Family-based training program improves brain function, cognition, and behavior in lower socioeconomic status preschoolers

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Using information from research on the neuroplasticity of selective attention and on the central role of successful parenting in child development, we developed and rigorously assessed a family-based training program designed to improve brain systems for selective attention in preschool children. One hundred forty-one lower socioeconomic status preschoolers enrolled in a Head Start program were randomly assigned to the training program, Head Start alone, or an active control group. Electrophysiological measures of children's brain functions supporting selective attention, standardized measures of cognition, and parent-reported child behaviors all favored children in the treatment program relative to both control groups. Positive changes were also observed in the parents themselves. Effect sizes ranged from one-quarter to half of a standard deviation. These results lend impetus to the further development and broader implementation of evidence-based education programs that target at-risk families.

Children from different socioeconomic status (SES) backgrounds display profound disparities in cognitive skills, brain structure and function, and academic outcomes (e.g., refs. 1–4). Because academic disparities associated with SES are increasing in many societies (5), there is strong motivation to develop and implement training programs that can narrow these achievement gaps. Moreover, advances in developmental cognitive neuroscience now permit the identification of candidate neurobiological targets for training programs. One such neurobiological target is selective attention, a foundational developmental skill important for academic outcomes (6–10), sensitive to environmental differences associated with SES (3, 11, 12), and capable of considerable neuroplasticity (13–16). Here we report the results of a randomized, controlled trial in which we tested the hypothesis that an 8-wk training program that targeted selective attention by engaging the larger context of parents and the home environment would result in significant gains, among preschool children from lower SES backgrounds, in multiple outcome domains relevant to school success, including the neural systems that mediate selective attention and standardized measures of language and cognition.

Considerable evidence documents the central role of selective attention in all aspects of learning and memory, and school readiness in particular (6, 7, 9, 10). This has led to renewed interest in training aspects of attention to promote academic success (17, 18). This approach may be particularly valuable for children from lower SES backgrounds, who enter school less ready to learn and consistently underperform their higher SES peers (e.g., refs. 1–4). Indeed, several studies report differences in aspects of attention in lower SES children (19–21), including reduced effects of selective attention on neural processing (11, 12). At the same time, attention skills are highly malleable, displaying improvements with training and altered sensory experience (2, 11, 14, 16). This raises the hypothesis that training programs for lower SES children that target the neural systems mediating selective attention would be a powerful means for improving other domains of cognition and academic outcomes for children from lower SES backgrounds.

Several studies have begun examining the possibility of training different aspects of attention and domain-general cognitive processes in early to middle childhood (e.g., refs. 22–25). These approaches target the child directly but, to date, have not engaged the larger context of parents and the home environment. However, the family context plays a key role in supporting children's attention development and may specifically be targeted in intervention programs aimed at improving child outcomes. For example, decades of research indicate that children from lower SES backgrounds are more likely to grow up in homes that are more stressful and less cognitively stimulating than their higher SES peers (for reviews, see refs. 2, 3, and 26–29). Children in lower SES homes also often experience more chaotic living conditions (e.g., crowding, noise, family instability) and more inconsistent and harsh disciplinary practices than their higher SES peers; such characteristics have been shown to account for up to half of the academic disparity associated with SES (27, 30–33). Critically, several studies document that acute and chronic stress adversely affect brain development, particularly the prefrontal cortex and hippocampus, which are central to many aspects of attention, working memory, and executive function (2, 3; e.g., refs. 34 and 35; for a review, ref. 36). Parent stress levels are also negatively correlated with children's receptive and expressive vocabularies (37), although this relationship may be mediated by the quality of parent–child interactions and aspects of parent language use with the child. Indeed, a robust association exists between parent language use and interaction patterns and children's language development (26, 38), with other studies suggesting this relationship is directly linked to language exposure and experience (39). Thus, the home environment contains multiple pathways that may impact children's attention development, perhaps most importantly stress and parent–child interaction patterns.

