CHILD DEVELOPMENT

Child Development, September/October 2009, Volume 80, Number 5, Pages 1376–1384

Three Randomized Controlled Trials of Early Long-Chain Polyunsaturated Fatty Acid Supplementation on Means-End Problem Solving in 9-Month-Olds

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This study examines whether feeding infants formula supplemented with long-chain polyunsaturated fatty acids (LCPUFA) improves cognitive function of 9-month-olds. Participants included 229 infants from 3 randomized controlled trials. Children received either formula supplemented with docosahexaenoic acid and arachidonic acid, or a control formula beginning at 1–5 days (12-month feeding study), or following 6 weeks (6-week-weaning study) or 4–6 months of breastfeeding (4-to 6-month weaning study). Infants were assessed with a 2-step problem solving task. In the 12-month feeding and 6-week weaning studies, supplemented children had more intentional solutions (successful task completions) and higher intention scores (goal-directed behaviors) than controls. These results suggest that LCPUFA supplementation improves means-end problem solving.

Studies of infant nutrition suggest that the long-chain polyunsaturated fatty acid (LCPUFA), docosahexaenoic acid (DHA), may be essential for optimal cognitive development. Breastfeeding, a natural source of DHA, is often associated with superior cognitive skills compared to feeding of formula that lacks DHA, even when differences in socioeconomic and home environment variables are controlled (Anderson, Johnstone, & Remley, 1999; Horwood & Fergusson, 1998; Kramer et al., 2008; Oddy et al., 2003; Slykerman et al., 2005). In addition, maternal supplementation with DHA during pregnancy and lactation via consumption of high-DHA eggs, fish oil, or capsules results in higher concentrations of DHA in breast milk and in infant erythrocytes and plasma (Helland et al., 2006; Lauritzen et al., 2004), as well as enhanced cognitive development (Helland, Smith, Saarem, Saugstad, & Drevon, 2003; Jensen et al., 2005; Judge, Harel, & Lammi-Keefe, 2007). Collectively, these findings suggest that supplementation of infant formulas with LCPUFA might improve cognitive development. However, study results are mixed, as some report beneficial effects of LCPUFA-supplemented formulas on cognitive development (Agostoni, Riva, Trojan, Bellu, & Giovannini, 1995; Birch et al., 2007; Gibson, Neumann, & Makrides, 1997) whereas others do not (Agostoni et al., 1997; Auestad et al., 2001; Makrides, Neumann, Simmer, & Gibson, 2000; Scott et al., 1998).

The authors thank the newborn nursery and postpartum care staffs of Margot Perot Women's and Children's Hospital at Presbyterian Medical Center of Dallas and of Medical City, Dallas for their collaboration. The authors are also grateful for the continuing pediatric support from Pediatric Associates of Dallas, Woodhill Pediatric Associates, North Dallas Pediatrics, Clinical Associates, and other participating pediatricians. The original studies quoted in this article were supported by Grant HD22380 from the National Institute of Child Health and Human Development. Mead Johnson Nutritionals (Evansville, IN) donated all infant formulas for the studies. Drs. Hoffman and Birch have received research funding from Mead Johnson Nutritionals for subsequent studies not reported here. Dr. Hoffman has subsequently received consultant fees from Mead Johnson Nutritionals to provide educational seminars to pediatricians and pediatric nutritionists.

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There are several potential explanations for these discrepant results. First, some studies that failed to find a benefit of supplementation on cognitive outcome used concentrations of DHA (.12%–.25% of total fatty acids; Auestad et al., 2001; Scott et al., 1998) that are well below mean levels reported in breast milk worldwide (.32%–.41%; Brenna et al., 2007; Yuhas, Pramuk, & Lien, 2006) and might, therefore, be insufficient to provide functional benefits. Second, researchers might be relying on relatively insensitive tests to detect group differences in cognitive development. Specifically, the original version of the Bayley Scales of Infant Development (BSID; Auestad et al., 2001; Makrides et al., 2000; Scott et al., 1998) and the Brunet-Lézine Test (Agostoni et al., 1997; Willatts, Forsyth, DiModugno, Varma, & Colvin, 1998a) do not primarily assess cognitive skills but instead are indices of perceptual and motor skills (Willatts et al., 1998a). Third, the age at which the tests are administered may be critical. For example, BSID scores of normal, healthy, term children less than 18 months of age are not correlated with later IQ scores (Slater, 1995), but BSID scores at 18 months of age correlate highly with scores on the Wechsler Preschool and Primary Scale of Intelligence at age 4 years (Birch et al., 2007). Fourth, because these cognitive outcome measures are typically assessed well after the time period of DHA supplementation has ended, it is possible that intervening events may affect variability among children to such a degree that the tests used in the studies (i.e., the Brunet-Lézine Test and the BSID) are no longer sensitive to the effects of infant DHA intake.

