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A theory-based approach to teaching young children about health: A recipe for understanding

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Abstract

The theory-theory account of conceptual development posits that children's concepts are integrated into theories. Concept learning studies have documented the central role that theories play in children's learning of experimenter-defined categories, but have yet to extensively examine complex, real-world concepts such as health. The present study examined whether providing young children with coherent and causally-related information in a theory-based lesson would facilitate their learning about the concept of health. This study used a pre-test/lesson/post-test design, plus a five month follow-up. Children were randomly assigned to one of three conditions: theory (i.e., 20 children received a theory-based lesson); nontheory (i.e., 20 children received a nontheory-based lesson); and control (i.e., 20 children received no lesson). Overall, the results showed that children in the theory condition had a more accurate conception of health than children in the nontheory and control conditions, suggesting the importance of theories in children's learning of complex, real-world concepts.

Keywords

concept of health; evaluative categories of food; theory-theory

The theory-theory account of children's conceptual development argues that children's concepts are embedded into theories, or coherent and causally-related systems of knowledge. Hence, the term theory-theory refers to a theory about children's theories. These systems of knowledge are coherent and causally-related in that they are organized in a logical manner and are connected together through cause and effect explanations. Thus, children's concepts are integrally tied to their larger knowledge of the world around them (see Gelman & Kalish, 2006; Murphy & Medin, 1985; Wellman & Gelman, 1997). Concept learning studies have focused on how children's theories are used as a basis for accumulating knowledge, and have demonstrated the central role that theories play in children's acquisition of artificial experimenter-generated categories (e.g., fictitious animals). For example, when learning about these new categories, children will tie this novel information into their own background knowledge (Barrett, Abdi, Murphy, & Gallagher, 1993; Hayes & Taplin, 1992) and also benefit from being given a theory that provides causal

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explanations for category membership (e.g., explaining the function of animals' features, Krascum & Andrews, 1998).

However, very few concept learning studies have investigated the centrality of theories in children's acquisition of real-world concepts. Examining such concepts is a crucial area of study that can lead to understanding how theories are relevant to children's concept learning both inside and especially outside of the laboratory (see Ahn, Goldstone, Love, Markman, & Wolff, 2005). To date, the few studies that have begun to examine the acquisition of real-world concepts have focused on reasoning within the context of children's naive theory of biology, or children's intuitive beliefs about the world of living things. The idea is that children are predisposed to pay attention to causal patterns and to pick out information about the domain of living kinds, including plants and animals (see Inagaki & Hatano, 2002; Wellman & Gelman, 1997). For example, Solomon and Johnson (2000) found that when 5- and 6-year-olds are taught facts about inheritance and are provided with a causal mechanism (e.g., genes) that links the facts together, children make more accurate judgments about the inheritance of traits from parent to offspring. Au and Romo (1996) also found that providing 4th, 5th, and 6th graders information about a causal mechanism (e.g., virus) for AIDS transmission helps children form a more accurate conception of AIDS and enhances their caution regarding AIDS without producing unwarranted fear (see also Zamora, Romo, & Au, 2006 for analogous work with 7th graders). Au et al. (2008) also found that when Chinese 3rd and 4th graders are taught about the biological mechanisms for cold/flu transmission, they showed a more scientific understanding and made more behavioral changes than children who were not taught this information.

Thus, the aim of the present study is to further investigate the role of theories in children's learning about a real-world concept. The present study is distinct from previous work in that it focuses on the concept of health in young preschool-aged children, particularly 4-year-olds, as opposed to older elementary school-aged children. This study aims to capitalize on young children's naive theory of biology, well before they receive any formal education regarding health in elementary school. The concept of health is one that is in need of critical attention within this population given the astounding prevalence of young children who are overweight in the United States. The National Health and Nutrition Examination Survey (NHANES) indicates that the percentage of young children ages 2- to 5-years who are overweight has nearly doubled over the last ten years from 7.2% to 13.9% (Center for Disease Control and Prevention, 2006). The present study applies the theory-theory to teaching young children specifically how to maintain a healthy body through physical activity and eating healthy food. If the theory-theory can be effectively applied to teaching young children about health, then children's learning should be facilitated by coherent and causally-related health information. Coherence and causality are essential components of a theory-based lesson: *coherence* meaning the information is presented in a logically ordered manner in which the facts are related and the information is presented clearly and *causality* meaning that separate facts are connected together through the explanation of causes and effects. The notion here is that coherent and causally-related information should be straightforward for children to learn, use, and remember since it can be integrated into their naive theory of biology.

A major limitation on this prediction, however, is that health is an especially difficult area of biological reasoning for young children. On the one hand, research has found that young children have some basic understanding of healthy foods and physical activity. For example, research has found that by age 3- to 4- years, children are able to categorize foods based on their health status (Nguyen, 2007a, b; Nguyen & Murphy, 2003) and understand that eating food can impact the human body over a period of time (e.g., providing it with strength and energy) (Guérin & Thibaut, 2008; Inagaki & Hatano, 2004; Nguyen, 2008; Nguyen &

McCullough, 2009; Wellman & Johnson, 1982). Yet, on the other hand, at this age, children still have a number of misconceptions about food consumption (e.g., “you’ll become a hotdog if you eat too many,” “people can grow up to be giants if they eat really good,” Nguyen & Rosengren, 2004). Children will also misclassify some unhealthy foods as healthy (e.g., potato chips, fried chicken, Nguyen, 2007a, b; Nguyen & Murphy, 2003) and misclassify disgusting or contaminated foods (e.g., juice with a fly or a dirty comb submerged in it) as edible (e.g., Rozin, 1990; Rozin, Fallon, & Augustoni-Ziskind, 1985; Rozin, Hammer, Oster, Horowitz, & Marmora, 1986). Furthermore, although many children associate being active with playing team sports (e.g., soccer, basketball), even grade school children will fail to recognize other forms of physical activity such as riding a bike and walking. Children also mistake sedentary activities such as reading a book, singing a song, and doing homework as physical activity (Trost et al., 2000). These types of misconceptions may pose challenges to efforts focused on teaching children about health because they are at odds with an accurate biological understanding and may potentially interfere or hinder children’s ability to learn this information.

To date, a theory-based approach to teaching young children about health has yet to be designed and empirically tested within the conceptual development literature. Most of the existing health-related teaching materials are intended for older school-aged children (e.g., *Media Smart Youth*, NICHD, 2005; *We Can!*, NIH, 2005; and, *The Power of Choice*, USDA, 2003) and the few that are intended for young children offer information in the form of games and songs (e.g., Levin, Maurice, McKenzie, & DeLouise, 2002; Sesame Street, 2006). Thus, in the present study, we developed a theory-based lesson that is grounded in a coherent and causally-related theory for preschool-aged children. Specifically, the sentences within the theory-based lesson were coherently organized around the theme of how to have a healthy body. For example, the theory-based lesson began with the following introduction: “We are going to learn today about how to have a healthy body.” The theory-based lesson included factual information about healthy foods (e.g., vegetables), unhealthy foods (e.g., high-fat foods), physical and nonphysical activities, along with causal explanations for why they are/are not beneficial to the human body. The causal explanations offered in the lesson were child-friendly in order to pitch the lesson at an appropriate level for preschool-aged children. For example, children receiving the theory-based lesson heard that “healthy foods give your body what it needs” because they have “vitamins inside” that “help you grow, give you long-lasting energy, and keep you from getting sick.” Similarly, children heard that “exercise is healthy for you,” because it “makes your bones and muscles strong, makes your heart beat faster, gives you energy, and keeps you from getting sick.” Although such explanations are not as deep and complex as what would be expected for school-aged children and beyond, they do provide causal information regarding health that preschoolers can understand. Indeed Keil (2008) argued that causal explanations for young children may fail if they are too detailed or make certain assumptions about children’s preexisting knowledge. For example, Keil (2008) reasoned that young children would be lost by an overly detailed causal account of how eating food is related to energy level that includes information about chemistry, cells, and anatomy. Thus, in the present study, the causal explanations in the theory-based lesson were carefully developed to be comprehensible by preschool-aged children.