Studies initiated in the 1960s have shown that costly programs directed toward lower SES preschoolers and their parents ameliorate many of the short- and long-term deficits in at-risk children (2, 40). More recent studies report that parent training can reduce stress and cortisol levels in children (41) and that, in children, measures of early parental nurturance predict volume of the hippocampus, a brain structure important for learning and memory (42). Studies of costly home-visiting programs targeting mothers have shown that such programs improve cognitive and behavioral outcomes in children (e.g., ref. 43), and a recent systematic review of international studies found that interventions including parent involvement produced the strongest effects on cognition and educational achievement (44). This research suggests that parent training might be a powerful component of programs that succeed in improving children's attention and cognitive skills, especially if

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incorporated together with more child-focused attention training approaches.

In the present study, we developed and assessed an 8-wk, family-based training program designed to improve lower SES preschool children's academic readiness and, centrally, selective attention. The program, Parents and Children Making Connections – Highlighting Attention (PCMC-A), was unique in combining training sessions for parents/guardians/caregivers (hereafter "parent") with attention training exercises for children. Details of PCMC-A are provided in *Methods* and online (*SI Appendix*). Briefly, parents attended eight weekly, 2-h small-group classes that occurred in the evenings or on weekends, and their children participated in concurrent small-group training activities. The parent component of PCMC-A was adapted from Linking the Interests of Families and Teachers (LIFT) curriculum, an evidence-based conduct disorder prevention program for elementary-aged students (45). The adapted LIFT intervention consisted of strategies targeting family stress regulation, contingency-based discipline, parental responsiveness and language use, and facilitation of child attention through links to child training exercises. The child component of PCMC-A consisted of small-group activities (four to six children, two adults) designed to address the fundamental goal of improving regulation of attention and emotion states.

To assess PCMC-A, 141 children enrolled in Head Start (HS) and their parents were randomly assigned to PCMC-A or one of two comparison groups. One comparison group, HS-alone, participated in HS but received no supplemental services or activities. The second comparison group, Attention Boost for Children (ABC), was an active training comparison program of equivalent intensity in terms of contact hours, but unlike PCMC-A, the focus of the program was primarily on child classroom training. The ABC comparison group was important to test whether a family-based parent and child combined approach would be as effective with greatly reduced parent involvement and more time devoted specifically to child training. Children participating in ABC received 40 min of small-group training, 4 d per week, as pull-out from regular HS time. Their parents received three training classes held across the 8-wk period. ABC was not designed to be a parametric manipulation of features of PCMC-A but instead provided a realistic, competing model for child attention training that was more child-focused.

Before and after the 8-wk intervention period, a multimethod, multirater assessment was conducted. The primary outcome measure was a neural measure of selective attention, using an event-related brain potential (ERP) paradigm that has been used to demonstrate that children from lower SES families have reduced effects of attention compared with higher SES children (11). This measure of selective attention was selected because it assesses the earliest stages of sensory processing affected by selective attention (within 100 ms), it separately indexes the specific mechanisms of signal enhancement and distractor suppression, and it is not confounded by response selection and other, later cognitive processes that can impact behavioral measures of selective attention. The specific paradigm used has previously been shown to be sensitive to short-term (6 to 12 wk) training for children with language or reading impairments (15, 46), making it an ideal outcome measure of selective attention for our 8-wk family-based training. Children were also assessed using a standardized assessment battery including nonverbal intelligence quotient (IQ), receptive language, and preliteracy skills by testers blind to children's experimental group, and also using parent and teacher reports of children's social skills and problem behaviors. Finally, given the predicted role of the program on parents themselves, we examined parent self-reports of parenting stress levels, as well as parent self-reports of their parenting confidence and ability. In addition, a 7-min video recording was also taken of a play dyad between parent and child to objectively quantify four aspects of parent–child interaction: parents' turn-taking in conversation, lexical diversity, language modeling, and mean length of utterance. Details of each measure can be found in *SI Appendix*. It was predicted that the PCMC-A intervention, with its greater emphasis on parents, would produce the greatest gains. Specifically, we predicted that children in the PCMC-A group would show improvements in ERP indices of selective attention. In addition, given the central role of attention on cognition, we predicted that the improvement in selective attention would be accompanied by gains in standardized measures of children's nonverbal IQ, receptive language, and preliteracy skills.