Here, we investigate the effects of LCPUFA supplementation on cognition in 9-month-old infants participating in three randomized controlled trials. This study remedies the methodological limitations outlined above as the supplemented formulas contained LCPUFA concentrations representative of those found in human breast milk worldwide, .36% of total fatty acids as DHA and .72% of total fatty acids as arachidonic acid (ARA). Furthermore, cognitive ability was assessed using a test of means-end problem solving, i.e., the ability to complete a sequence of steps to achieve a goal, such as obtaining a toy (Judge et al., 2007). Importantly, performance on means-end problem solving tasks is correlated with vocabulary and IQ at 3 years of age (Slater, 1995; Willatts, 1992, 1997). Finally, cognitive ability was assessed during the formula-feeding period at 9 months of age to avoid intervening events and to ensure the test was sensitive to the effects of DHA supplementation.

Method

Participants

Participants included a total of 229 infants enrolled in three different randomized clinical trials conducted primarily to investigate the effects of LCPUFA supplementation on visual acuity development. The study designs and visual acuity outcomes of these trials have been published previously (Birch et al., 2002; Birch et al., 2005; Hoffman et al., 2003). Of the participating children, the majority was male (56%) and White (83%). Participants received all formulas free of charge, a $25 gift card for each completed study visit, and a $100 U.S. Savings Bond at the completion of the 12-month visit. Enrollment and other details of the three trials are provided in Table 1.

All participants were born in the Dallas area at 37–40 weeks postmenstrual age as determined by early sonogram, date of previous menstrual period, and physical and neurodevelopmental assessment

Table 1
Enrollment Details and Feeding Protocols From the Three Randomized Clinical Trials

	12-month feeding study		6-week weaning study		4- to 6-month weaning study	
	LCPUFA	Control	LCPUFA	Control	LCPUFA	Control
Enrollment[a] (*n*)	51	52	33	32	31	30
Age at randomization	3.6 ± 1.3 days		5.1 ± 1.2 weeks		19.7 ± 4.5 weeks	
Breastfeeding period	Not breastfed		Birth to 6 weeks		Birth to 4–6 months	
Formula feeding period	1–5 days to 12 months		6 weeks to 12 months		4–6 months to 12 months	

Note. LCPUFA = long-chain polyunsaturated fatty acid.
[a]Number of children completing the two-step test is presented in Table 2.

at birth. Only singleton births with birthweight appropriate for gestational age were included in the trials. Infants were excluded if there was a family history of milk protein allergy, genetic or familial eye disease, vegetarian or vegan maternal dietary patterns, maternal metabolic disease or infection, jaundice, perinatal asphyxia, meconium aspiration, or any perinatal event that resulted in placement of the infant in the neonatal intensive care unit.

In the 12-month feeding study, parents of eligible neonates were provided a brief information sheet about the dietary study only after the hospital records indicated that they had elected to feed formula. In each weaning study, parents of eligible neonates were provided a brief information sheet about the study and were asked to call if they were planning to wean the infant from breastfeeding at either 6 weeks of age or 4–6 months of age. Parents also were informed that the American Academy of Pediatrics recommends breastfeeding for 12 months and that other ongoing studies in our laboratory were available for infants who were breastfed. All trials observed the tenets of the Declaration of Helsinki and were approved by the University of Texas Southwestern Medical Center (Dallas), Presbyterian Hospital (Dallas), and Medical City Hospital (Dallas).

Protocol

In each of the three trials, infants were randomly assigned on the day of enrollment to consume one of two infant formulas described below. Each trial followed a double-blind design and the formula manufacturer masked both diets with two color/number codes for a total of four possible diet assignments for each infant. The randomization schedule was blocked with variable length blocks. After obtaining signed informed consent from a parent, the study coordinator opened the next sequentially numbered opaque sealed envelope to determine color/number code assignment for each infant and dispense the appropriate formula. Diet codes were not revealed until the studies were complete. In two of the trials, infants were breastfed initially but then weaned at 6 weeks or 4–6 months and fed the assigned formula until 12 months of age (see Table 1). During the breastfeeding phase, one formula feeding per day (maximum 120 ml at a single feeding) was permitted. Note that even with this allowance, formula feeding accounted for less than 20% of total nutritional intake.

