaking through the puppet in lessons. The surface of the puppet can be washed with cold water.

Stethoscope: this instructional device is to be used only under adult supervision and guidance. Children should not be left alone to play with this device. Instructions are printed on the box.

Heart Ball: Heart Ball uses the fun of play (a gentle game of catch) to help children express positive emotions. Surface washable.

Heart Pillow: this fluffy red pillow with the blue hand invites children to use it when feeling upset or out of sorts. They can either hold it to their chest or sit on it while practicing one of the self-regulation techniques. Surface washable.

The Kissing Hand, a book by Audrey Penn: this classic story further expands on the expression of positive emotion.

Photo Emotion Cards: these ten cards help children better identify five different emotional states. The cards are spaced out over three lessons.

Problem-Solving Cards: six cards showing typical age-related emotional issues are presented to children over three lessons to help activate problem-solving choices and skills.

Problem-Solving Poster: a poster with three steps to guide children through the problem-solving process.

Appendix 2. Descriptive Statistics for Time 1 – Time 3: Performance of Sample Population on Measurement Constructs — Total Development, Development Dimensions and Dimension Subcomponents

Raw Score - Descriptive Statistics

	N	Mean	SEM	SD	Min	Max
Time 1, Fall						
Total Development Score	375	47.71	0.99	19.18	0	112
Social/Emotional Development Score	375	12.26	0.27	5.31	0	30
Physical Development Score	375	9.29	0.15	2.84	0	21
Cognitive Development Score	375	13.90	0.36	6.95	0	35
Language Development Score	375	12.26	0.31	6.00	0	32
Sense of Self	375	3.71	0.10	1.93	0	10
Responsibility for Self and Others	374	4.87	0.11	2.20	0	12
Prosocial Behavior	373	3.71	0.09	1.77	0	9
Gross Motor	375	5.80	0.10	1.92	0	15
Fine Motor	375	3.49	0.07	1.43	0	9
Learning and Problem Solving	375	4.18	0.12	2.29	0	12
Logical Thinking	374	6.84	0.20	3.93	0	19
Representation and Symbolic Thinking	374	2.90	0.07	1.36	0	7
Listening and Speaking	375	6.67	0.16	3.15	0	15
Reading and Writing	374	5.61	0.16	3.18	0	18
Time 2, Winter						
Total Development Score	366	90.71	1.22	23.30	16	145
Social/Emotional Development Score	366	23.80	0.36	6.79	5	39
Physical Development Score	366	16.24	0.18	3.46	2	24
Cognitive Development Score	366	27.87	0.43	8.25	2	47
Language Development Score	366	22.81	0.37	7.16	2	38
Sense of Self	366	7.52	0.12	2.37	0	12
Responsibility for Self and Others	366	9.04	0.15	2.82	1	15
Prosocial Behavior	366	7.23	0.12	2.22	1	12
Gross Motor	365	9.97	0.12	2.24	3	15
Fine Motor	366	6.30	0.09	1.65	1	9
Learning and Problem Solving	365	8.33	0.15	2.78	0	15
Logical Thinking	366	13.90	0.24	4.59	0	24
Representation and Symbolic Thinking	366	5.66	0.09	1.73	1	9
Listening and Speaking	366	11.36	0.19	3.66	1	18
Reading and Writing	366	11.45	0.21	3.96	1	20
Time 3, Spring						
Total Development Score	375	124.15	1.13	21.82	45	150
Social/Emotional Development Score	375	32.39	0.33	6.44	5	39
Physical Development Score	375	21.56	0.14	2.79	10	24
Cognitive Development Score	375	38.79	0.41	7.95	12	48
Language Development Score	375	31.42	0.36	6.98	9	39
Sense of Self	375	10.11	0.11	2.06	0	12
Responsibility for Self and Others	375	12.44	0.15	2.84	2	15
Prosocial Behavior	375	9.84	0.11	2.17	1	12
Gross Motor	375	13.64	0.10	1.85	7	15
Fine Motor	375	7.92	0.07	1.44	1	9
Learning and Problem Solving	375	11.57	0.15	2.87	4	15
Logical Thinking	375	19.35	0.22	4.33	4	24
Representation and Symbolic Thinking	375	7.87	0.08	1.55	3	9
Listening and Speaking	375	14.96	0.17	3.21	5	18
Reading and Writing	374	16.50	0.21	4.05	4	21