Results

Measures of children's brain systems supporting selective attention and standardized cognitive assessments served as primary outcome measures, with secondary outcome measures including parent and teacher reports of child behavior and a set of self-report and laboratory measures of the parents. Below, only results significant at $P < 0.1$ for comparisons against both the HS-alone and ABC comparison groups are reported and discussed, because these are considered the most robust gains favoring PCMC-A. Full descriptive statistics presented separately for each group and full details of the statistical results from each domain are presented in *SI Appendix*. As detailed below, across all domains examined, the more parent-focused PCMC-A program was associated with more favorable outcomes relative to both comparison groups.

First we examined whether the PCMC-A program, which specifically targeted selective attention, improved brain functions supporting selective attention in children relative to the two comparison groups. We used the same spatial selective auditory attention ERP paradigm as in our previous studies of preschool-aged children (11, 47), in which the mean amplitude ERPs are compared with identical probe stimuli embedded in auditory stories when attended and unattended. Analysis of the early ERP amplitudes elicited by probes embedded in the attended and unattended stories revealed group differences in improvements in early attentional modulation from the pre- to posttraining interval (attend–unattend × group × time × anterior/posterior, $P < 0.05$). Follow-up analyses revealed that these changes were driven by posttraining increases in the neural response to probes *when attended* in the PCMC-A group (group × time × anterior/posterior, for attended probes: $P < 0.005$; for unattended probes: $P = 0.939$). After examination of pretest data to confirm that there were no significant group pretest differences in the ERP response to probes in the attend channel (all interactions with group nonsignificant), subsequent step-down analyses were conducted to directly compare changes in the neural response to attended stimuli between the PCMC-A and each of the two comparison groups.

Children in the PCMC-A group showed greater changes in the neural response to attended stimuli after training compared with both children in the HS-alone group (group × time × anterior/posterior, $P < 0.005$) and the ABC group (group × time × anterior/posterior, $P < 0.05$) (Fig. 1). Whereas neither the HS-alone nor the ABC groups showed significant changes in the neural response to attended stimuli from pre- to posttest (all interactions with time were nonsignificant in the HS-alone and ABC groups), the PCMC-A group showed a significant increase in this response (time, $P < 0.05$) that was largest at posterior recording sites (time × anterior/posterior, $P < 0.005$; posterior rows: time, $P < 0.0005$). These data show that only children in the PCMC-A group displayed improvements in early attentional processing from the pre- to posttraining period, and these changes were specific to increased signal enhancement of stimuli when attended. Details of ERP results are provided in *SI Appendix*.

Next, we examined standardized laboratory assessments of children's nonverbal IQ, receptive language, and preliteracy skills. Analysis of these three measures revealed that children in PCMC-A made greater gains than children in the comparison groups in nonverbal IQ and receptive language (Fig. 2). After the PCMC-A program, children demonstrated significantly increased nonverbal intelligence scores relative to children in both the HS-alone ($P < 0.005$, $d = +0.40$) and contrasting ABC program ($P < 0.01$, $d = +0.38$). Children in the PCMC-A program also showed improved receptive language abilities relative to both