We also developed a nontheory-based lesson that was not coherently organized around the theme of how to have a healthy body. For example, this lesson began with the following introduction: “We are going to learn today about different things.” The nontheory-based lesson also included the same basic factual information about healthy foods (e.g., vegetables), unhealthy foods (e.g., high-fat foods), physical and nonphysical activities, but without causal explanations. For example, children were merely told that “healthy foods

give your body what it needs” and that “exercise is healthy for you,” but were not given any explanations.

To examine the effectiveness of the lessons, children were randomly assigned to one of three conditions, which corresponded to the type of lesson children would receive: theory; nontheory; or, control. This methodological approach differed from the usual approach of assigning children to only one of two conditions. In past studies, children were exposed to either an experimental theory-based lesson/“training” session or a control (i.e., children did not interact with the experimenters at all, Solomon & Johnson, 2000)/conventional lesson plan in which children were presented with publicly available resources (Au et al., 2008) or lesson plans already employed in the school (Au & Romo, 1996). Thus, the control/conventional lesson plans in these studies were not necessarily equivalent to the theory-based lesson in all other aspects except for the theory-based components. The inclusion of the nontheory-based condition in the present study was of particular importance because it allowed for a direct comparison between the effects of providing children with or without coherent and causal explanations related to health. In this study, the only difference between the theory and nontheory-based lessons was the invocation of coherent and causally-related information. The control condition served as a baseline, and allowed us to also investigate whether simply receiving any kind of information (whether it be coherent and causally-related or not) would be more beneficial than not receiving any information at all.

In this study, we implemented a pre-test/lesson/post-test design. Children were also followed-up approximately five months after the post-test. This methodology is different than previous research, which has focused on the immediate benefits of theory-based instruction on children’s learning of biological concepts. For example, in previous research, post-tests have been administered 20 (Au et al., 2008) to 30 days (Au & Romo, 1996) or two weeks (Solomon & Johnson, 2000) after the lessons. Follow-ups, however, are commonly found within the cognitive development literature more generally and provide important insights into children’s development over a short period of time (e.g., Johnson, Alexander, Spencer, Leibham, & Neitzel, 2004; Shatz, Behrend, Gelman, & Ebeling, 1996; Slade & Ruffman, 2005; Woolley, Boerger, & Markman, 2004).

Overall, if the theory-based approach is an effective way of teaching children about health, then children exposed to the theory-based information should show expansions in their health-related knowledge and understanding from pre- to post-test. Children exposed to the theory-based information should also show advantages in their performance at post-test, as a nontheory-based lesson may be of limited benefit to children without coherent and causally-related information.

Method

Participants

Participants were 60 four-year-olds (27 females, 33 males, $M_{\text{age}} = 4.51$, range = 3.8 – 4.9). Twenty participants were randomly assigned to each of the three conditions: theory-based (9 females, 11 males, $M_{\text{age}} = 4.53$, range = 3.9 – 4.9); nontheory-based (8 females, 12 males, $M_{\text{age}} = 4.46$, range = 3.8–4.8); and control (10 males, 10 females, $M_{\text{age}} = 4.55$, range = 4.0 – 4.9). There were no significant age differences between the conditions as revealed by a one-way ANOVA, $F(2, 59) = 0.47$, $p = 0.62$. Children’s Body Mass Index (BMI) was also calculated based on children’s height and weight. Please see Table 1. The majority of the children across all of the conditions had a healthy weight status (defined as falling within the 5th to 85th percentile, CDC, 2008); there were no significant differences in BMI ($F(2, 59) = 1.99$, $p = 0.14$) and percentile rankings ($F(2, 59) = 0.84$, $p = 0.43$) between children in each condition. Based on parental report, most of the children across conditions were allergy-free,

were provided with options for healthy foods and activities each day, and were receiving the daily recommended amount of nutrition and physical activity.

In addition, the materials in this study were developed and based on ratings provided by a total of 60 adults (26 males, 34 females; $M_{\text{age}} = 20.1$, range = 18.5, 24.6) and 10 four-year-olds (7 females, 3 males, $M_{\text{age}} = 4.14$, range = 3.4–4.9), none of whom participated in the actual study.

All of the child and adult participants were recruited from preschools and a university located in a predominately European-American, middle-class community in the Southeastern United States.

Materials and Procedure

The teaching materials included theory-based and nontheory-based lessons about health. In particular, the lessons focused on how different foods and activities can contribute to having a healthy body. The information for these lessons was drawn from several sources including the National Institutes of Health, the National Institute of Child Health and Human Development, and the American Heart Association. Both lessons included five sections focusing on 1) an introduction; 2) healthy foods (e.g., vegetables); 3) unhealthy foods (e.g., high-fat foods); 4) physical/nonphysical activities; and, 5) a conclusion. See the Appendix for the two lessons. Both lessons included the same basic facts, except that the theory-based lesson was organized around a coherent health theme, and included causally-related explanations. The following is a sample excerpt from the theory-based lesson: “We are going to learn today about how to have a healthy body...To have a healthy body, you need to feed it right. Healthy foods give your body what it needs *because they have many vitamins. Vitamins are inside of healthy foods...Vitamins help you grow, give you long-lasting energy, and keep you from getting sick.* There are many healthy foods you should eat a lot of. For example, vegetables are healthy foods *because they have many vitamins inside of them.* You should eat vegetables every day. Examples of vegetables that have many vitamins inside are beans, celery, carrots, broccoli, and corn. *These foods help you grow, give you long-lasting energy, and keep you from getting sick.*” In this excerpt, coherence is illustrated by the logical organization of the sentences around the theme of learning how to have a healthy body. Causality is illustrated by the vitamin-related explanations in italics for why foods are healthy.

In contrast, coherence was eliminated from the nontheory-based lesson by removing the health theme in the introductory sentence, and by rearranging the sentences. Causality was also eliminated from the nontheory-based lesson by removing the causal explanations. The following is an excerpt from the nontheory-based lesson: “We are going to learn today about different things...Examples of vegetables are beans, celery, carrots, broccoli, and corn... Healthy foods give your body what it needs. You should eat vegetables every day. There are many healthy foods you should eat a lot of. For example, vegetables are healthy foods.”

