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The Development of Preschoolers' Living Kinds Concept: A Longitudinal Study

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by

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DISSERTATION

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DEDICATION

I dedicate my dissertation to my Dad, Dennis G. Margett. Thank you for all the encouragement.

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ABSTRACT

The overarching goal of this study was to examine the structural organization of preschoolers' living kinds concept and the nature of developmental change in that concept from roughly 3.5- to 4.5-years-old. Specifically, this study was designed to assess whether preschoolers' living kind conceptual development involves progressive elaboration of an existing biologically based skeletal framework or conceptual reorganization. Unlike previous studies, this study employed a longitudinal design, an extensive stimulus set, alternate indices of understanding, and complementary statistical analyses. Thirty-five 3.0- to 3.5-year-olds participated in four testing sessions over the course of one year; each testing session included three phases that involved four object classes: plants, animals, mobile and immobile objects. The phases involved statements participants generated relative to the four classes, what biological and psychological properties they attributed to the classes, their assignment of "alive" to the classes, and their answers to open-ended questions about living kinds. By examining preschoolers' responding in the different testing contexts over time and examining the relationship of responding across testing context and across the domains of biological and

psychological understanding, this study was able to assess the structure of preschoolers' living kinds concept and whether that structure is organizationally stable or labile during the preschool period. Results suggest that certain aspects of a mature, biologically based framework are in place early in the preschool period while other aspects have not yet been developmentally constructed and that the nature of the developmental change that takes place between roughly 3.5 to 4.5 years involves *both* progressive elaboration of an existing biologically based skeletal framework and organizational restructuring.

Table of Contents

Introduction

The distinction between living things (such as, plants and animals) and person-made things (such as, tools and toys) is essential for our understanding of the world. If we know something is alive, we can assume that it engages in biological processes, such as growing and needing nutrients. If we know something is person-made, we can assume that it was designed to serve a function. The question of how a living kinds concept develops in early childhood has been extensively investigated since Piaget's (1929) seminal work, *The Child's Conception of the World*, particularly within the last 30 years. Despite considerable research in this area, however, a basic developmental question remains open to debate: how is preschoolers' conceptualization of living and nonliving things structured, and to what extent does this structural organization undergo transformative changes during the preschool period? Continued debate in this literature over the very nature of preschoolers' living kinds understanding stems from both theoretical considerations and methodological limitations.

Theoretical Considerations

Two distinct theoretical accounts currently inform the question of what constitutes the nature of children's living kinds understanding and its development. By one account, preschoolers' living kinds conceptualization is qualitatively different from that of adults, suggesting that a developmental reorganization must occur in order for children's living kinds conceptualization to be organized along the same lines as adults. As the foundation for this account, Piaget (1929) argued that young children initially conflate livingness with motion, resulting in their over extending the label of alive to nonliving entities that display motion (i.e., bicycles) and their under extending the label of alive to living entities that do not display motion (i.e., plants). For Piaget, not until the concrete operational period and beyond (i.e., well into the later portions of middle childhood) has a child's conceptualization undergone sufficient reorganization such that the child no longer conflates motion with life but has a mature understanding of living kinds as distinct from nonliving kinds.

Like Piaget, Carey (1985) has argued for a qualitative reorganization taking place during childhood in living kinds conceptualization; but unlike Piaget, Carey has targeted a transition in thinking from preschoolers' incorrect reliance on naive psychology to school aged children's correct reliance on naïve biology for judging livingness. For Carey, preschoolers conflate livingness with psychological agency and frame life in uniquely psychological rather than broadly biological terms; only by late childhood does this conceptualization undergo thorough reorganization to more adequately reflect the biologically oriented living kinds understanding of the adult.

An alternative theoretical account to both Piaget and Carey argues against the idea of qualitative reorganization in children's living kinds understanding, promoting instead a core competence view of living kinds conceptual development. For Keil (1994; Keil, Levin, Richman, & Gutheil, 1999) and others (e.g., Greif, Kemler Nelson, Keil, & Gutierrez, 2006; Inagaki & Hatano, 2002; Leddon, Waxman, & Medin, 2008; Waxman, 2005), the basic biological framework for differentiating living and nonliving kinds is already evident in the preschool period and, though skeletal in nature, provides the young child with an abstract set of regularities for organizing the living world (Erickson, Keil, & Lockhart, 2010). By this approach, conceptual development proceeds not by means of major shifts in the structural organization of the living kinds concept, but by means of a progressive elaboration of a framework that is similar in organization yet impoverished when compared to that of adults. (e.g., Inagaki & Hatano, 2002; Leddon et al., 2008; Keil, 1992; Waxman, 2005).

Over the last two decades, broad consensus has emerged in favor of the core competence approach over the qualitative reorganization approach to preschoolers' living kinds conceptualization (Inagaki & Hatano, 2006). Research investigating preschoolers' understanding of the commonalities among living things has demonstrated that preschoolers clearly group living things with respect to biological properties. Specifically, they correctly assert that both animals and plants grow, (Inagaki & Hatano, 1996; Rosengren, Gelman, Kalish & McCormick, 1991) and, when damaged, can recover through regrowth (Backscheider, Shatz & Gelman, 1993); they attribute the need for nourishment to plants and animals (Inagaki & Hatano, 1996, 2002); and they apply the biological property of death to plants and animals, but not to person-made objects (Nguyen & Gelman, 2002; Waxman, 2005). Research investigating preschoolers' understanding of how living entities differ from person-made objects has demonstrated that preschoolers also conceptually distinguish living kinds from nonliving objects. Children as young as 3-years-old recognize that properties of biological kinds enhance survival, whereas properties of person-made objects largely function to benefit people (Keil, 1992, 1994); these children furthermore privilege functional information when encountering novel objects and biological classification information when encountering novel animals (Greif et al., 2006). Brandone and Gelman (2013) have argued that by 5-years-old, children are making principled, theory-laden domain distinctions between animals and objects.

Nonetheless, this understanding of commonalities among and differences between living and nonliving kinds does not translate into reliable integration of plants with animals or classification of plants as alive (e.g., Carey, 1985; Meunier & Cordier 2004; Richards & Siegler, 1984). Children have difficulty with the concept "alive," and when asked to categorize objects on the basis of "alive," young children systematically exclude plants (Carey, 1985; Opfer &

Siegler, 2004; Waxman, 2005). Even first year high school students rate animals as alive at much higher rates than plants (Yorek, Sahin & Aydin, 2009).