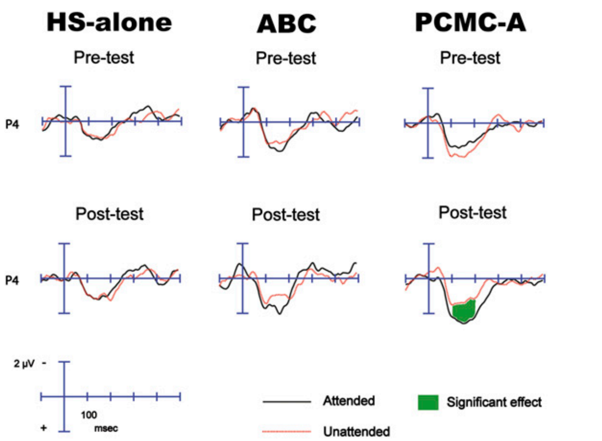

Fig. 1. ERPs from the selective auditory attention paradigm, averaged across all participants in each group, separately at pretest and at posttest. Children were cued to attend selectively to one of two stories presented simultaneously from separate speakers located to the left and right of the child. The electrophysiological response to identical probes embedded in attended and unattended stories was compared. Significantly greater increases in the ERP early attentional modulation (100–200 ms) in children in the PCMC-A group compared with the HS-alone and ABC groups in representative waveforms from centro-parietal electrode P4. Complete waveforms for each analysis are provided in *SI Appendix*.

the HS-alone group ($P < 0.05$, $d = +0.22$) and the ABC group ($P < 0.05$, $d = +0.22$).

We also examined parent and teacher reports of children's behavior using a standardized measure (*SI Appendix*). PCMC-A parents reported greater improvements in their preschoolers' social skills compared with HS-alone parents ($P < 0.05$, $d = +0.34$) and ABC parents ($P < 0.05$, $d = +0.35$), as well as greater decreases in children's problem behaviors compared with HS-alone or ABC parents ($P < 0.05$, $d = -0.26$; and $P < 0.01$, $d = -0.39$, respectively) (Fig. 2). Teacher reports followed the same pattern of means but generally did not show statistically significant differences between groups (*SI Appendix*).

Finally, one of the predictions of the study was that the PCMC-A intervention, which included a strong family-based component targeting parents' behaviors in the home environment, would result in changes in secondary measures taken of the parents themselves. Both parent self-report and laboratory data confirmed this prediction. As indexed by the Parent Daily Report, PCMC-A parents reported significantly reduced parenting stress relative to the HS-alone group ($P < 0.05$, $d = -0.41$) and a trend toward reduced parenting stress relative to the ABC group ($P < 0.1$, $d = -0.29$) (Fig. 2). PCMC-A parents also showed favorable changes in objective laboratory observations of language and interaction patterns during the parent–child play dyad session. After the training period, PCMC-A parents had more balanced turn-taking during these interactions compared with parents in both the HS-alone ($P < 0.005$, $d = +0.58$) and ABC groups ($P < 0.01$, $d = +0.56$) (Fig. 2). Other changes in parents were observed but favored PCMC-A against only one, rather than both, comparison groups, as reported in *SI Appendix*.

Discussion

The present study advances the field in four important ways. First, the study demonstrates that the neural mechanism of selective attention, previously shown to be vulnerable in children from lower SES backgrounds (11, 12), can be improved in children from lower SES backgrounds in the relatively short time frame of 8 wk. Second, the study is unique in engaging the larger family context, as well as direct child training, to support the development of selective attention. The results favoring PCMC-A underscore the importance of engaging parents to support child development. Third, the effectiveness of PCMC-A supports the design of programs that efficiently build on evidence from basic research on neuroplasticity and on evidence-based practices and that can be delivered in relatively short time frames. Finally, by including multiple outcome measures, the study provides a comprehensive picture of the changes resulting from a family-based training model, including not only gains for children in a direct neural measure of selective attention but also specific skills assessed by standardized tests, parent reports of child behavior, and parent behaviors and parenting stress levels.