Appendix 3. Validity and Reliability of Measurement Analysis, Time 1 – Time 3

	Items, N	Cases, N	Point Bi-serial Correlation Min	Point Bi-serial Correlation Max	Mean	SD	SEM	Cronbach's Alpha
Fall Pre Study Score (Time 1)								
Total Development	50	274	0.26	0.77	51.57	17.43	1.05	0.97
Social/Emotional Development	13	340	0.57	0.71	12.85	5.01	0.27	0.92
Physical Development	8	345	0.43	0.62	9.45	2.79	0.15	0.80
Cognitive Development	16	336	0.52	0.78	14.78	6.59	0.36	0.93
Language Development	13	340	0.47	0.77	12.87	5.73	0.31	0.92
Sense of Self	4	353	0.63	0.66	3.86	1.88	0.10	0.82
Responsibility for Self and Others	5	366	0.52	0.72	4.95	2.12	0.11	0.85
Prosocial Behavior	4	361	0.58	0.69	3.79	1.72	0.09	0.82
Gross Motor	5	351	0.51	0.66	5.92	1.87	0.10	0.79
Fine Motor	3	365	0.46	0.64	3.52	1.41	0.07	0.71
Learning and Problem Solving	5	365	0.63	0.77	4.26	2.25	0.12	0.87
Logical Thinking	8	342	0.56	0.71	7.27	3.76	0.20	0.88
Representation and Symbolic Thinking	3	367	0.63	0.70	2.93	1.35	0.07	0.81
Listening and Speaking	6	355	0.47	0.81	6.87	3.03	0.16	0.88
Reading and Writing	7	353	0.46	0.72	5.80	3.12	0.17	0.85
Winter Pre Study Score (Time 2)								
Total Development	50	326	0.47	0.78	91.54	23.33	1.29	0.98
Social/Emotional Development	13	356	0.65	0.78	23.90	6.74	0.36	0.94
Physical Development	8	354	0.42	0.68	16.39	3.32	0.18	0.86
Cognitive Development	16	352	0.57	0.77	27.93	8.27	0.44	0.95
Language Development	13	356	0.51	0.82	22.85	7.17	0.38	0.94
Sense of Self	4	362	0.71	0.76	7.54	2.36	0.12	0.87
Responsibility for Self and Others	5	363	0.63	0.81	9.07	2.80	0.15	0.90
Prosocial Behavior	4	363	0.62	0.72	7.25	2.23	0.12	0.84
Gross Motor	5	359	0.62	0.73	10.00	2.22	0.12	0.87
Fine Motor	3	360	0.52	0.70	6.34	1.61	0.08	0.77
Learning and Problem Solving	5	362	0.72	0.79	8.33	2.79	0.15	0.90
Logical Thinking	8	359	0.55	0.78	13.94	4.60	0.24	0.92
Representation and Symbolic Thinking	3	362	0.65	0.77	5.68	1.72	0.09	0.84
Listening and Speaking	6	357	0.57	0.83	11.39	3.67	0.19	0.91
Reading and Writing	7	364	0.55	0.79	11.45	3.97	0.21	0.90
Spring Post Study Score (Time (3)								
Total Development	50	341	0.45	0.81	124.44	22.20	1.20	0.98
Social/Emotional Development	13	362	0.58	0.78	32.57	6.44	0.34	0.94
Physical Development	8	367	0.38	0.74	21.60	2.80	0.15	0.86
Cognitive Development	16	364	0.53	0.81	38.80	7.99	0.42	0.95
Language Development	13	368	0.62	0.81	31.52	6.91	0.36	0.95
Sense of Self	4	365	0.61	0.76	10.20	2.02	0.11	0.84
Responsibility for Self and Others	5	372	0.65	0.82	12.46	2.84	0.15	0.91
Prosocial Behavior	4	374	0.59	0.76	9.85	2.17	0.11	0.86
Gross Motor	5	370	0.57	0.74	13.68	1.83	0.10	0.85
Fine Motor	3	372	0.59	0.78	7.95	1.40	0.07	0.83
Learning and Problem Solving	5	373	0.73	0.79	11.58	2.86	0.15	0.91
Logical Thinking	8	367	0.52	0.81	19.39	4.34	0.23	0.93
Representation and Symbolic Thinking	3	374	0.71	0.81	7.87	1.55	0.08	0.87
Listening and Speaking	6	371	0.62	0.83	15.01	3.19	0.17	0.90
Reading and Writing	7	371	0.64	0.83	16.53	4.05	0.21	0.92

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