We designed the nontheory-based lesson in this way so that the two lessons would be directly comparable; the basic facts in the two lessons remained constant, and only the coherent and causal elements of the lessons varied. Of course in developing the lessons, a concern was that the theory-based lesson would have more words than the nontheory-based lesson because it included coherent and causal elements. We had considered developing a nontheory-based lesson that would have the exact number of words as the theory-based lesson by including additional health-related facts, or by simply repeating the same facts. We also considered including causally-implausible explanations. However, we soon observed that inclusion of such information could potentially confound the results, making it difficult to directly compare the lessons because they would no longer vary only on

coherence and causality, that is, the presence/absence of a theory. Thus, we decided to take special care to reduce, as much as possible, the difference in the number of words between the theory (692) and nontheory-based (337) lessons without compromising our ability to directly compare the two lessons.

Coherence and causality ratings—To verify that the theory- and nontheory-based lessons indeed differed on their levels of coherence and causality, these lessons were independently rated by adults who were not involved in their design, but who were capable of rating the lessons based on these dimensions. Obtaining these adult ratings was crucial because they could offer data beyond experimenter intuition about the key distinctions between the two lessons. Thus, 28 adults were asked to rate these lessons for coherence and causality on a scale ranging from 1 (*not at all coherent/causal*) to 7 (*very coherent/very causal*). Coherence was defined for adults as the degree to which material is presented in a clear and logical manner. Causality was defined for adults as the degree to which separate facts are connected together through causal explanations. The results indicated that the theory-based lesson ($M = 6.61$, $SD = 0.88$) was more coherent than the nontheory-based lesson ($M = 3.46$, $SD = 1.43$), $t(27) = 9.46$, $p < .001$. The ratings also showed that the theory-based lesson ($M = 6.75$, $SD = 0.52$) was more causally-related than the nontheory-based lesson ($M = 3.32$, $SD = 1.39$), $t(27) = 12.97$, $p < .001$.

The teaching materials also included three demonstration pictures. The first item was a picture of lettuce with flaps that children could lift to reveal a representation of vitamins inside. The second item was a picture of a cookie with flaps that children could lift to reveal a representation of no vitamins inside. The third item was a picture of the human body with flaps that children could lift to reveal a representation of a heart, muscles, and bones inside.

Typicality and palatability/enjoyability ratings—The teaching materials also included 20 laminated color photographs ($4'' \times 5''$) of specific foods (5 vegetables, 5 high-fat foods) and activities (5 physical, 5 nonphysical). These 20 photographs were also used in the pre- and post-tests, in addition to four novel items (1 vegetable, 1 high-fat food, 1 physical and 1 nonphysical activity). These novel items were not explicitly taught in the lessons, but offered children an opportunity to generalize their acquired knowledge in the post-test. Overall, these stimuli were selected from a larger set of stimuli based on two sets of ratings provided by 32 adults and 10 children. The first set of ratings focused on typicality to help select items that were in fact representative examples of vegetables, high-fat foods, physical and nonphysical activities. The second set of ratings focused on palatability (for foods)/enjoyability (for activities) to help select items that were in fact likeable examples of vegetables, high-fat foods, physical and nonphysical activities. Equating typicality as well as palatability/enjoyability within and across categories was important so that children's performance in the actual study would not be affected by any differences in the items' typicality or palatability/enjoyability. For example, an item that is not at all typical of its category may be more difficult to learn than an item that is very typical of its category because children may be unfamiliar with this item. Similarly, an item that is not at all palatable/enjoyable may be more difficult to learn than an item that is very palatable/enjoyable because children may have an aversion towards this item. Adults rated the stimuli on rating scales ranging from 1 (e.g., *not at all typical*, *not at all palatable/enjoyable*) to 7 (e.g., *very typical*, *very palatable/enjoyable*). Children rated the stimuli using a child-friendly version of the rating scales ranging from 1 (e.g., *not at all a good example*, *not at all yummy/fun*) to 5 (e.g., *very good example*, *very yummy/fun*). Only items that both adults and children considered as at least somewhat typical and palatable/enjoyable were selected for the final stimulus set. Adults' mean typicality and palatability/enjoyability ratings from the final stimulus set for each of the categories were the following: vegetables (6.12, 4.61); high-fat foods (6.00, 4.89); physical activities (6.67, 4.25); and, nonphysical activities (6.48,

4.18). Children's mean typicality and palatability/enjoyability ratings from the final stimulus set were the following: vegetables (3.63, 3.46); high-fat foods (4.09, 4.38); physical activities (4.04, 4.05); and, nonphysical activities (3.22, 3.48).

Two opaque black boxes were also included as materials in the pre- and post-tests. The boxes had slits on the top so that children could place the photographs of the foods and activities inside. One box was designated for healthy foods/physical activities and the other box was designated for unhealthy foods/nonphysical activities.

Measures

The pre- and post-tests were identical and consisted of three types of questions: general classification; specific classification; and, selection. These three types of questions allowed us to tap into different aspects of children's understanding about health. The four *general classification* questions assessed children's general health knowledge of the broad categories of vegetables, high-fat foods, physical activities, and nonphysical activities. For example, "Are vegetables (high-fat foods, physical activities, nonphysical activities) healthy or not healthy for you? Why?" The 24 *specific classification questions* assessed children's specific health knowledge of particular foods and activities. For example, "This is a carrot. Is a carrot healthy or not healthy?" Finally, the 24 *selection questions* assessed children's ability to apply their health knowledge to the selection of specific healthy foods and activities. For example, "To have a healthy body, would you eat a carrot?" Please see Table 2 for a complete list of the 24 target foods and activities for the specific classification and selection questions, including four novel ones marked with an asterisk.

The same scoring procedure was used for the pre- and post-tests. Children's correct responses to the general classification, specific classification, and selection questions were assigned a 1 and incorrect responses were assigned a 0. Next, four separate summary variables were created for the specific classification questions: vegetables, high-fat foods, physical activities, and nonphysical activities. This was also the case for the selection questions. Each summary variable was created by summing children's responses across their respective trials, and then converting this sum into a percentage. Note that for the specific classification and selection questions, the summary variables included both the items learned in the lessons as well as the novel items.

The same coding scheme was also used to score children's explanations for their general classifications for the pre- and post-tests. Children's explanations were coded as either correct (e.g., "vegetables have vitamins inside," "exercise makes you stronger") or incorrect (e.g., "cookies and cake are good for you," "because I like to eat them," "I don't know"). Correct explanations were assigned a "1" whereas incorrect explanations were assigned a "0." For both the pre-and post-test, each child provided only one response for each of the four questions, and thus there were a total of 480 explanations, 160 per condition. Two researchers independently coded the explanations, as well as discussed and resolved disagreements. The overall percentage of inter-rater reliability between the two researchers was 92.3% and Cohen's Kappa Coefficient was .88.

Using the pre-test data from the present sample, Pearson correlation coefficients were calculated to examine the relationship between the general, classification, and selection questions. There was a significant positive correlation between the general and classification questions ($r(58) = .306$, $r^2 = .093$, $p = .01$), the classification and selection questions ($r(58) = .694$, $r^2 = .481$, $p < .001$), and a trend towards significance between the general and selection questions ($r(58) = .251$, $r^2 = .063$, $p = .05$). Thus, these concepts are related, yet the r squared coefficients indicate that each measure is capturing conceptually distinct constructs.