The present study sought to examine whether an 8-wk, family-based training program could improve the neural systems mediating selective attention in lower SES preschool children. Results indicated improved effects of selective attention on neural processing, as well as large gains in standardized measures of language and cognition. In addition, parent reports indicated improvements in children's behavior, and there were also positive changes in the parents themselves. Importantly, all of these improvements were observed relative to both an HS-alone comparison group, as well as a contrasting intervention, ABC, that was more child-focused but included a comparable number of intervention contact hours.

These results indicate that the neural systems mediating selective attention, a foundational skill for cognitive development (6–10), are malleable, and they show that these neural systems can be improved in lower SES children in the relatively short time frame of 8 wk through a family-based training format. This finding is particularly important given the documented vulnerability of attention in lower SES children (3, 11, 12) and the proposed role of selective attention for learning and memory (e.g., ref. 9). As our primary outcome measure, aspects of selective attention were targeted through multiple pathways in the PCMC-A intervention, including direct activities with children as well as alterations to aspects of the home environment through parent training sessions. Attention skills in children were targeted directly via engaging, evidence-based, small-group activities. These activities emphasized metacognition (e.g., "you can use your brain to control your attention"), sensory and bodily awareness, and recognition and regulation of sustained attention and emotional processing. The parent-training component of PCMC-A also included strategies to foster child attention skills. Parents in PCMC-A were taught the background and rationale for training child attention and were given examples of, and materials from, the child attention training activities to facilitate practice in the home environment. Parents in PCMC-A were also encouraged to support emerging attention skills via activities in which children were given the opportunity to make choices and solve problems in a variety of situations. In addition, a number of strategies in the parent training sessions supported improved consistency and routine in the home environment to reduce parent and family stress levels.

Along with the gains in neural measures of selective attention, children in the PCMC-A intervention made greater gains than those in either comparison group on several additional measures. Most notably, children in the PCMC-A group made greater gains on standardized measures of language and IQ. These results are particularly important because children's IQ and early language abilities are predictive of school readiness and later academic achievement (4, 7, 48–51). Parents of children in the PCMC-A group also reported greater improvements in child social skills and reductions in problem behaviors. Although the pattern of means for teacher reports followed the same pattern favoring PCMC-A, the differences were not statistically significant. The differences between parent and teacher report could reflect differences in actual child behavior across the two environments but may also be explained by differences (or biases) in observers or differences in the sensitivity of parents vs. teachers to changes in child behavior. However, the emerging pattern across child measures consistently favored children randomly assigned to the PCMC-A intervention over either comparison group.

Importantly, the differences observed were significant not only against the HS-alone group but also against an active comparison group. We had predicted that gains for children in PCMC-A would