From Piaget's (1929) and Carey's (1985) vantage point of qualitative reorganization in the development of children's living kinds conceptualization, the fact that young children have difficulty correctly applying the concept "alive"—evidenced by their seldom judging plants as alive and often judging mobile person-made objects as living—highlights the qualitative difference between preschoolers' and adults' living kinds conceptualization. Such results demonstrate that children understand the living world in fundamentally different terms than adults and that it is not until the child's conceptualization has undergone sufficient reorganization that children will reliably classify both plants and animals as living things.

For those who favor the core competence approach (e.g., Anggoro, Waxman & Medin, 2008; Leddon et al., 2008; Opfer & Gelman, 2001; Opfer & Siegler, 2004), the fact that young children have difficulty with classifying objects as "alive" demonstrates that the concept of "alive" is simply a detail of the skeletal biological framework that has not yet been worked-out or elaborated for the preschooler. Opfer and colleagues (Opfer & Gelman, 2001; Opfer & Siegler, 2004), for example, have argued that young children's failure to recognize plants as animate—few preschoolers realize that plants possess the capacity for movement and do so to sustain life (e.g., growing towards the sun)—plays a role in their difficulty unifying plants and animals into a living kinds concept, because they lack the understanding that plants as well as animals move in goal-directed ways. Therefore, until children work out the detail that plants engage in goal-directed movements, which Opfer and Siegler (2004) have argued does not occur until 7 years of age, children will not classify plants as living.

Similarly, Waxman and colleagues (Leddon et al., 2008; Anggoro et al., 2008) have explained the problems that children have integrating plants with animals and considering plants alive as primarily due to linguistic issues. For Waxman and colleagues, the word “animal” in the English language has at least two distinct conceptual meanings and, as such, poses a unique interpretive challenge for young children learning English, resulting in their not classifying plants as things that are alive. In one meaning, “animal” includes humans and animals (animal_inclusive); this meaning subsumes the other meaning of “animal” which refers to animals only (animal_exclusive). Given that words serve as catalysts in object categorization and that children prefer to assign different words to different categories (Waxman & Lidz, 2006), in order to avoid mapping the same word (“animal”) on to the two hierarchically nested concepts, children erroneously map the word “alive” onto the concept animal_inclusive and classify the subordinate concepts “human” and “animal_exclusive” as things which are “alive” (See Figure 1). Waxman and colleagues (Leddon et al. 2008; Anggoro et al. 2008) assert that because both humans and animals are animate things, children essentially equate the concept “alive” with the concept “animate” (things which self-initiate and sustain movement). Because plants are not overtly observably animate things, children do not classify them as things that are “alive.” Therefore, when researchers investigate young children’s living kinds understanding and use the word “alive,” as is often done, it masks children’s true understanding. Indeed, Waxman and colleague’s (Leddon et al., 2008) research comparing English-speaking children’s responding when the word “alive” is used and when the word “living thing” is used, showed that 6- and 7-year-old children attribute life status to plants at higher rates when the word “living thing” is used rather than the word “alive.” Furthermore, Waxman and colleague’s cross linguistic study (Anggoro et al., 2008), which compared English speaking children and

Indonesian speaking children—because in the Indonesian language "animal" only refers to the concept of animal (animal_exclusive)—found that that Indonesian-speaking 9-year-old children showed more precocious application of "alive" by grouping plants with animals and humans as living kinds at a higher rate than their English speaking counterparts.

Is the classification of objects as "alive" an integral part of a core living kinds concept, or is it a more subsidiary detail? Do problems with the concept of "alive" reflect fundamental conceptual differences in younger children, or are they just reflective of minor content or processing issues? Although these theoretical considerations may never be fully adjudicated at an empirical level, methodological limitations in the literature further hamper efforts to answer even the most basic questions concerning children's living kinds conceptualization and the nature of its development.

Methodological Limitations

One problem with much of the existing research on children's living kinds conceptualization is that although it is extensive and thorough in its methodological precision, it is limited in its integrative scope and therefore limited in the conclusions that can be drawn. First, individual studies routinely isolate certain subclasses of the living-nonliving kinds distinction. For example, Brandone and Gelman (2013) employed animals and artifacts but not plants. Greif et al. (2006) employed animals and inanimate objects but not plants and animate artifacts. Jipson and Gelman (2007) employed animals, animate and inanimate objects but not plants, and Opfer and colleagues (Opfer & Gelman, 2001; Opfer & Siegler, 2004) focused on plants and animals but excluded from consideration person-made objects, both mobile and immobile. Second, individual studies isolate certain biological processes to the exclusion of others. For example, Backscheider et al. (1993) focused on children's understanding of regrowth while Nguyen and Gelman (2002) focused on children's understanding of death, and Waxman and colleagues (Leddon et al., 2008; Anggoro et al., 2008) focused on children's understanding of alive. Third, individual studies often employ only one methodological index to assess children's living kinds understanding,relying either on children's responses to questions posed by the experimenter (e.g., Backscheider et al., 1993; Nguyen & Gelman, 2002; Opfer & Gelman, 2001; Opfer & Siegler, 2004) or on the questions / statements children generate about living and nonliving kinds (e.g. Brandone & Gelman, 2013; Greif et al., 2006). Fourth, nearly all research examining children's living kinds concept has employed a cross-sectional design and, therefore, cannot adequately address the issue of the nature of developmental change over time. Finally, too often individual studies collapse across ages in the preschool period (e.g., Greif et al., 2006; Jipson & Gelman, 2007; Kemler Nelson, Egan, & Holt, 2001), further limiting the conclusions that can be drawn regarding the nature of developmental change during the preschool years. Without looking at children's living kinds understanding (1) across a broad spectrum of living and nonliving classes, (2) across a broad spectrum of biological and psychological process, (3) across testing contexts, and (4) across time, all within the same sample, the conclusions regarding the nature of preschooler's living kinds understanding and its development are limited.