Procedure

The procedure involved two sessions. During session one, a pre-test was administered and during session two, a teaching lesson, immediately followed by a post-test was administered. Four days was the average number of days elapsed between the two sessions, which did not vary significantly between the three conditions: theory ($M = 4.8$ days); nontheory ($M = 4.7$ days); and, control ($M = 3.6$ days), $F(2, 57) = 1.51, p = 0.22$.

Two researchers implemented the procedure onsite at the children's preschools. Researcher one administered the pre-test to each child individually during the first session, and was blind to the children's condition assignment throughout the study. First, children were asked general classification questions. For example, "Are vegetables (high-fat foods, physical activities, nonphysical activities) healthy or not healthy for you?" The child responded with either a "healthy" or "not healthy." Children were also asked to provide an explanation for their general classifications ("Why?"). Next, children were asked specific classification questions, accompanied by the foods and activities from Table 2. For example, the researcher showed children a photograph of a carrot and said, "This is a carrot." Then, the researcher asked, "Is a carrot healthy or not healthy?" The child responded by placing the photograph in either the "healthy" or "not healthy" box, which were positioned randomly to the left or right of the child. Finally, children were asked selection questions, also accompanied by photographs of the foods and activities from Table 2. For example, the researcher showed the child a photograph of a target food or activity such as a carrot and then asked, "To have a healthy body, would you eat a carrot?" The child responded either "yes" or "no." To check for potential response biases, children were also shown a photograph of an animal, shape, and color, and asked a filler question about each ("Is this a cat?", "Is this a circle?", "Is this the color blue?"). All of the children answered the filler questions correctly.

During session two, researcher two administered the lessons to each child individually, depending upon their condition assignment. Children in the theory-based condition were provided with the theory-based lesson whereas children in the nontheory-based condition were provided with the nontheory-based lesson. Please see the Appendix for the exact wording of the lessons that researcher two read aloud to children. Note that the lessons involved interactive components as well to help maintain children's attention and interest. For example, the researcher asked children questions (e.g., "Now can you point to your body?") and offered children a chance to examine the demonstration pictures (e.g., "This is lettuce...Let's look inside! These are vitamins, see? Can you point to the vitamins? Would you like to see the lettuce? ..."). Children in the control condition did not receive a lesson.

Immediately following the lesson, researcher one administered the post-test to each child individually in all three conditions. The post-test was the same as the pre-test. To ensure that children's performance would not be affected by the order in which information was presented in the pre- and post-tests, children were given one of four orders of the tests. Children were randomly assigned to each order, and orders were distributed equally throughout each of the conditions (e.g., five children assigned to each order in all three conditions). An initial analysis of the data revealed that there was not a significant order effect in the pre-test ($F(3, 56) = 2.43, p = .074$) and post-test ($F(3, 56) = 0.89, p = 0.45$).

Both the pre- and post-tests lasted approximately 10–15 minutes each. The theory- and nontheory-based lessons also lasted approximately 10–15 minutes for each child.

Results

Three $2 \times 3 \times 4$ (Time [pre-test, post-test] $\times$ Condition [theory, nontheory, control] $\times$ Domain [vegetables, high-fat foods, physical activities, nonphysical activities]) repeated measures ANOVAs were conducted to examine performance on the general classification, specific classification, and selection questions. Please see Table 3 for these data. Note that of special interest is whether there is an interaction between condition and time in which the conditions do not differ at pre-test, but only at post-test, with highest performance by children in the theory condition relative to the others. To foreshadow the results, there was a significant condition by time interaction for the specific classification questions, and a trend towards significance for the general classification questions. There was not a significant condition by time interaction for the selection questions.

General classification questions

The first analysis, a $2 \times 3 \times 4$ (Time [pre-test, post-test] $\times$ Condition [theory, nontheory, control] $\times$ Domain [vegetables, high-fat foods, physical activities, nonphysical activities]) repeated measures ANOVA, examined children's performance on the general classification questions. The results revealed only a trend towards a significant interaction between condition and time, $F(2, 114) = 2.82, p = .06, \eta_p^2 = 0.04$. To further examine this trend, two follow-up analyses were conducted. The first analysis, a one-way ANOVA, examined whether there were condition differences at pre-test and then at post-test. The results indicated that while there was not a significant difference between the theory, nontheory, and control conditions at pre-test (M 's = 61%, 66%, 65%, SD 's = 24%, 19%, 24%, respectively), there was a significant difference at post-test, $F(2, 57) = 3.72, p = .03$. Specifically, Tukey post-hoc analyses revealed that at post-test, the theory condition ($M = 83\%$; $SD = 20\%$) performed significantly better than the control condition ($M = 63\%$; $SD = 21\%$), $p = .02$. There was not a significant difference between these conditions and the nontheory condition ($M = 73\%$, $SD = 27\%$). The second analysis, Bonferroni corrected paired sample t-tests, examined whether children's performance differed from pre- to post-test within each condition. The theory group emerged as improving the most, such that only children in the theory condition showed a significant improvement in performance on the general classification questions from pre- to post-test, $t(19) = 3.84, p < .001$. Children in the nontheory and control conditions did not show significant improvements on the general classification questions from pre-test to post-test.

Other findings included a significant main effect of time, $F(1, 114) = 4.07, p = .04, \eta_p^2 = 0.03$ as well as domain, $F(3, 342) = 56.90, p < .001, \eta_p^2 = 0.33$. These main effects were moderated by a time by domain interaction, $F(3, 342) = 4.16, p = .01, \eta_p^2 = 0.03$. A follow-up one-way ANOVA was conducted to examine whether children's performance varied from pre- to post-test for each of the domains. The results showed that children's performance on the high-fat foods increased significantly from pre- to post-test, $F(1, 118) = 4.10, p = .04$. This was also the case for children's performance on the nonphysical activities, $F(1, 118) = 5.95, p = .01$. However, there was not a significant difference in performance on the vegetables or on the physical activities from pre- to post-test, which could be explained by children's already extremely accurate performance on these two domains at pre-test.

There were no other significant effects or interactions.

Children's justifications for their responses to the general classification questions were examined through a series of Bonferroni corrected paired sample t-tests that compared performance on the pre-versus post-test within each condition.

There was a significant increase in the prevalence of correct explanations in the theory condition from pre- to post test (M 's = 44%, 60%, SD 's = 31%, 35%), $t(19) = 2.6$, $p = .01$. There was not a significant difference in the prevalence of accurate explanations in the nontheory condition from pre- to post-test (M 's = 41%, 49%, SD 's = 27%, 38%). This was also the case for the control condition (M 's = 44%, 45%, SD 's = 30%, 32%). Examples of children's correct responses included, "Vegetables have a lot of vitamins inside," "High-fat foods are not healthy because they make you tubby and fat," "Exercise gives your body air," and "Not exercising does not make your heart beat." Examples of children's incorrect responses included, "Vegetables do not have vitamins inside," "Because its exercise," and "I want to eat them."