Problem Solving

Problem solving was assessed using a two-step task in which the infant had to successfully complete two steps to retrieve a rattle. Importantly, the two-step means-end problem solving task was chosen because it has been shown that intention scores on the two-step task at 8 and 9 months of age correlate well with performance on both the British Ability Scale IQ test and the British Picture Vocabulary Scale at 3 years of age (rs = .42–.64; Willatts, 1992). Infants were tested at 9 months of age within a time limit of ± 2 weeks. Testing was conducted during each child's normal waking hours, when the child was alert, and followed the procedure implemented by Willatts, Forsyth, DiModugno, Varma, and Colvin (1998b).

Before beginning the test, the child was allowed to play with the rattle for approximately 20 s. The child then underwent a pretest assessing his or her ability to complete each step of the task separately. In the pretest phase, the rattle first was placed out of the child's reach on the far end of a 45 × 49 cm cloth. The child was required to pull the near end of the cloth, thereby placing the rattle within his or her reach. Second, while the child was watching, the rattle was placed within his or her reach but was covered by a 25 × 27.5 cm cloth. The child was required to remove the cover and retrieve the rattle. Each infant was allowed up to three attempts to accomplish each of the two tasks that composed the pretest, with each attempt lasting up to 30 s. Once the infant completed the pretest successfully, the testing trials began. Those who could not complete the pretest after three attempts did not participate in the test trials.

The testing phase included three trials during which the rattle was placed on the larger cloth out of the child's reach, and then covered. The infant was required to complete the component steps consecutively. The number of intentional solutions, that is, trials in which the child obtained the rattle successfully, was recorded. In addition, each child's intentionality throughout the test phase was assessed following the scoring procedure of Willatts et al. (1998b). Specifically, each trial was divided into six separate components: (a) pulls cloth, (b) looks at cover, (c) grasps cover, (d) removes cover, (e) looks at toy, and (f) picks up toy, and within each component, his or her level of intention was scored. The infant was assigned an intention score ranging from 0 to 2 (0 = *failure to complete the component*, 1 = *accomplished component without clear intention*, 2 = *accomplished the component*

with clear intention) on each component of the test trial. Clear intention (score = 2) required that the infant appear visually focused on the task, performed no irrelevant behaviors, and accomplished the step quickly (Willatts, 1997). Thus, on each trial the child could obtain an intention score ranging from 0 to 12. Average intention score for the three trials was recorded. Note that children who could not complete both steps of the pretest were included in the analysis but assigned a score of −1 on both number of intentional solutions and average intention score. A score of −1 was assigned instead of 0 because it was decided that these children did not display the same level of cognitive functioning as children who could complete both components of the pretest but could not complete a single step of the test phase.

Diets

In each study, the control formula consisted of a commercial infant formula (Enfamil® with iron; Mead Johnson Nutritionals, Evansville, IN) with neither DHA nor ARA. The LCPUFA-supplemented formula consisted of the same formula supplemented with .36% DHA and .72% ARA. Both formulas provided 15% linoleic acid and 1.5% α-linolenic acid. The DHA/ARA-supplemented formulas contained single-cell oils (DHASCO and ARASCO; Martek Biosciences, Columbia, MD). Both formulas were packaged in 946-ml ready-to-feed cans and provided 14.7 g/L protein, 37.5 g/L fat, 69.0 g/L carbohydrate, and 2805 kJ/L. All nutrients met existing standards for commercial formula established by the Infant Formula Act of 1980 (U.S. Public Law 96-359) that ensures the safety and nutrition of infant formulas in the United States by including minimum, and in some cases, maximum levels of specified nutrients.

Sample Size

As each clinical trial reported here was part of an earlier study investigating the effects of LCPUFA supplementation on visual acuity, sample sizes were chosen based on this outcome measure (Birch et al., 2002; Birch et al., 2005; Hoffman et al., 2003). Note that because the 12-month feeding study was composed of two smaller substudies (a visual evoked potential substudy and an electroretinogram substudy), the sample sizes were considerably larger than for the two other trials (see Table 1 for sample sizes). Importantly, the sample sizes of each trial (see Table 2) surpassed those required (22 per group) to detect a difference of one intentional solution on the means-end problem solving task for $\alpha = 0.05$ and $1-\beta = 0.90$ (Willatts et al., 1998b).