To overcome some of these limitations, my previous work (Margett & Witherington, 2011) investigated preschoolers' living kinds conceptualization by employing an extensive stimulus set and alternate indices of understanding. Preschoolers completed three testing phases involving four object classes: plants, animals, mobile and immobile objects. The phases involved inquiries preschoolers' generated, what biological properties they attributed and their assignment of "alive" to the four classes. The broad spectrum of class types and alternate methodologies revealed both competence and gaps in preschoolers' living kinds conceptualization. Preschoolers in each of the three phases largely distinguished between the animals and immobile objects; however, when representatives of the nonliving class that involved clearly observable movement (mobile objects) and representatives of the living class that lacked clearly observable movement (plants) were considered, preschoolers' clear understanding of the distinction between living and nonliving kinds broke down to reveal some measure of confusion. Specifically, preschoolers (1) generated more functional questions/statements (q/s) for immobile objects and more biological q/s for mobile objects; (2) attributed the need for food to the animal class at a higher rate relative to the plant class; and (3) classified animals as living at a higher rate than plants and classified immobile objects as nonliving at a higher rate than mobile objects.

My previous work (Margett & Witherington, 2011) also looked at preschoolers' living kinds concept by examining their responding across methodological indices. I found no evidence that preschoolers' concept of alive was related to the type of q/s they generated in response to different classes of objects. Neither did I find evidence that preschoolers' concept of alive was associated with their conceptualization of biological properties like growth, need for water and food. However, I did find some evidence that preschoolers' concept of alive and their conceptualization of biological properties across object kinds (living vs. nonliving) is related. For example, the more likely preschoolers were to say animals were alive, the less likely they were to say mobile or immobile objects grow, need water or food, and the less likely preschoolers were to say mobile or immobile objects were alive, the more likely they were to say animals and plants grow. Furthermore, preschoolers' conceptualization of biological properties and their finding functional and/or biological information conceptually salient were related. For example, the less likely preschoolers were to say the immobile objects grow, the less likely they were to make biological q/s and the more likely they were to make functional q/s about that class. In addition, the more likely preschoolers were to say animals grow, the more likely they were to make functional q/s about the mobile objects. Lastly, the less likely preschoolers were to say mobile objects need food, the more likely they were to make functional q/s and the less likely they were to make biological q/s about the immobile objects.

The above results provide some evidence that preschoolers' responding across phases is related, suggesting that preschoolers are able to employ a biologically appropriate abstract set of regularities for differentiating and organizing the living and nonliving world, as Erickson et al. (2010), Keil (1994; Keil et al., 1999) and Waxman (2005) have outlined. While my previous study (Margett & Witherington, 2011) added to understanding of the nature of preschoolers' living kinds conceptualization by employing a broad set of stimuli and alternate indices of preschoolers' comprehension, the results are really only relevant to the characterization of the typical 4-year-old's living kinds conception, as I collapsed across the 3- to 5-year age range, treating the 3- to 5-year-old participants as a single group. The mean age of participants was 4 years 3 months, and the sample consisted of relatively few 3 and 5 year olds, insufficient numbers to allow for adequate testing of age differences within the 3 to 5 grouping. While studying this age range as a single group is consistent with recent work on preschoolers' naïve biology (e.g., Greif et al., 2006; Jipson & Gelman, 2007; Kemler Nelson et al., 2001), it may not be warranted, given that the period between 3 and 4 years has reliably been established as involving major developmental changes in the organization of preschoolers' conceptualization, across multiple domains of cognition.

Piaget, for example, distinguished the 3- to 5-year-old period as a transitional period in children's logical reasoning skills, wherein children by 4 to 5 years of age begin demonstrating a growing conceptualization characterized by pockets of competence that resemble later concrete operational cognitive abilities (Piaget, 1947). Wellman, Cross and Watson's (2001) meta-analysis on the development of Theory of Mind in children has pointed to a clear transition between 3 and 4 years in preschooler's Theory of Mind development indexed by the emergence of false belief understanding. Povinelli and Simon's research (1998; see also Povinelli, Landau, & Perilloux, 1996; Povinelli, Landry, Theall, Clark, & Castille, 1999) on preschoolers' recognition of self across time has identified the emergence of a temporally extended, autobiographical self between 3 and 4 years, with children by 4 to 5 years, but not at 3 years, able to interpret a briefly delayed video presentation of themselves as themselves. More recently, Einav and Robinson (2011) have demonstrated a transition taking place between 3 and 4 years in children's ability to distinguish a knowledgeable source from an unknowledgeable source, with 4- and 5-year-olds more likely to trust information from a knowledgeable source but with 3-year-olds equally likely to trust a knowledgeable source as a source who is just repeating facts.

Together, the above mentioned research lends strong support to the view that conceptual reorganization occurs across a broad range of cognitive domains between 3 and 4 years of age, with children showing marked differences in their logical reasoning, understanding of Theory of Mind, self-recognition, and recognition of knowledgeable sources. Given the abundance of work demonstrating a major developmental change occurring between 3 and 4 years, a more systematic investigation of potential organizational change taking place between 3 and 4 years in preschoolers' living kinds conceptualization is clearly warranted. It remains unclear if a biologically based, skeletal framework for distinguishing living kinds from nonliving kinds characterizes all of the preschool period or whether such a framework is being developmentally constructed between 3 and 4 years. It is possible that 3-year-olds' conceptual framework for distinguishing living from nonliving kinds is not biologically based as it is in the older preschooler and adult and that conceptual reorganization, rather than simply the filling in of details for an already existing, biologically mature skeletal framework, better characterizes development during the early preschool period. Conclusions that the typical preschooler possesses a skeletal biological framework for distinguishing living kinds from nonliving kinds are premature without more systematic developmental investigation of the preschool period between 3 and 5 years.

Current Study

I designed the current study to offer a more complete assessment of what constitutes the nature of preschooler's living kinds concept and its development during the preschool period. The current study extended my previous methodology (Margett & Witherington, 2011) by (1) employing a longitudinal design with four testing sessions conducted over the course of approximately one year; (2) asking children to reason about psychological properties in addition to biological properties; (3) asking children open-ended, follow-up questions to gain insight into the reasoning behind their ascriptions of "alive" and particular biological or psychological properties to an object; and (4) asking children to generate a list of objects that are alive.

I employed a longitudinal design, the first extension to my previous methodology, to examine the extent to which preschooler's living kinds conceptualization undergoes organizational restructuring during the preschool period. The second extension to my methodology involved the addition of psychological property questions asked in Phase 2. In my previous study, I limited the questions asked in Phase 2 to specifically focus on biological properties that all living kinds engage in, such as growing and needing water and food.