Specific classification questions

The next analysis, a $2 \times 3 \times 4$ (Time [pre-test, post-test] $\times$ Condition [theory, nontheory, control] $\times$ Domain [vegetables, high-fat foods, physical activities, nonphysical activities]) repeated measures ANOVA, examined children's performance on the specific classification questions. The results indicated that there was a main effect of condition ($F(2, 114) = 3.77$, $p = .02$, $\eta_p^2 = 0.060$) that was indeed moderated by a condition by time interaction ($F(2, 114) = 3.01$, $p = .04$, $\eta_p^2 = 0.05$). Two sets of analyses were conducted to follow-up this interaction. The first set of analyses, one-way ANOVAs, examined whether there were condition differences at each time point. The results revealed that although there was not a significant difference between the theory, nontheory, and control conditions at pre-test, there was a significant difference at post-test, $F(2, 57) = 6.22$, $p = .004$. Tukey post-hoc analyses revealed that at post-test, children in the theory condition performed significantly better than children in the nontheory and control conditions, p 's = .009, .010. No significant differences emerged between the nontheory and control conditions. The second set of analyses, Bonferroni corrected paired sample t -tests, examined whether there were differences in performance from pre- to post-test within each of the conditions. Results revealed that only children in the theory condition showed significant improvement in their performance from pre- to post-test, $t(19) = 4.65$, $p < .001$. Children in the nontheory and control conditions did not show significant improvements from pre- to post-test.

A main effect of domain also emerged, $F(3, 342) = 35.19$, $p < .001$, $\eta_p^2 = 0.23$. Bonferroni corrected paired-sample t -tests indicated that children were significantly more accurate on vegetables and physical activities compared to high-fat foods and nonphysical activities, t 's (119) > 5.0 , p 's $< .001$. There were no significant differences between children's accuracy on vegetables and physical activities or between high-fat foods and nonphysical activities.

There were no other significant main effects or interactions.

To summarize, the results demonstrate that children in all three conditions performed similarly on the specific classification questions at pre-test, while the theory group outperformed both the nontheory and control conditions at post-test. Furthermore, only children in the theory condition showed significant improvements from pre- to post-test, with notable improvements on the most challenging domains for children, high-fat foods and nonphysical activities.

Selection questions

Finally, the last analysis, a $2 \times 3 \times 4$ (Time [pre-test, post-test] $\times$ Condition [theory, nontheory, control] $\times$ Domain [vegetables, high-fat foods, physical activities, nonphysical activities]) repeated measures ANOVA, examined children's performance on the selection questions. Even though this analysis did not reveal a significant condition by time interaction, several main effects emerged, including a main effect of time, in which

children's performance was better at post-test ($M = 68\%$, $SD = 19\%$) than pre-test ($M = 61\%$, $SD = 15\%$), $F(1, 114) = 4.38$, $p = .039$, $\eta_p^2 = 0.37$.

There were also main effects of domain ($F(3, 342) = 52.95$, $p < .001$, $\eta_p^2 = 0.31$) and condition ($F(2, 114) = 3.25$, $p = .04$, $\eta_p^2 = 0.05$). These main effects were moderated by a significant domain by condition interaction, $F(6, 342) = 2.46$, $p = .024$, $\eta_p^2 = 0.04$. A follow-up one-way ANOVA examined whether there were condition differences for each of the domains. The results showed that although children in the theory, nontheory, and control conditions performed similarly on the vegetables (M 's = 85%, 82%, 77%, SD 's = 20%, 22%, 34%) and physical activities (M 's = 77%, 81%, 85%, SD 's = 28%, 21%, 22%), there was a condition difference for the domain of nonphysical activities, $F(2, 117) = 4.38$, $p = .015$. Children in the theory condition ($M = 61\%$, $SD = 33\%$) were significantly more accurate than children in both the nontheory ($M = 41\%$, $SD = 38\%$) and control ($M = 40\%$, $SD = 35\%$) conditions on the nonphysical activities, Tukey post-hocs, p 's = .038, .025. There was also a trend towards a significant difference between the theory, nontheory, and control conditions on the domain of high-fat foods, (M 's = 58%, 43%, 45%, SD 's = 31%, 33%, 35%, respectively), $p = .08$. In sum, although the results from the selection questions did not reveal a significant condition by time interaction, the domain by condition interaction revealed that children in theory condition performed better than children in the other conditions on nonphysical activities, and almost high-fat foods.

Follow-up

To further examine the extent to which children within each condition maintained their level of understanding over time, the post-test was administered again to children at their preschools approximately five months ($M = 160$ days) after the initial post-test. There was not a significant difference in months between the conditions ($M_{\text{theory}} = 173$ days, $M_{\text{nontheory}} = 146$, $M_{\text{control}} = 162$ days), $F(2, 45) = 2.26$, $p = 0.11$. During those months, none of the children received reviews of the lessons or refresher information. Follow-up data using the post-test measure were collected from 48 (80%) of the original 60 children in the study. The other 12 children were no longer enrolled in the preschools and so were unavailable to continue participating in this research. Thus, follow-up data were collected from 16 children in the theory (7 females, 9 males, $M_{\text{age}} = 4.89$, range = 4.32 – 5.36), 17 children in the nontheory (8 females, 9 males $M_{\text{age}} = 4.95$, range = 4.35 – 5.37) and 15 children in the control (8 females, 7 males, $M_{\text{age}} = 5.02$, range = 4.68–5.39) conditions.

Using the pre-test and follow-up data from the subset of children who participated in the follow-up, Bonferroni corrected paired sample t-tests were conducted on the general classification, specific classification, and selection questions for each of the domains. Please see Table 4 for the pre-test and follow-up data for this subset of children. The results indicate that for the general questions, children in the theory condition performed significantly better at follow-up than at pre-test on high-fat foods and nonphysical activities, t 's (15) > 2.0, p 's = .002, .041. There were no significant differences in the nontheory and control conditions from pre-test to follow-up.

Children's justifications for their responses to the general classification questions were also coded and scored as in the post-test (92.7% inter-rater agreement, Cohen's Kappa Coefficient of 0.98). There were a total of 195 explanations at follow-up, with some children providing more than one explanation per general classification question. There were also a total of 192 explanations at pre-test for the subset of children who participated in the follow-up. A series of Bonferroni corrected paired sample t-tests were conducted to compare performance at pre-test versus follow-up. The results showed that there was a significant increase in the prevalence of correct explanations in the theory condition from pre-test to follow-up (M 's = 36%, 61%, SD 's = 30%, 27%), $t(15) = 2.6$, $p = .01$. However, there was

not a significant difference in the prevalence of correct explanations from pre-test to follow-up for the nontheory (M 's = 42%, 53%, SD 's = 27%, 33%) and control (M 's = 43%, 55%, SD 's = 33%, 33%) conditions.

As for the specific classification and selection questions, there were no significant differences from pre-test to follow-up for each of the conditions.

Overall, these results suggest that although children in the theory condition did not have an advantage over their counterparts on the specific and selection questions at follow-up, these children did show an increase in general understanding of high-fat foods and a trend towards an increase in general understanding of nonphysical activities from pre-test to follow-up.