Statistical Analyses

In both the 12-month feeding study and the 6-week weaning study, statistical comparisons for number of intentional solutions were conducted using group medians and one-tailed Mann–Whitney *U* tests as these data did not meet normality criteria (Kolmogorov–Smirnov, $p < .05$). In

Table 2
Summary of Means-End Problem Solving Results From the Three Randomized Clinical Trials

	12-month feeding study		6-week weaning study		4- to 6-month weaning study	
	LCPUFA	Commercial	LCPUFA	Commercial	LCPUFA	Commercial
Participants tested (*n*)[a]	43	45	26	30	29	29
Number of intentional solutions[b]	3.0 (1.0–3.0)	2.0 (0–3.0)*	2.0 (0–3.0)	0 (0–1.0)*	1.0 (1.0–3.0)	1.0 (0–3.0)
Average intention score[c]	8.6 ± 3.7	6.9 ± 4.0*	6.8 ± 5.2	4.3 ± 3.8*	6.6 ± 4.0	6.7 ± 4.4
Percentage successful on all three trials	51	29*	46	13**	28	28
Percentage who obtained a perfect intention score	26	16	35	7**	7	7
Percentage who could not complete the pretest	2	2	12	13	7	7

Note. LCPUFA = long-chain polyunsaturated fatty acid.
[a]Over all three randomized trials, 27 infants were lost to follow-up prior to the 9-month visit, 24 who dropped from the trials due to their pediatricians' recommendation to switch to a soy protein-based formula following symptoms suggestive of lactose or cow's milk protein intolerance prior to the 6-week visit, 2 due to infant illnesses unrelated to formula intake, and 1 for whom we were unable to contact the parent to schedule an appointment. [b]Numbers represent medians. Numbers in parentheses represent upper and lower quartiles, respectively. [c]Numbers represent means ± 1 *SD*.
*$p < .05$. **$p < .01$.

both studies, average intention scores were distributed normally (Kolmogorov–Smirnov, $p > .05$) and were analyzed using analysis of variance (ANOVA). In the 4- to 6-month feeding study, diet groups differed on number of both parents with education above high school level. Thus, number of intentional solutions and average intention score, both of which were distributed normally (Kolmogorov–Smirnov, $p > .05$), were compared using ANCOVA with parental education as the covariate. In each clinical trial, the percentage of participants who were successful on all three test trials, the percentage who obtained a perfect intention score, and the percentage who could not complete the pretest among diet groups were compared using the z test for two proportions. All analyses were conducted using the Statistica 7.1 software package (StatSoft Inc, Tulsa, OK).

Results

The results of the three clinical trials are presented in Table 2. Table 1 reveals that a total of 27 children did not complete the two-step test at 9 months of age due to the parents' decision to drop out of the study (see note below Table 2). As noted above, diet groups differed on the number of both parents with education above the high school level in the 4- to 6-month weaning study (see Hoffman et al., 2003). However, there were no other significant differences between diet groups on any demographic variables measured in any of the three studies, which included participant variables (sex, race, birth weight, birth length, birth head circumference, Apgar scores) and maternal and paternal variables (age, weight, height, education).

Table 2 indicates that although diet groups did not differ on any 9-month cognitive outcome measure in the 4- to 6-month weaning study, they differed on a number of outcome measures in both the 12-month feeding study and the 6-week weaning study. Specifically, infants who were fed LCPUFA-supplemented formula in the 6-week weaning study had more intentional solutions than those fed control formula (*Mdn*s = 2 vs. 0, respectively; Mann–Whitney $U = 276$, $p = .031$). This was also the case in the 12-month feeding study (*Mdn*s = 3 vs. 2, Mann–Whitney $U = 734$, $p = .025$). In the 12-month feeding study and the 6-week weaning study, LCPUFA-supplemented groups obtained higher average intention scores than the control groups—12-month feeding study (*M*s = 8.6 vs. 6.9, respectively), $F(1, 86) = 4.29$, $p = .041$, $\eta_p^2 = .047$, and 6-week weaning study (*M*s = 6.8 vs. 4.3, respectively), $F(1, 54) = 4.47$, $p = .039$; $\eta_p^2 = .076$—and a higher percentage of the LCPUFA-supplemented children were successful on all three test trials (12-month feeding study: 51% vs. 29%, z test for proportions, $p = .018$; 6-week weaning study: 46% vs. 13%, z test for proportions, $p = .0042$). In addition, in the 6-week feeding study, a higher percentage of the LCPUFA-supplemented group obtained a perfect intention score of 12 than in the control group (35% vs. 7%, z test for proportions, $p = .0057$). Interestingly, in each of the trials, diet groups did not differ on the percentage of children who could not complete the pretest (12-month feeding study: 2% vs. 2%, z test for proportions, $p = .49$; 6-week weaning study: 12% vs. 13%, $p = .46$; 4- to 6-month weaning study: 7% vs. 7%, z test for proportions, $p = .50$). This finding implies that the above differences shown in the 12-month feeding and 6-week weaning studies were not due to the infants' inability to complete the main component tasks (i.e., pull cloth, remove cover) but rather, by their relative inability to plan and execute the component steps consecutively.