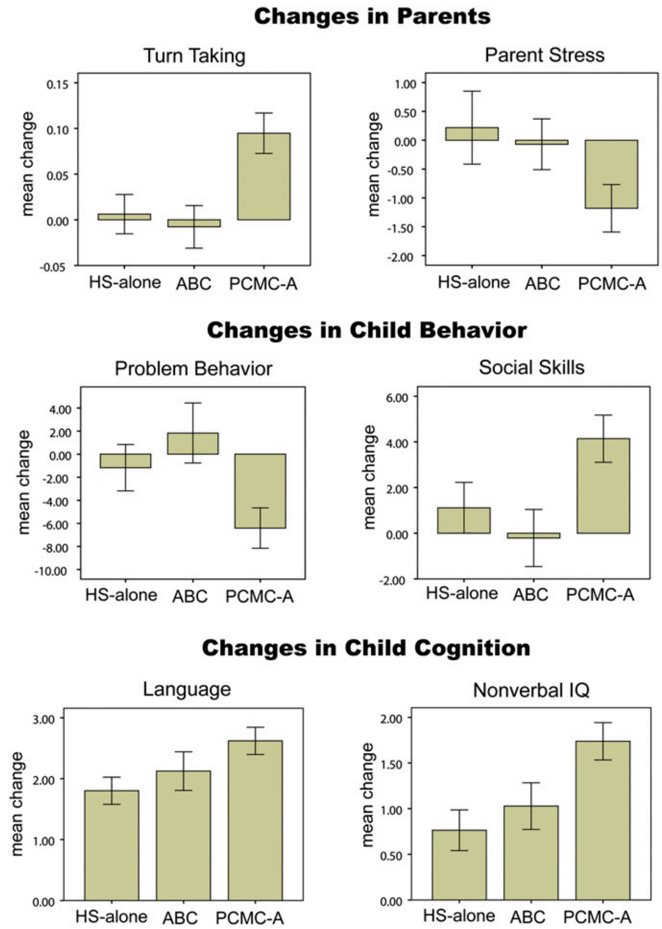

Fig. 2. Significantly greater changes in the PCMC-A group compared with HS-alone and ABC groups in three domains: changes in parents, parent reports of changes in child behavior, and changes in child cognition. Error bars represent SE.

be greater than those for children in the more child-focused ABC comparison group, given PCMC-A's emphasis on engaging the larger context of child development in the home environment. Although the study was not designed for a direct comparison of ABC to HS-alone, it is interesting to note that the pattern of means suggests few advantages to the ABC intervention over HS-alone, which does raise questions about the degree to which gains in PCMC-A can be attributed to the direct child training component. However, the overarching picture supported by the data is the importance of an increased emphasis of working with parents, with part of the parent training involving the application of child training exercises to the home environment. Thus, in neither ABC nor PCMC-A were the two components fully separable, but instead we find that their combination, with greater emphasis on parent training, leads to the most robust gains for children across a wide range of outcome measures. Although this also raises questions about the effectiveness of ABC as a stand-alone intervention, the inclusion of the ABC comparison group makes explanations related to the Hawthorne effect unlikely and therefore suggests that gains in PCMC-A are not simply the result of receiving any form of attention from researchers. This suggests, consistent with previous research (43, 44), that more classroom-based models with little involvement of parents are less likely to realize large gains for young children. Indeed, the primary difference between PCMC-A and ABC was the former's emphasis on parent training and support, suggesting that the additional time spent working with parents may be a key feature of PCMC-A. This allowed for both elaborated training of parents and also allowed time to share examples of, and materials from, the child attention training activities to facilitate practice in the home environment. The changes in parents themselves, detailed below, support this interpretation.

Parents in the PCMC-A intervention reported greater decreases in parenting stress relative to parents in either comparison group. Stress pathways have been identified as a major risk factor for children growing up in lower SES or adverse environments (52–54), and the effects of chronic stress on the structure and function of brain areas such as the hippocampus and prefrontal cortex are well documented (e.g., refs. 2, 3, 34, and 35). However, it has also been shown that exposure to as little as 1 mo of elevated psychosocial stress can impair prefrontal processing and attention but that these short-term effects are reversible (55). The PCMC-A program included specific strategies to target family stress regulation. For example, consistency and predictability were emphasized in strategies encouraging the implementation of structured routines and the use of picture-based schedules ("success charts"). An increased sense of control for children was also emphasized by strategies encouraging parents to give children the opportunity to make choices in potentially stressful situations, such as bedtime. Although we were unable to monitor sleep habits directly, change in sleep habits represent another factor that may have been improved by strategies targeting household stress reduction and encouraging consistency and structure. Poor sleep habits have been linked to poor academic outcomes in children from lower SES backgrounds, and family stress and inconsistency in the home environment have been hypothesized as moderating factors in this relationship (56). Part of the PCMC-A curriculum involved a discussion of the importance of sleep for preschoolers, and anecdotally many parents in the PCMC-A group reported that the emphasis on routines resulted in their children regularly going to bed earlier and with fewer problems than before they began to implement the strategies.