Discussion

In this study we investigated the effectiveness of applying a theory-based approach to teaching preschool-aged children about how to have a healthy body. Overall, the findings from this study highlight that a theory-based approach is an effective means to teaching children, as young as 4 years of age, about health.

In the following section, we summarize the specific findings for the three types of questions that children were asked during testing as they relate to our predictions. First, the general classification questions were designed to tap into children's broad knowledge and understanding of health. The results revealed a trend towards a significant interaction between condition and time. Regarding effect size, this interaction accounted for 4% of the total variance of the dependent variable. As predicted, children in the theory condition, relative to children in the other conditions, showed the largest improvement from pre- to post-test, including improvements in the ability to provide accurate, health-related explanations. However, children's performance at post-test provided only partial support for our predictions; children in the theory condition outperformed children in the control condition, but not children in the nontheory condition.

The lack of difference between children in the theory and nontheory conditions at post-test hints at the possibility that children in the nontheory condition may still have been able to glean some general information from their lesson. These findings suggest that perhaps receiving any health-based information, including directives (even if they are not causally-related or coherent) may be somewhat helpful in gaining a broad concept of health. Recall that in both the theory and nontheory lessons, children heard many directives in the form of "should" statements (e.g., "You should eat vegetables everyday"), which may have heightened children's attention to the importance of the healthy/unhealthy distinction. However, until further studies are conducted examining more carefully how learning can be potentially improved through either lesson, such a conclusion about the impact of receiving any form of health-based information should be taken with caution. Also, recall that in the present study, the amount of information that children in the nontheory condition gleaned from the directives was not necessarily enough to distinguish them from children in the two other conditions. It was only children in the theory condition who showed a significant improvement from pre- to post-test on the general questions, and showed a marked increase in correct explanations, suggesting that the causally-related and coherent aspects of the theory-based lessons contributed above and beyond the directives.

Next, turning to the specific classification questions, these questions were designed to tap into children's detailed knowledge and understanding of health. The results revealed a significant condition by time interaction. Regarding effect size, this interaction accounted for 5% of the total variance of the dependent variable. As predicted, children in the theory condition, relative to children in the other conditions, showed the greatest gains from pre- to

post-test. Also, as predicted, children in the theory condition outperformed children in the two other conditions at post-test. The findings suggest that for children in the theory condition, the coherent and causally-related explanations served as the basis for a solid framework or peg for children to hang specific information about health. Such a framework was not available to children in the nontheory and control conditions, perhaps making it more difficult for these children to relate and integrate detailed information.

Finally, the selection questions were designed to explore children's ability to apply their understanding in a practical manner. The results did not reveal a significant condition by time interaction, and only provided partial support for our predictions. However, any support for our predictions from the selection questions is a noteworthy finding given the challenging nature of these questions. Recall that children were asked whether they would eat a food or engage in an activity in order to have a healthy body. In order for children to do well on the selection questions, children needed to put aside any unique personal preferences or aversions they may have had for or against the foods and activities tested in this study. Children's post-test performance in the theory condition, especially on the nonphysical activities and high-fat foods, suggests that the explanations from the theory-based lesson gave children a compelling enough reason to make choices that were consistent with the information they learned in their lesson. Future research should also examine the extent to which children's learning in the theory-based condition directly influences children's health-related behaviors, including eating and physical activity. Such an examination would involve measuring children's consumption of healthy foods and engagement in physical activity before and after receiving a theory-based lesson about health.

A caveat should also be made regarding the large effects of domain found in this study, which accounted 33%, 23%, and 31% of the total variability in performance on the general, classification, and selection questions, respectively. For all of the question types, children's performance on the high-fat foods and nonphysical activities was extremely informative regarding the effect of the theory-based lesson. At pre-test, children performed poorly on high-fat foods and nonphysical activities, indicating very little knowledge and understanding of the concept of "unhealthy." In contrast, at pre-test, children in all of the conditions performed relatively well on vegetables and physical activities, indicating knowledge and understanding of the concept of "healthy." Thus, if the theory-based lesson was efficacious, then its effects should be best seen with the domains of high-fat foods and nonphysical activities where there was ample room for potential improvement from pre- to post-test. As would be expected, overall, the results revealed that only children in the theory condition showed improvements from pre- to post-test on high-fat foods and nonphysical activities. There were absolutely no improvements from pre-to post-test in the nontheory and control groups' performance on these domains. Also, as would be expected, children in all three conditions maintained their high level of performance on vegetables and physical activities from pre- to post-test, which ultimately serves as a good point of comparison to the other domains. Taken together, these results highlight how a coherent, causally-related lesson about health can be especially effective when applied to domains that children lack robust knowledge and understanding.

A caveat should also be made regarding the results for the follow-up. Recall that during the five month lag between the post-test and follow-up, children did not receive reviews of the lessons or refresher information. Therefore, given this five month lag, the gains in performance on the general questions in the theory group are quite impressive from pre-test to follow-up. Recall that children in the theory group showed a significant increase in general understanding of high-fat foods and a trend towards an increase in general understanding of nonphysical activities from pre-test to follow-up. In addition, only children

in the theory group showed a significant increase in the prevalence of correct explanations in the theory condition from pre-test to follow-up.

Overall, the findings from the three types of questions examined in this study suggest that the pay-off of a theory-based lesson is an increase in both children's knowledge as well as their abstract understanding of the relationship between food/activity and health. The benefit of a theory-based lesson on children's knowledge was evident in children's performance on the general classification (e.g., classifying vegetables as a "healthy food"), specific classification (e.g., classifying carrots as a "healthy food"), and selection questions (e.g., selecting carrots as a food one would eat to have a healthy body). Also, the benefit of a theory-based lesson on children's abstract understanding was evident in children's ability to provide correct health-related explanations for their general classifications (e.g., "vegetables are healthy because they have a lot of vitamins inside"). Recall that children in the theory group had a 16% and 25% increase in correct explanations from pre- to post-test and from pre-test to follow-up, respectively. Of course as discussed in the Methods section, the causal explanations that were offered in the theory-based lesson in this study were pitched at a level that was most appropriate for 4-year-olds. Now that we know that young children can benefit from basic level causal explanations, future research could attempt to examine the effectiveness of explanations that vary in explanatory depth (see Keil, 2006; Keil & Wilson, 2000).

In future research, it will also be crucial to systematically collect fidelity of implementation information to ensure that the lessons are delivered to children as designed in this study. A concern that could be raised about this study is that researcher two, who delivered the lessons to all of the children, could have been biased towards better instruction in the theory condition compared to the other conditions. Although we did not record researcher two's delivery of each lesson, a third researcher did make periodic observations to ensure that the exact wording of the lessons from the Appendix was read to children. These observations did not reveal any apparent biases in the instruction.