Discussion

The results reported here suggest that LCPUFA supplementation of infant formula beginning shortly after birth, or after 6 weeks of breastfeeding, leads to superior performance on a means-end problem solving task at 9 months of age. Specifically, compared to children fed the control formula, children fed the LCPUFA-supplemented formula in the 6-week weaning study and the 12-month feeding study were successful on a greater number of trials, had higher intention scores, and were more likely to be successful on all three trials. In addition, in the 6-week weaning study, LCPUFA-supplemented children were more likely to obtain perfect intention scores. As performance on means-end problem solving has been shown to be correlated with later IQ scores and vocabulary (Slater, 1995; Willatts, 1992, 1997), it is possible that the superior performance on the two-step task reported here might correspond to enhanced IQ and vocabulary at later ages. In addition, it is noteworthy that the effect sizes for the average intention score in the 12-month feeding and 6-week weaning studies (Cohen's $d = .55$ and .44, respectively) are similar to those found by Birch et al. (2007) on Full Scale IQ of the Wechsler Preschool and Primary Scale of Intelligence when comparing children fed

DHA + ARA formula to those fed control formula (Cohen's $d = .54$). Note however, the difference between groups in the Birch et al. (2007) study was not statistically significant due to small sample sizes.

In contrast to the 12-month feeding and 6-month weaning studies, diet groups did not differ in the 4- to 6-month weaning study. There are at least three explanations for the lack of diet group differences. First, it is possible that the duration of LCPUFA supplementation was too short to provide cognitive benefits. Specifically, the LCPUFA-supplemented groups received only 3–5 months of supplementation between weaning and the time of testing. Conversely, LCPUFA-supplemented children in the 12-month feeding and 6-week weaning studies received 9 and 7.5 months of supplementation, respectively. Second, our results might suggest that early in life, there is a critical point during which LCPUFA supplementation can influence the development of the brain regions that have been implicated in means-end problem solving (e.g., prefrontal cortex; Judge et al., 2007). If this critical period occurs over the first 4 months of life (before supplementation began in the 4- to 6-month weaning study), the diet groups in this study would not be expected to differ on the two-step task. Finally, the lack of diet group differences in the 4- to 6-month weaning study might suggest that both groups were demonstrating beneficial effects of the extended period of breastfeeding. If so, we still do not know whether these beneficial effects extend beyond the 1st year of life. It would be of particular interest to assess these children at a later age to determine whether there are any functional benefits of postweaning LCPUFA supplementation on cognitive function later in childhood.

To date, Willatts et al. (1998b) have conducted the only other study examining the effects of LCPUFA-formula supplementation on means-end problem solving in 9-month-olds. Although they obtained a range of scores similar to that of the present study for both the number of intentional solutions and intention scores, they found no diet-related differences. However, when these data were reanalyzed based on the infants' results from earlier habituation trials conducted at 3 months of age, they reported that among those who were late peakers (i.e., peak stimulus fixation occurred after Trial 1), LCPUFA-supplemented children had higher intention scores and more intentional solutions than control children. In a similar study, Willatts et al. (1998a) found that 10-month-old infants fed LCPUFA-supplemented formula yielded higher intention scores and more successful solutions than control children on a three-step test of means-end problem solving. The somewhat discrepant results of these studies might be explained by the use of low concentrations of DHA in the supplemented formulas (.15%–.25%; Willatts et al., 1998a, 1998b). Our results suggest that LCPUFA-supplemented formula provides a significant cognitive benefit when DHA is provided at .36% of total fatty acids in the infant diet. The beneficial effects of LCPUFA might not be restricted to formula supplementation, as Judge et al. (2007) reported that maternal consumption of DHA-rich functional foods during pregnancy also improves means-end problem solving at 9 months of age. Conversely, Lauritzen, Jorgensen, Olsen, Straarup, and Michaelsen (2005) found no benefit for means-end problem solving in a study in which Danish mothers were supplemented postnatally with fish oil capsules (experimental group) or olive oil capsules (control group). Yet, mothers in the control group had breast milk with DHA concentrations twice as high as commonly found in the breast milk of American women (.40% vs. ~.20% of total fatty acids; Auestad et al., 1997, 2001; Brenna et al., 2007; Cherian & Sim, 1996; Francois, Connor, Bolewicz, & Connor, 2003; Hall, 1979; Henderson, Jensen, Lammi-Keefe, Ferris, & Dardick, 1992; Innis, Akrabawi, Diersen-Schade, Dobson, & Guy, 1997; Jensen et al., 2005; Yuhas et al., 2006). Given that the baseline concentration was so high, it is possible that DHA supplementation provided no additional benefits.