Psychological properties such as thinking, feeling and remembering are also important in distinguishing living kinds from nonliving kinds although not all living kinds (i.e., plants) engage in psychological properties. Jipson and Gelman's (2007) work examined children's ascription of psychological properties to living and mobile nonliving kinds and found that preschoolers were more likely to ascribe psychological properties to animals and animate objects than to inanimate objects, but their work did not employ as broad a class set (i.e., they did not include plants) so the question remains whether preschoolers are more likely to assign psychological properties to mobile objects than to plants. The third extension to my previous methodology involved my asking a random subset of the preschooler sample open-ended, follow-up questions in Phases 2 and 3. In my previous work (Margett & Witherington, 2011) the questions I asked elicited only "yes" or "no" answers from the preschoolers; thus the results obtained neglected the rationale behind children's answers. In the current study I asked a subset of children an additional six open-ended, follow-up questions in Phase 2 in order to gain insight into the reasoning behind their ascription of certain biological or psychological properties to objects. Furthermore, in Phase 3, I asked an additional open-ended, follow-up question to gain insight into preschoolers' reasoning behind their ascription of "alive" to objects. The fourth and final extension to my previous methodology involved my asking each child in the subset of children who received additional open-ended questions, to generate a list of objects that are alive. Previous research (e.g., Carey, 1985; Meunier & Cordier, 2004; Richards & Siegler, 1984) has shown that when young children are asked to name things that are alive or asked to judge an object as alive, they often name and judge animals as living but seldom name or judge plants as living. In the current study, I examined if and how the type (e.g., humans, animals, plants, mobile or immobile objects) and number of objects listed as alive by preschoolers changed across the four testing sessions.

The current research project, unlike previous studies, employed a longitudinal design with a broad class set and multiple indices of understanding in order to maximize the likelihood of obtaining results that bear directly on the nature of the developmental change that occurs in preschoolers' living kinds conceptualization during a period of development that has been reliably identified as involving major changes in cognitive reasoning. Is preschooler's living kinds conceptualization, from roughly 3.5- to 4.5-years-old, best characterized as a process of organizational restructuring along the lines that Piaget (1929) and Carey (1985) have described or as a process of skill refinement and extension of application along the lines articulated Keil (1994; Keil et al., 1999) and others (e.g., Greif et al., 2006; Inagaki & Hatano, 2002; Waxman, 2005). Thus, the objective of the current study was to examine how preschooler's living kinds concept is structured, and to what extent this structural organization undergoes transformative change during the preschool period.

Methods

Participants

Thirty-five preschoolers between the ages of 3 and 4 years (16 female, 19 male) participated in a total of four testing sessions over the course of approximately one year. Recruited from two local preschools, preschoolers on average were 3 years, 4 months (*SD* = 2.73 mo) and 3 years, 7 months (*SD* = 2.77 mo) at their first and second testing sessions, respectively; at their third and fourth testing sessions, preschoolers were 4 years, 0 months (*SD* = 2.93 mo) and 4 years, 4 months (*SD* = 3 mo), respectively. A three month interval elapsed between Testing Sessions 1 and 2 and between Testing Sessions 3 and 4, with a six month interval elapsing between Testing Sessions 2 and 3, for all preschoolers. Demographic breakdown for this sample at Testing Session 1 was as follows: ethnicity: 54.3% Caucasian, 14.3% Hispanic, 22.9% White/Hispanic, 2.9% other; parent's education level: 2.9% high school, 14.3% Bachelor's, 40% Masters, 40% Doctorate; parent's income: 8.6% 20-50K, 31.4% 50-80K, 57.1% greater than 80k.

An adult comparison sample (*M* = 27.22 years, *SD* = 10. 45 months) consisted of 36 undergraduates (21 female, 15 male) recruited from undergraduate psychology classes at the University of New Mexico. Ethnicity breakdown for this sample was as follows: 41.7% Caucasian, 30.6% Hispanic, 2.8% White/Hispanic, 25% Other.

Materials

Stimuli. I used the same twenty-eight test objects for each of the four testing sessions. These test objects consisted of four classes of object: animals (e.g., klipspringer, bearded dragon, vulture, etc.), plants (e.g., succulent plant, venus fly trap, cactus, etc.), immobile objects (e.g., hand operated egg beater, antique tools, wooden garlic press, etc.) and mobile objects (e.g., mechanized toys, Newton's cradle, etc.). I employed a total of seven objects per class at each testing session: four objects per class in phase 1 (see Figure 2) and the same three objects per class in both phases 2 and 3 (see Figure 3). Test objects consisted of 4-second, real-time video clips displays on a laptop computer. Video displays of both the animal and mobile artifact classes involved motion, with actions such as chewing or walking for animals and spinning, gyrating or rolling for mobile objects. Each mobile object's motion appeared to be self-initiated and sustained. Video displays of both the plant and immobile objects classes involved no motion. I selected the mobile and immobile objects to be roughly equivalent in terms of number or parts, size, and material composition (metal, wood, plastic). All video displays featured the test object against a plain background to eliminate the possible effect of contextual cues.

Procedure

For my preschool sample, children completed the same three testing phases, in the same order, at each of the four testing sessions. Prior to the first testing session, each child's parent or guardian completed a demographic questionnaire. For each of the four testing sessions, a daycare provider (or parent) escorted the preschooler to a conference room within the preschool where I had set up a laptop. At the beginning of each session, I explained to the preschooler that she or he was going to play a game and look at some neat things on the computer. I asked the child to sit at the table, next to me, in front of the computer. Every testing session over the course of the year consisted of the same 3-phase plan of administration, as follows.

Phase 1. Phase 1 specifically focused on statements and questions that preschoolers generated about the four classes of objects. Consistent with my previous methodology (Margett & Witherington, 2011), I began each session by introducing a hand puppet, for example a dog puppet named Charlie. I told the preschooler that Charlie had lived for a long time in a doghouse and now would like to know about things found in the world. I then told the child that there were some new things for her or him to see on the computer and that her or his job was to tell the puppet everything that she or he could about the things she or he saw in order to help the puppet learn about those things. I started a computer program that displayed a matrix of boxes with a black question mark in the middle of each and encouraged the child to pick any box. Once chosen (by clicking on the black question mark), each box presented a full screen display of a test object. After the 4 second video clip, the image of the object remained on the screen while I exclaimed, "Wow! That is interesting. What can you tell Charlie about that thing?" I encouraged the child to tell the puppet about the object. Then I clicked on the box to reduce it back to the matrix, marked the box to prevent it from being re-selected, and encouraged the child to choose another box. This procedure continued until all 16 objects were displayed and the preschooler had been given the opportunity to make statements about each item. For each testing session, I used a different puppet (4 total) in order to keep the context of the testing session new and to provide a different character with whom the child could interact and help teach.