The ability for children in the theory condition to benefit from a theory-based lesson highlights how children's understanding of health is open to change at an early age (see also Carey, 1985; 2000 and Gopnik, 2000 for further discussion regarding conceptual change in scientific reasoning). This openness creates an opportunity to build on children's background knowledge and to teach them about a very difficult to grasp biological concept with the aid of a theory at a young age. Future research should examine how children integrate and maintain their knowledge over different periods of time, in addition to the five month period that we investigated in the current study. To provide a fine-grained analysis of the effects of a theory-based lesson, future studies could repeatedly measure children's performance within a certain window of time, and perhaps include "refresher" lessons to help remind children of the information they have learned. It would also be beneficial to examine in future research the underlying mechanisms that contribute to the effectiveness of the theory-based lesson, both in the short- and long-term. For example, future research could examine what specific cognitive abilities (e.g., memory, attention, reasoning) need to be in place in order for preschoolers to fully benefit from this type of lesson. Such prerequisites could also potentially be examined in toddlers and infants (see Gopnik & Shultz, 2004 for discussion).

A major contribution of this study is that it highlights the importance of theories in concept acquisition outside of the laboratory, adding to the small body of research that examines the role of theories in children's learning about real-world concepts (Au et al., 2008, Au & Romo, 1996; Solomon & Johnson, 2000; Zamora et al., 2006). The study of the concept of health is of great significance because of the rate of childhood obesity in the U.S. is

increasing exponentially (CDC, 2006) and overweight children are at a greater risk for developing numerous health problems throughout their lifetime (DHHS, 2001). To our knowledge, the theory-based lesson developed and tested in this study is the first attempt within the conceptual development literature at applying the theory-theory to teaching young children about health before entering elementary school. As described in the Introduction, health-related teaching materials that specifically target young children typically do not couch information into a theory, but rather offer information in the form of games and songs (e.g., Levin et al., 2002; Sesame Street, 2006). The findings from the present study show that young children can and do benefit from health-related information presented within the context of a theory, which can then serve as a foundation for further learning about health in elementary school and beyond (see Keil, 2008; Keil & Silberstein, 1996; and, Zimmerman, 2007, for a discussion on the implications of theories on science education for older children). Thus, future research may want to consider creating theory-based lessons for preschool-aged children that focus on other content areas including ones that have already been studied with older children such as inheritance (Solomon & Johnson, 2000), AIDS (Au & Romo, 1996) and cold/flu transmission (Au et al., 2008). In creating these lessons for preschool-aged children, as discussed in the Introduction, it would be important to incorporate causal explanations that are comprehensible to young children, so that children's learning can be fairly measured.

In conclusion, the current study suggests the effectiveness of providing young children with coherent and causally-related information about the concept of health. An important question that arises from this study is what was the active ingredient in the theory-based lesson? Thus, a remaining question is what aspects of the theory-based lesson versus the nontheory-based lesson were effective. Was the theory-based lesson effective because of the coherence or causality component? Since the theory-based lesson was composed of both of these two intimately linked parts, it is difficult to determine if one component contributed more to the lesson's effectiveness. For this study, as a starting point, it was important to first establish the effectiveness of the entire lesson or whole package because both components are critical to a theory-based approach to teaching and learning. To clarify this issue, it would be necessary to examine each component individually to see how each contributes to and facilitates children's learning. In future studies, the theory-based lesson could be tested against a different version of itself (e.g., testing a coherent version of the theory-based lesson against an incoherent version or scrambled version of the lesson). By examining and testing the components or "ingredients" that comprise the theory-based lesson, we can further develop and provide children with an informative and interesting (nutritious and delicious) "recipe" for understanding health-related concepts.

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Appendix The Theory-based and Nontheory-based Lessons

The theory-based lesson

1. Introduction

- “We are going to learn today about how to have a healthy body. I’m going to point to my body. Now can you point to your body? Having a healthy body means your body has energy and strength to grow, learn, and play.

2. Healthy Foods

- To have a healthy body, you need to feed it right. Healthy foods give your body what it needs because they have many vitamins. Vitamins are inside of healthy foods. Look! This is lettuce. Lettuce is a vegetable and a healthy food because has vitamins inside. Let’s look inside! These are the vitamins, see? Can you point to the vitamins? Would you like to see the lettuce? Vitamins help you grow, give you long-lasting energy, and keep you from getting sick.
- There are many healthy foods you should eat a lot of. For example, vegetables are healthy foods because they have many vitamins inside of them. You should eat vegetables every day.
- Examples of vegetables that have many vitamins inside are beans, celery, carrots, broccoli, and corn. These foods help you grow, give you long-lasting energy, and keep you from getting sick.

3. Unhealthy Foods

- Remember, to have a healthy body you need to feed it right. Foods that are not healthy do not give your body what it needs because they do not have many vitamins. Foods that are not healthy do not have vitamins inside. Look! This is a cookie. Cookies are a high-fat food and are not healthy because they do not have vitamins inside. Let’s look inside. There are no vitamins inside, see? Would you like to see the cookie? High-fat foods do not have vitamins that help you grow, do not give you long-lasting energy, and do not keep you from getting sick.
- There are many foods that are not healthy that you should not eat a lot of. For example, foods that are high in fat are not healthy foods because they do not have many vitamins inside of them. You should not eat foods with a lot of fat every day.
- Examples of foods that are high in fat and do not have many vitamins inside are potato chips, bacon, cake, doughnuts, and fudge. These foods do not help you grow, do not give you long-lasting energy, and do not keep you from getting sick.

4. Physical/nonphysical Activities

- To have a healthy body, you also need to treat it right by exercising. Exercise is anything that gets your body & muscles moving, your heart working, and keeps your body healthy and fit. Look! This is a human body. Let’s look inside! There is a heart, bones, and muscles. Can you point to the heart? Can you point to the bones? Can you point to the muscles? Would you like to see the body?

- Exercise is healthy for you because it makes your bones and muscles strong, makes your heart beat faster, gives you energy, and keeps you from getting sick. You should exercise every day.
- Examples of exercises that make your bones and muscles strong, make your heart beat faster, give you energy, and keep you from getting sick are playing soccer, canoeing, playing on the jungle gym, playing tag, and riding a bike. But, some things we do are NOT exercise. Let me show you. Watching TV, reading a comic book, typing on the computer, writing a letter, and watching a movie are not exercises because they do not make your bones and muscles strong, do not make your heart beat faster, do not give you energy, and do not keep you from getting sick.

5. Conclusion

- Today we learned about how to have a healthy body. We learned about healthy foods like vegetables that have many vitamins inside that help you grow, give you long-lasting energy, and keep you from getting sick. We learned about foods that are not healthy like foods that are high in fat that do not have many vitamins inside. We also learned about exercise that makes your bones and muscles strong, makes your heart beat faster, gives you energy, and keeps you from getting sick. You should eat vegetables and exercise every day.”

The nontheory-based lesson

Note: There were five learning objectives for the lessons: 1) Introduction; 2) Healthy Foods; 3) Unhealthy Foods; 4) Physical/nonphysical Activities; 5) Conclusion. There are also three main points within each of the three core learning objectives (Healthy Foods, Unhealthy Foods, and Physical/nonphysical Activities).

For the nontheory-based lesson, the order of the points within each of the core learning objectives has been changed to last point, 1st point, 2nd point.

Additionally, within each point, the ordering of the sentences has been changed depending on the number of sentences. For points with 2 sentences: 2nd sentence, 1st sentence. For points with 3 sentences: 3rd sentence, 1st sentence, 2nd sentence.