The mechanisms underlying improved means-end problem solving in LCPUFA-supplemented infants are not currently understood, but two overlapping explanations have been posited (Forsyth, Willatts, DiModogno, Varma, & Colvin, 1998; Willatts et al., 1998a). First, it is possible that the accumulation of LCPUFA in cell membranes of the central nervous system results in increased speed of information processing, thereby enhancing one's ability to complete a task that involves the sequential execution of two or more steps. Specifically, infants can quickly determine the steps necessary to complete the task and are able to execute these steps before forgetting the final goal. This hypothesis is supported by studies utilizing the Fagan Test of Infant Intelligence, a test that measures preference for a novel stimulus over a familiar stimulus following habituation. Infants fed LCPUFA-supplemented formulas yield shorter look durations to both novel and habituated stimuli (Carlson & Werkman, 1996; Werkman & Carlson, 1996), a finding that has been argued to reflect the

ability of infants to process the information from the stimuli more rapidly (Carlson & Werkman, 1996; Jacobson et al., 1992; Werkman & Carlson, 1996). Similarly, Colombo et al. (2004) reported that infants whose mothers had high erythrocyte DHA concentrations at birth demonstrated a more rapid decline in peak look duration during a traditional stimulus habituation sequence, with heart rate recordings typical of older infants who exhibit more efficient visual information processing.

Second, some researchers have suggested that LCPUFA supplementation improves means-end problem solving by enhancing attentional control (Colombo et al., 2004; Judge et al., 2007; Willatts et al., 1998a, 1998b). In essence, LCPUFA-supplemented infants demonstrate a more mature state of attentional control in that they can disengage their attention more readily from one component of the task, and move quickly to the next. Instead of becoming mired in any one component of the task, the infant can accomplish the steps consecutively and, ultimately, obtain the rattle. Several lines of evidence suggest stimulus disengagement is mediated by the prefrontal cortex. For instance, electroencephalographic recordings and near-infrared spectroscopy suggest that in humans, the prefrontal cortex is involved in tasks used to assess mastery of object permanence, similar to the two-step problem solving task (Baird et al., 2002; Bell & Fox, 1992, 1997). In addition, children with prefrontal lesions experience difficulty in disengaging attention (Anderson, Jacobs, & Harvey, 2005). In light of these findings, it is possible that LCPUFA improve attentional control by facilitating the development of the prefrontal cortex. This explanation is plausible as studies of rats, pigs, and nonhuman primates demonstrate that the neuronal membranes within the prefrontal cortex are particularly sensitive to both DHA deficiency (Neuringer & Connor, 1986; Rao et al., 2007) and DHA supplementation (Connor, Neuringer, & Lin, 1990).

Alternatively, it might be argued that the results reported here are due to superior visual function and/or motor skills in LCPUFA-supplemented children, both of which could enable the infants to complete the task more easily. Indeed, in each of the clinical trials, children receiving the supplemented formulas had better visual acuity than control children (see results from the initial publications, Birch et al., 2002; Birch et al., 2005; Hoffman et al., 2003). However, this explanation is unlikely given that the control group's performance on the pretest was equal to that of the LCPUFA-supplemented group (see Table 2), suggesting they were limited not by visual function or motor skills but, as noted above, by their relative inability to plan and execute the component steps consecutively.

In summary, the results reported here indicate that LCPUFA supplementation improved performance on means-end problem solving at 9 months of age. Given that performance on means-end problem solving is correlated with later IQ and vocabulary, this implies that the cognitive benefits of DHA supplementation might persist well beyond infancy. Currently, we are investigating cognitive and executive function in preschoolers and school children to determine whether the beneficial effects are indeed long lasting.

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