Phase 2. Phase 2 specifically investigated what biological and psychological properties preschoolers attributed to the four classes of objects by examining their responses to questions asked about twelve objects (three from each class). I told the preschooler that now the puppet was going to ask her or him questions about the objects that she or he was about to view. As in Phase 1, I started the program and the child chose a box to display a test object. After the video clip finished, a still-frame of the test object remained on the screen while I asked the child three biological questions—"Does this one need water?" "Does this one grow?" "Does this one need food?"—and three psychological questions—"Can this one feel happy?" "Does this one remember yesterday?" "Does this one think thoughts?"—to which the child answered "yes" or "no." I asked these questions in random order for each test object at each testing session. The procedure continued until all 12 objects were displayed and the preschooler had been given the opportunity to answer all questions about each item.

Phase 3. Phase 3 investigated preschoolers' classification of test objects as living or nonliving and consisted of the same twelve objects as in Phase 2 (three of each class). I asked the preschooler to tell the puppet if the things that she or he was about to see were alive or not alive. I started the program in one of two randomized orders and clicked on a box to view the four-second video clip that ended in a still frame. I then asked the preschooler, "Is this one alive?" to which the preschooler should respond "yes" or "no". The procedure continued until all 12 objects were displayed.

Qualitative condition. I randomly assigned a subset of 10 preschoolers to an additional qualitative questioning condition. At each of the four testing sessions I asked each of these children eight open-ended, follow-up questions (six after Phase 2 and two after Phase 3). After Phase 2, I asked the following questions in a random order across children and testing sessions: "How do you know something needs water?" "How do you know something can grow?" "How do you know something needs food?" "How do you know something can feel happy?" "How do you know something can remember yesterday?" How do you know something can think thoughts?" The child could respond as much or as little as she or he chose during this questioning session. After Phase 3, I asked, "How do you know something is alive?" and "Can you tell me and (puppet's name) some things that are alive?" I encouraged each child to list as many things that are alive as she or he could in order to teach the puppet about things in the world.

The adult sample encountered the same stimuli and game displays and completed all three phases, just like the preschool sample. The adult procedure differed, however, from the preschool procedure in that (1) there was no puppet and accompanying story line, (2) adults completed only one testing session, (3) adults were tested in groups of 1-10 and were administered a paper-and-pencil version of the testing procedure, and (4) all of the adults answered the qualitative questions. Table 1 presents a summary of the procedures including stimuli presented, questions asked and the type of responses generated by participants.

Data Reduction and Transformation

Phase 1: Coding of Statements

Consistent with my previous coding procedures (Margett & Witherington, 2011), I had all statements that preschoolers made in Phase 1, at each the four testing sessions, coded into one of three general categories: (1) Biological type statements, comprised of both biological category membership statements (e.g., "It's a cow.") and biological statements (e.g., "It has ears."); (2) Functional type statements, comprised of both functional category membership statements (e.g., "It's a mixer.") and functional statements (e.g., "It's for chopping."); and (3) Other type statements, comprised of both ambiguous statements that can be applied appropriately to either living or nonliving objects (e.g., "It's moving.") and non-informative statements that do not readily indicate how a preschooler conceptualized the object (e.g., "It is black."). Table 2 presents the number of biological and functional statements made for each object class at each testing session.

Four trained research assistants blind to the hypotheses of the study transcribed and coded video recordings of all testing sessions. I extensively trained one research assistant in the coding procedures and had this research assistant complete a coding test made up of exemplar statements preschoolers might make during a testing session. The research assistant accurately coded 97% of the statements and, as an expert coder, checked all codes assigned by the other three research assistants. When disagreements arose, the research assistants met to discuss and come to an agreement on what code best characterized the statement.

Phases 2 and 3: Data Transformation

Missing data. I encountered two types of missing data. The first type of missing data was due to preschoolers missing an entire testing session. Two preschoolers each missed two testing sessions, and three preschoolers each missed one testing session. One preschooler elected not to participate in a testing session, and all other missed sessions were due to preschoolers no longer being enrolled in a participating preschool. This resulted in a total of 5% of data being missed. The second type of missing data was due to preschoolers not answering all of the *yes/no* questions within a testing session. For those sessions where the preschooler participated, 1.9% of the *yes/no* data were missing. Of this type of missing data, half were due to occasional computer malfunction or experimenter error and half were due to preschoolers not wanting to answer the question(s) or asking to move on.

The analytic procedures I used (difference matrices) required that I have complete data on the Phase 2 and 3 *yes/no* responses. Therefore, when data were missing due to a preschooler not completing an entire testing session, I imputed the missing data using the SPSS Multiple Imputation function (version 17).[1] When data were missing due to a preschooler missing an entire testing session, I did not impute the missing data.

Preschoolers' response patterns. My aim was to characterize each preschooler's *yes/no* response pattern, at each testing session, in order to get a sense of how she or he was treating the stimulus exemplars in relation to one another. For example, were a preschooler's response patterns for the animal and plant stimulus exemplars similar? Did the preschooler distinguish the animal and plant stimulus exemplars from the mobile and immobile object exemplars? Or did the preschooler employ similar response patterns for the stimulus exemplars depicted in motion

[1] Fully conditional specification (an iterative Markov chain Monte Carlo method) with 10 iterations was used. The imputation model included the preschooler's ID number, the testing session, the stimulus number, whether or not the stimulus was mobile, whether or not the stimulus was alive (as predictors only), and all seven of the Phase 2 and 3 *yes/no* questions (as predictors and imputed variables). All of the variables in the model were nominal scale, and I used logistic regression models to impute the *yes/no* responses. I averaged eight imputations and then rounded to either 0 or 1.

(animals and mobile objects)? Did the preschooler distinguish the stimulus exemplars depicted in motion from those depicted as immobile (plants and immobile objects)?