1. Introduction

- “We are going to learn today about different things. I’m going to point to my body. Now can you point to your body?”

2. Healthy Foods

- Examples of vegetables are beans, celery, carrots, broccoli, and corn.
- Look! This is lettuce. Lettuce is a vegetable and a healthy food. Let’s look inside! Can you point to the inside? Would you like to see the lettuce? Healthy foods give your body what it needs.
- You should eat vegetables every day. There are many healthy foods you should eat a lot of. For example, vegetables are healthy foods.

3. Unhealthy Foods

- Examples of foods that are high in fat are potato chips, bacon, cake, doughnuts, and fudge.

- Look! This is a cookie. Cookies are a high fat food and they are not healthy. Let's look inside! Can you point to the inside? Would you like to see the cookie? Foods that are not healthy do not give your body what it needs.
- You should not eat foods with a lot of fat every day. There are many foods that are not healthy that you should not eat a lot of. For example, foods that are high in fat are not healthy foods.

4. Physical/nonphysical Activities

- But, some things we do are NOT exercise. Let me show you. Watching TV, reading a comic book, typing on the computer, writing a letter, and watching a movie are not exercises. Examples of exercises are playing soccer, canoeing, playing on the jungle gym, playing tag, and riding a bike.
- Look! This is a human body. Let's look inside! Can you point to the inside? Would you like to see the body? Exercise is anything that gets your body & muscles moving, your heart working, and keeps your body healthy and fit.
- You should exercise every day. Exercise is healthy for you.

5. Conclusion

- You should eat vegetables and exercise every day. Today we learned about different things. We learned about healthy foods like vegetables, foods that are not healthy and high in fat, and exercise."

Table 1

Overall mean, standard deviation, and range for participants' age, height, weight, body mass index, and body mass index percentile

	Mean	Standard Deviation	Range
Age	4.52	0.29	3.88-4.96
Height in feet, inches	3'6"	0.2"	3'1"-3'9"
Weight in pounds	39.66	4.69	30-50
BMI	15.38	1.26	13-18.3
BMI percentile	48.51	29.42	1-97

Table 2

Target items for the specific classification and selection questions

Vegetables: beans, celery, carrots, broccoli, corn, * red pepper
High fat foods: potato chips, bacon, cake, doughnuts, fudge, * cheetos
Physical Activities: soccer, canoeing, playing on the jungle gym, playing tag, riding a bike, * running
Nonphysical Activities: watching television, reading a comic book, typing on the computer, writing a letter, watching a movie, * playing a video game

Note.

* novel items not taught in the lessons

Table 3

Mean percent (standard deviation) accuracy on the pre- and post-tests for each condition by question type

Question Type	Pre-test	Post-test
General classification		
Total		
Theory	61 (24)	83 (20)
Nontheory	66 (19)	73 (28)
Control	65 (24)	63 (21)
Vegetables		
Theory	90 (30)	100 (0)
Nontheory	85 (36)	85 (36)
Control	100 (0)	95 (22)
High-fat foods		
Theory	30 (47)	75 (44)
Nontheory	55 (51)	65 (49)
Control	35 (49)	35 (49)
Physical activities		
Theory	95 (22)	85 (37)
Nontheory	95 (22)	90 (31)
Control	90 (31)	80 (91)
Nonphysical activities		
Theory	30 (47)	70 (47)
Nontheory	30 (47)	50 (51)
Control	35 (49)	40 (50)
Specific classification		
Total		
Theory	68 (13)	82 (16)
Nontheory	68 (19)	64 (19)
Control	66 (20)	64 (20)
Vegetables		
Theory	86 (16)	87 (18)
Nontheory	87 (18)	78 (27)
Control	76 (26)	70 (32)
High-fat foods		
Theory	49 (32)	78 (29)
Nontheory	45 (35)	47 (32)
Control	54 (30)	53 (34)
Physical activities		
Theory	76 (24)	88 (24)
Nontheory	81 (23)	76 (30)
Control	83 (21)	76(18)
Nonphysical activities		

Question Type	Pre-test	Post-test
Theory	61 (33)	77 (27)
Nontheory	58 (38)	55 (39)
Control	48 (38)	59 (33)
Selection		
Total		
Theory	64 (28)	77 (27)
Nontheory	60 (29)	64 (29)
Control	60 (30)	62 (21)
Vegetables		
Theory	83 (24)	87 (17)
Nontheory	79 (25)	85 (19)
Control	71 (32)	76 (38)
High-fat foods		
Theory	44 (27)	73 (30)
Nontheory	41 (31)	45 (36)
Control	41 (35)	49 (36)
Physical activities		
Theory	79 (26)	74 (30)
Nontheory	81 (20)	82 (22)
Control	88 (17)	80 (26)
Nonphysical activities		
Theory	51 (34)	72 (30)
Nontheory	39 (39)	43 (39)
Control	38 (34)	44 (36)

Table 4

Mean percent (standard deviation) accuracy on the pre- and follow-up tests for each condition by question type for the subset of children who participated in the follow-up

Question Type	Pre-test	Follow-up
General classification		
Total		
Theory	55 (21)	75 (20)
Nontheory	69 (17)	72 (28)
Control	68 (26)	68 (22)
Vegetables		
Theory	88 (34)	94 (25)
Nontheory	88 (33)	94 (24)
Control	100 (0)	93 (26)
High-fat foods		
Theory	25 (45)	75 (44)
Nontheory	65 (49)	65 (49)
Control	40 (51)	47 (52)
Physical activities		
Theory	94 (25)	94 (25)
Nontheory	94 (24)	88 (33)
Control	87 (35)	93 (26)
Nonphysical activities		
Theory	13 (34)	38 (50)
Nontheory	29 (47)	41 (51)
Control	47 (52)	40 (51)
Specific classification		
Total		
Theory	68 (13)	77 (16)
Nontheory	68 (18)	71 (23)
Control	68 (23)	70 (18)
Vegetables		
Theory	83 (17)	84 (25)
Nontheory	86 (17)	78 (27)
Control	77 (27)	76 (29)
High-fat foods		
Theory	51 (31)	67 (32)
Nontheory	47 (37)	56 (37)
Control	57 (34)	66 (26)
Physical activities		
Theory	72 (26)	84 (17)
Nontheory	82 (19)	85 (18)
Control	79 (24)	82 (17)

Question Type	Pre-test	Follow-up
Nonphysical activities		
Theory	59 (30)	72 (27)
Nontheory	64 (35)	63 (38)
Control	51 (34)	56 (35)
Selection		
Total		
Theory	65 (13)	70 (16)
Nontheory	60 (16)	65 (22)
Control	60 (17)	69 (16)
Vegetables		
Theory	80 (25)	81 (22)
Nontheory	79 (25)	73 (32)
Control	68 (31)	79 (23)
High-fat foods		
Theory	50 (24)	56 (37)
Nontheory	42 (34)	47 (37)
Control	31 (30)	59 (29)
Physical activities		
Theory	80 (21)	88 (18)
Nontheory	79 (21)	88 (15)
Control	91 (16)	84 (18)
Nonphysical activities		
Theory	52 (34)	54 (33)
Nontheory	47 (39)	54 (40)
Control	31 (28)	53 (38)