Parents in the PCMC-A intervention also showed increased turn-taking behavior. The quality of parent–child interactions, and in particular specific aspects of parent language input, is a robust predictor of child language outcomes (38, 39, 57); indeed, we observed improvements in receptive language skills in children who participated in PCMC-A. PCMC-A included strategies targeting specific aspects of parent–child interactions. For example, one strategy used a "piggy bank" metaphor to encourage the parent to reduce their mean utterance length to match the child's utterances in conversation ("only deposit as many words as the child deposits"). This encouraged parents to more closely match their utterances to their child's speech output while simultaneously reducing the amount of information a child needed to process from a single parent statement.

Although the strengths of the present study included its comprehensive assessment of children and their parents across a range of domains and the inclusion of both an active and HS-alone control group, this necessarily resulted in a large number of possible comparisons. This issue has been discussed in the statistical methods literature with respect to multiple outcome measure intervention research (e.g., refs. 58 and 59). Although there is no agreed-upon solution, we followed the recommendation of specifying primary outcome measures. It is also noteworthy that, across the full set of 30 comparisons made (i.e., comparisons of PCMC-A to each control group on each of 15 measures), 15 were statistically significant at the $P < 0.05$ level, and all favored the PCMC-A group, with effect sizes ranging from one-quarter to half of a standard deviation. Thus, a consistent pattern of results emerged that strongly favored the PCMC-A training program relative to both comparison groups.

Taken together, these data are suggestive concerning the mechanisms mediating PCMC-A's positive changes in children. Future research including direct measures of parent and child stress physiology (e.g., cortisol, respiratory sinus arrhythmia), as well as language and interaction patterns in the home, could be used to assess path models evaluating the mechanism of change, and specifically whether changes in children's cognition and neural systems for selective attention are mediated by parent changes and/or decreases in child stress. However, absent these path models, the gains observed in children remain robust, and the specificity of gains to the PCMC-A intervention, with its greater emphasis on parent training, suggests that involving parents is a key component of the program success. Moreover, these results are consistent with those of older programs with strong parent components (e.g., Abecedarian, Perry Preschool) (60–63). Although these older programs were costly, the cost of PCMC-A, implemented within the current HS infrastructure, is estimated to be only approximately $800 per child.

One limitation of the present study is that the sample of children tested is relatively homogeneous (i.e., right-handed monolingual native speakers of English, primarily Caucasian). Although this homogeneity permitted a stringent test of the PCMC-A program and avoided potential confounds, it is desirable to test the degree to which these results will hold in a more representative sample. To that end, we have now completed a cultural adaptation and translation of the PCMC-A program for Spanish-speaking families in HS, and an evaluation of the program with this population is underway. Furthermore, to examine whether changes in the children reported here persist after school entry, we have begun a longitudinal follow-up of program participants as they enter the public school system. Such studies will better inform subsequent benefit–cost analyses of PCMC-A and help prepare for a broader-scale implementation of the program.

Conclusion

The present study shows that a program that targets child attention using a family-based model involving children and their parents is highly effective in changing children's neurocognitive function as well as their parents' caregiving behaviors in the relatively short timeframe of 8 wk. The evidence presented here suggests that programs that target multiple pathways, including parents and the home environment, have the potential to narrow the large and growing gap in school readiness and academic achievement between higher and lower SES children.

Methods

Participants. A total of 141 3- to 5-y-old children enrolled in HS completed pre- and posttesting and were randomly assigned to either the PCMC-A program ($n = 66$) or one of two comparison conditions, HS-alone ($n = 38$) or an active, child-focused program (ABC, $n = 37$). There were no significant differences between groups in age, SES, attrition rate, or sex distribution (*SI Appendix*). In addition, 65 children successfully completed pre- and posttesting of ERPs during selective auditory attention (PCMC-A, $n = 33$; ABC, $n = 16$; HS-alone, $n = 16$); these groups did not differ from each other or from the larger groups on demographic variables (all nonsignificant).