In order to characterize the pattern of preschoolers' *yes/no* responses, I employed difference matrices and created three distinct difference matrices for each preschooler at each testing session, one based on her or his answers to the three biological property questions, one based on her or his answers to the three psychological property questions, and a third based on her or his answers to the alive question. To construct a difference matrix, I counted the number of questions that were answered differently for all possible pairs of exemplars. Thus, a difference score with respect to any given pair of exemplars for the three biological questions or for the three psychological questions could range from 0 (all questions answered the same) to 3 (all questions answered differently). The range was 0 to 1 for the alive question for a pair of stimulus exemplars. For illustration purposes, Figure 4 presents a sample preschooler's biological processes matrix. The preschooler responded "yes" to the three biological properties for both the animal 1 exemplar and the animal 2 exemplar; therefore, the preschooler's difference (or dissimilarity) score for the *animal 1-animal 2* pair is 0 (see Figure 4, row 1, column 2). The preschooler responded "yes" to the three biological properties for the animal 1 exemplar but answered "no" to one of the three biological properties for the animal 3 exemplar; thus, the preschooler's difference score for *animal 1-animal 3* pair is 1 (see Figure 4, row 1, column 3). Had the preschooler answered "no" to two of the three biological property questions for the animal 3 exemplar and "yes" to the three biological property questions for the animal 1exemplar, the difference score would be 2. Had the preschooler answered "no" to all three of the biological property questions for the animal 3 exemplar and "yes" to the three biological property questions for the animal 1 exemplar, the difference score would be 3.

Adults' response patterns. I also employed difference matrices with my adult data to characterize how the group of 36 adults treated the stimulus exemplars in relation to one another. I created three distinct difference matrices on the average of the adults' response patterns, one based on the average answers to the three biological property questions, one based on the average answers to the three psychological property questions, and a third based on the average answer to the alive question. Though I created the adults' difference matrices similarly to the preschoolers', the adults' answers were averaged together before differences were calculated so the values in the matrices are not necessarily whole numbers. Figure 5 shows the adults' biological property difference matrix.

Preschooler's response patterns in relation to adults' response pattern. To characterize the difference between each preschooler's pattern of *yes/no* responses, at each testing session, and the adults' average pattern of *yes/no* responses, I calculated the absolute difference between each preschooler's three difference matrices and the three adult matrices to derive a between-sample (preschooler, adult) matrix difference for biological properties, for psychological properties, and for alive understanding The resulting between-sample matrices differences provide an index of how adult-like a preschooler's conceptualization of the relationships between the exemplars was at each testing session, based on the different types of questions asked (biological, psychological, and alive). For example, the preschooler in Figure 4 had a difference score of 0 for the *animal 1–animal 2* exemplar pair on the biological property questions at Testing Session 1, and the adults' average difference score for the same animal pair was 0.002 (see Figure 5). Thus, the absolute difference of the preschooler's difference score from the adult difference score for that pair would be 0.002. A score of 0 indicates that the preschooler treated the stimulus exemplars in relation to one another similarly to how adults treated the exemplars in relation to one another. Note that if the preschooler had said *no* to all three biological property questions for both animal 1 and animal 2 exemplars, that preschooler would still have an exemplar pair difference score of 0 and a between sample absolute difference score from adults' response pattern of 0.002 for that pair.

Once I had calculated the absolute difference between each preschooler's difference matrices and the adults' matrices across all exemplar pairs (see Figure 6 for an example), I then summed the absolute difference scores to derive a single score. In Figure 6, summing the absolute difference of the sample preschooler's biological difference matrix from the adults' biological difference matrix was 37.97.

Preschooler's' response patterns in relation to hypothetical models. Preschoolers' response patterns may differ qualitatively from adults' response patterns; therefore, consideration of alternative models for characterizing preschooler thought is required. In order to capture potential qualitative differences in preschoolers thinking, I created three hypothetical models to compare preschoolers' response patterns against. The first hypothetical model is the Mobile Model which contrasts mobile objects (animals and mobiles) with immobile objects (plants and immobile objects) and characterizes mobile—but not immobile—objects as engaging in the three biological processes, the three psychological processes, and as being alive. I designed the Mobile Model to represent a framework of understanding based on the presence and absence of motion. The second hypothetical model is the Animal Model which contrasts animals with the other three classes of objects (plants, mobile objects, and immobile objects) and characterizes only animals as engaging in biological and psychological processes and as being alive. I designed the Animal Model to represent a framework of understanding based on the idea that animals are biological, psychological, and alive but the other classes of objects (plants, mobile, and immobile objects) are not. The third hypothetical model is the Immobile Object Model which contrasts the immobile class of objects with the other three classes of objects (animals, plants, and mobiles) and characterizes immobile objects as the only class of objects *not* engaging in biological or psychological processes and not being alive. I designed this model to represent a framework of understanding based on the idea that immobile objects are not biological, psychological, or alive but the other three classes are. This third model represents a confusion based on motion: the presence of motion by the mobile objects makes them engage in biological and psychological processes as well as be alive. However, the absence of motion by the plants does not prohibit them from engaging in biological and psychological processes or being alive. Note that the hypothetical models are not orthogonal to each other and their degree of similarity is dependent on which questions are being asked (biological, psychological or alive). Thus, a change in preschoolers' pattern of responses that brings them closer to one model may also bring them closer to another model.

I created difference matrices for each of my hypothetical models based on how one would answer the *yes/no* questions if one held each of the three conceptual frameworks in mind. Again I made three distinct difference matrices for each model, one for the three biological questions, one for the three psychological questions, and one for the alive question. Then, I calculated the difference between each preschooler's matrix and each of the hypothetical model matrices the same way I calculated their difference from the adults' average response pattern. Figures 7 through 9 present the biological property difference matrix for the Mobile Model, Animal Model, and Immobile Object Model, respectively.

Data Analysis Strategy

The major purpose of my analyses was to examine how preschoolers' living kinds concept is structured across time and to what extent this structural organization undergoes transformative changes during the preschool period. To accomplish this, I employed two primary statistical techniques: hierarchical linear modeling (HLM) and paired sample *t*-tests. Given the nature of my data structure—testing sessions (Level 1) were nested within the contextual variable of preschooler (Level 2)—HLM allowed me to account for the non-independence of testing sessions within preschoolers. I employed HLM techniques (via SPSS version 21) to estimate models with linear slopes. I was primarily interested in looking at fixed effects, though I included the effect of random intercepts in the models. Including random intercepts in the models employed allowed for the examination of whether preschoolers start out with different levels of understanding on my outcome measures. I was unable to look at the effect of random slopes due to failures to converge with this parameter included; therefore, the models employed assumed that the rate of change across preschoolers was the same – an assumption that is undoubtedly false. Paired sample *t*-tests provided a way to examine how preschoolers treated the four classes of objects in relation to each other at each testing session. When all pairwise *t*-tests were conducted, I corrected for familywise Type I error through Dunn's test at a familywise alpha of .05 (see Howell, 1987).

Given my interest in examining preschoolers' conceptualization of the biological and psychological domains of understanding independently and in relation to one another, and in examining how this conceptualization changed over the course of the year-long study, the dependent variables I assessed were preschooler's response patterns to biological and psychological property questions as well as the alive question at each testing session, and how they compared to adults' response pattern and to response patterns based on hypothetical models that preschoolers may employ when asked to reason about living and nonliving kinds (in the form of the difference matrices described above).

In addition to examining preschoolers' response patterns at each testing phase and at each testing session, I was also interested in examining whether preschoolers' response patterns in one phase or in one domain of understanding (biological or psychological) mapped onto responding in another phase or domain of understanding. If preschoolers' responding within a particular phase or domain of understanding mapped onto responding in another phase or domain of understanding, this would demonstrate that a degree of structural organization exists in preschooler's living kinds concept. Thus, to further investigate the structural organization of preschoolers' living kinds concept and how it developed over the course of the year-long study, I used HLM to determine whether responding in one phase or domain of understanding predicted responding in other phases or domain of understanding.

Results

Phase 1: Statements Generated

Preliminary HLM analyses revealed no significant association between the number of statements generated in Phase 1 and preschoolers' gender, $t(28.034) = 1.496$, $p = .146$, 95% CI [-1.962, 12.596]; ethnicity, $t(27.949) = -.754$, $p = .457$, 95% CI [-9.593, 4.430]; parental education, $t(27.476) = -.266$, $p = .793$, 95% CI [-10.999, 8.476] or income, $t(27.425) = -.243$, $p = .810$, 95% CI [-15.309, 12.065]. Preschoolers' intercepts significantly varied when all of these predictor variables were centered at zero (female, minority, graduate degree and high income)[2], Wald Z = 2.765, p = .003, var = 70.116. Consequently, I eliminated these variables from further Phase 1 analyses.

Statement quantities. HLM analyses revealed that preschoolers significantly increased the number of statements they made for each class over the course of the year they were studied, with preschoolers significantly varying on the number of statements made when age was centered at the mean age (M = 3 years, 9 months, SD = 5 months). Specifically, as preschoolers got older, they increased the number of statements made for the *animal class*, $t(116.394) = 3.280$, $p = .001$, $b = .009$; for the *plant class*, $t(121.593) = 3.794$, $p < .001$, $b = .005$; for the *mobile class*, $t(120.209) = 3.137$, $p = .002$, $b = .004$; and for the *immobile class*, $t(122.348) = 2.630$, $p = .010$, $b = .004$ (see Table 3 for means and standard deviations). The number of statements that preschoolers made for each of these classes ranged from 0 to 39 for the animal class, 0 to 17 for the plant class, 0 to15 for the mobile class, and 0 to15 for the immobile class, and the slopes of .009, .005, .004, and .004 in the above analyses indicate that on average, the preschoolers in this study increased the number of statements made for each respective class by 3.285, 1.825, 1.46, and 1.46 over one year. In addition, preschoolers' intercepts significantly varied for each class: for animals, Wald $Z = 2.954$, $p = .002$, var = 14.553, indicating that the standard deviation of preschoolers' intercepts at the mean age was 3.815; for plants, Wald $Z = 2.491$, $p = .06$, var = 1.884, indicating that the standard deviation of preschoolers' intercepts at the mean age was 1.373; for mobiles Wald $Z = 2.607$, $p = .005$, var = 2.534, indicating that the standard deviation of preschoolers' intercepts at the mean age was 1.592; and for immobiles, Wald $Z = 2.365$, p =

[2] All demographics were dichotomized as follows: gender was coded as 1 = male, 0 = female; ethnicity was codes as 1 = white, 0 = other; education 1 = High School/Bachelors, 0 = Masters/PhD; income 1 = < 50,000, 0= greater than 50,000.

.009, var = 2.449, indicating that the standard deviation of preschoolers' intercepts at the mean age was 1.565.

In addition to increasing the number of statements they made for each class with age, preschoolers also made significantly more statements in response to the *animal class* than to any other class, irrespective of testing session (see Table 3 for means and standard deviations). Specifically, paired sample *t*-tests revealed more statements made for the animal class relative to the plant, mobile and immobile classes respectively at Testing Session 1, all ts > 3.42, all ps $<$ .003; at Testing Session 2, all ts > 4.018, all ps $< .001$; at Testing Session 3, all ts > 4.38, all ps $<$ .001; and at Testing Session 4, all ts > 4.31, all ps $< .001$ (see Table 4 for full test statistics). Preschoolers also made more statements about the *plant class* than the mobile class of objects at Testing Session 2, $t(34) = 3.106$, $p = .004$, and Testing Session 4, $t(30) = 3.344$, $p = .002$. However, there were no significant differences in the number of statements preschoolers made for the plant class and the immobile class at any of the four testing sessions. In addition, there were no significant differences in the number of statements preschoolers made in response to the mobile and immobile class of objects at any of the four testing sessions.

Statement qualities. With respect to the type of statements made, preschoolers generated significantly more biological statements than functional statements across all four testing sessions (see Table 5 for means and standard deviations): at Testing Session 1, $t(34) = 6.632$, $p < .001$; at Testing Session 2, $t(34) = 7.104$, $p < .001$; at Testing Session 3, $t(31) = 8.895$, $p < .001$; and at Testing Session 4, $t(30) = 8.672$, $p < .001$. The nature of the statements that the preschoolers made in response to the animal, plant and immobile classes were consistently of the "correct" type: biological statements for animal and plant classes and functional statements for immobile classes (see Table 3 for means and standard deviations). Specifically, paired sample *t*-

tests revealed significantly more biological statements than functional statements *across all four testing sessions* for the *animal class*, all *t*s > 6.99, all *p*s < .001, and for the *plant class*, all *t's* > 10.11, all *p's* < .001, and significantly more functional statements than biological statements across all four testing sessions for the *immobile class, all t*s *< -3.46, all ps < .002* (see Table 6 for full test statistics).

However, preschoolers in the sample were less clear on what type of statement to make for the *mobile class*. Although there was a significant difference in the type of statements (more functional than biological) preschoolers made in response to the mobile class at Testing Session 3, $t(31) = -4.153$, $p < .001$, no significant differences emerged at Testing Session 1, $t(34) = -1.968$, $p = .057$, at Testing Session 2, $t(34) = -1.462$, $p = .153$, or at Testing Session 4, $t(30) = -.523$, $p = .605$.