Training Program and Comparison Groups. ***PCMC-A description.*** The 8-wk PCMC-A intervention included both parent training sessions and child training activities. Details of PCMC-A are provided in *SI Appendix*. PCMC-A was delivered across an 8-wk intervention period. Parents attended eight weekly, 2-h classes that occurred in the evenings or on weekends. Family meals and childcare were provided. Parents also received seven support phone calls from the instructor between class meetings. The child-directed component of PCMC-A included eight, 50-min child sessions held concurrently with adult sessions in a separate room.

The parent component of PCMC-A was adapted from the evidence-based LIFT curriculum (45) and consisted of a scaffolded set of 25 strategies delivered in small-group format (the parents of four to six children, one interventionist) to address the overarching goals of (*i*) family stress regulation with consistency, predictability, planning, and problem solving strategies; (*ii*) contingency-based discipline; (*iii*) parental responsiveness and language use with child; and (*iv*) facilitation of child attention through links to child training exercises.

The child component of PCMC-A consisted of a set of 20 small-group activities (four to six children, two adults) designed to address the fundamental goal of improving regulation of attention and emotion states. The activities targeted aspects of attention, including vigilance, selective attention, and task switching. The activities and instructional model for the child component included a set of theory-informed and research-based practices. In each session, children completed two to four of the activities.

HS-alone comparison group. Children in the HS-alone comparison group attended their regular half-day HS classes over the 8-wk evaluation period. Within the half-day HS curriculum there are no special child attention training components. HS has a parent education component, but at the sites where the study was conducted it is currently limited to three home visits per year and monthly phone contacts, primarily to share information regarding HS policies and available services. Family activity nights also occur three to four times per year. Importantly, there is no required parent guidance curriculum.

ABC comparison group. The ABC program provided an active control condition that included many aspects of the child and parent components of PCMC-A described above, but delivered in a different format that placed more emphasis on the child component. The ABC control provided a realistic, competing intervention but was not designed to parametrically manipulate features of the PCMC-A intervention. In comparison with PCMC-A, ABC emphasized child-directed training in small groups (four to six children, two adults). Child sessions lasted 40 min/d, 4 d/wk, for 8 wk, and were held as pull-out sessions during the regular HS day during gross motor time and/or discovery time in the regular HS schedule. Across the 8-wk program period, parents received three small-group sessions (the parents of four to six children, one interventionist) and four support phone calls, held in alternating weeks. This limited parent component did not allow for the same degree of in-depth instructional techniques as PCMC-A. The parent sessions lasted 90 min and were held in the evening or on weekends, with family dinner and childcare provided.

Assessment Protocol. Before and after the 8-wk training period, a multimethod evaluation procedure assessed both the children and their parents. The four broad domains assessed included (*i*) electrophysiological assessments of children's selective attention using ERPs, (*ii*) laboratory measures of child cognition, (*iii*) parent and teacher reports of child behaviors and social skills, and (*iv*) parent self-reports of parenting stress, confidence, and ability, as well as laboratory observation of parent/child language and interaction behaviors during a videotaped parent–child play dyad. All testers and raters were blind to experimental condition. Details are provided in *SI Appendix*.

ERP data were analyzed using a factorial ANOVA, including factors of group (PCMC-A, ABC, HS-alone), time (pre, postintervention period), attention condition (attend, unattend), and three levels of anterior/posterior electrode location (anterior, central, posterior), with appropriate step-down analyses. All other measures were analyzed using multiple regression, with posttest score as the dependent measure and pretest score (mean-centered) and training program as predictors (*SI Appendix*). Measures of training program effect size were calculated using Cohen's d separately for the PCMC-A vs. HS-alone and PCMC-A vs. ABC comparisons, computed as the difference in covariate-adjusted posttest means divided by the pooled standard deviation of posttest scores. Positive values indicated a larger posttest mean for the PCMC-A condition.

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