Phase 2: Biological Process Questions

Preliminary HLM analyses revealed no significant association between a more adult-like response pattern to the biological property questions in Phase 2 and preschoolers' gender, $t(28.544) = -.702$, $p = .488$, 95% CI [-13.966, 6.831]; ethnicity, $t(28.418) = -.827$, $p = .415$, 95% CI [-14.057, 5.966]; parental education, $t(27.713) = .477$, $p = .637$, 95% CI [-10.640, 17.100] or income, $t(27.636) = -1.113$, $p = .275$, 95% CI [-30.073, 8.907]. Preschoolers' intercepts significantly varied when all of these predictor variables were centered at zero (female, minority, graduate degree and high income), Wald $Z = 2.089$, $p = .018$, var = 665. Consequently, I eliminated these variables from further Phase 2 Biological analyses.

Model comparisons for biological response patterns. To characterize how preschoolers' response pattern to the three biological property questions changed in relation to adults' response pattern (the "adult model") over the course of the year-long study, I employed

HLM analysis (see Table 7 for all means and standard deviations). Results revealed that over one year, preschoolers' response pattern linearly moved significantly closer to the adult model, $t(118.865) = -5.917$, $p < .001$, $b = -.054$. Given the structure of the adults' biological difference matrix, the potential minimum that a preschooler's biological difference matrix could differ from the adult model was 12.38, with a potential maximum difference from the adult model of 107.91, resulting in a range of 95.53. The model indicates that, on average, preschoolers in this study moved 19.71 units closer to the adult model over the course of one year, approximately 21% of the potential range. In addition, preschoolers' intercepts significantly varied in regard to how similar preschoolers' response pattern was to the adult model when preschoolers' response pattern was centered at the mean age, Wald $Z = 2.733$, $p = .003$, var = 126.084, indicating that the standard deviation of preschoolers' intercepts at the mean age was 11.23 units.

Although preschoolers' biological responding moved significantly closer to the adult model as they got older, was their responding significantly different than chance responding at each testing session? To answer this question, I created the hypothetical dissimilarity matrix that would be expected if the preschoolers randomly answered "yes" or "no" to the biological questions. For example, if the preschoolers randomly answered "yes" 50% of the time, then I would expect an average of 1.5 different answers for each pair of objects over the three biological questions. However, I did not want to assume that preschoolers necessarily said "yes" 50% of the time, so to account for any bias they may have had in word preference, I calculated the expected number of differences from the actual proportion of "yes" answers the preschooler gave for each question. Then, I calculated the difference between this "chance answering" dissimilarity matrix and the adults' dissimilarity matrix to get a comparison value that was on the same scale as my similarity to adults' biological processes outcome variable. The expected difference from the adult matrix for a preschooler whose response pattern was random in this way was 86.4. An average difference that is smaller than 86.4 indicates that the preschoolers were more similar to adults than chance (see Table 7 for the absolute difference between preschoolers' and the adult models biological responding, means and standard deviations). Results revealed that at Testing Sessions 1 and 2, the difference between preschoolers' response patterns and the adult model was not significantly different than chance, TS1, $t(34) = -.484$, $p = .632$, 95% CI [-5.550, 3.426]; TS2, $t(34) = -1.274$, $p = .211$, 95% CI [-7.081, 1.623]. However, at Testing Sessions 3 and 4, preschoolers' response patterns were significantly closer to the adult model than chance, TS3, $t(31) = -2.815$, $p = .008$, 95% CI [-21.512, -3.435]; TS4, $t(30) = -5.225$, $p < .001$), 95% CI [-30.077, -13.172].

How did the other proposed hypothetical models fare in characterizing preschoolers' response patterns across the four testing sessions? To answer this question, I took the absolute difference of preschoolers' response pattern to the three biological property questions at each testing session relative to the adult model and to the three hypothetical models (see Table 7 for means and standard deviations). All pairwise comparisons were conducted at each testing session. At all four testing sessions, preschoolers' responding was closer to the adult and animal models than the mobile or immobile models so I focused on the adult and animal models (see Figure 10 for Preschoolers' biological response pattern in relation to the adult model and hypothetical models). Paired sample *t*-tests revealed that at Testing Sessions 1 and 2, there was no significant difference in preschoolers' response patterns from the adult model and the animal model TS1, $t(34) = -1.291$, $p = .205$, 95% CI [-8.190, 1.827]; TS2, $t(34) = -1.607$, $p = .117$, 95% CI [-9.345, 1.091]. However, at Testing Sessions 3 and 4, preschoolers' response patterns were significantly closer to the adult model than the animal model, TS3, $t(31) = -3.276$, $p = .003$, 95% CI [-20.351, -4.733]; TS4, $t(30) = -4.497$, $p < .001$, 95% CI [-25.845, -9.701] (see Figure 10).

Thus, at the first two testing sessions, preschoolers' *yes/no* response patterns to the three biological questions could not be distinguished from guessing and the absolute difference of their response pattern was equally similar to both the adult model and the hypothetical animal model. However, at the final two testing sessions, preschoolers' *yes/no* response patterns to the three biological questions were significantly closer to the adult model than would be expected by chance and their response patterns were significantly closer to the adult model than to any of the hypothetical models.

Spatial representation of change in preschoolers' biological response pattern. To further investigate how preschoolers' *yes/no* response patterns to the three biological processes questions changed over the course of the study, I created Multidimensional Scaling (MDS) plots to spatially represent how preschoolers and adults conceptualized the relationships between exemplars of the different classes of objects. Specifically, I was interested in how the preschoolers and adults grouped and distinguished the exemplars from one another. MDS is typically used to determine the underlying structure of a set of objects based on proximities or similarities. For example, given the distances in miles between pairs of US cities, MDS could be used to plot those cities in two dimensions and would essentially produce a map of the US. The two dimensions would then be interpretable as east-west and north-south. Unlike this example however, most proximity, or similarity, data will contain "noise." If A is 3 units away from B, and B is 3 units away from C, but C is only 4 units away from A, then A, B, and C cannot be plotted in one dimension without stress. MDS finds the solution that produces the lowest stress for a given number of dimensions (For more details see Kruskal & Wish, 1978).

I created scree plots based on stress to decide how many dimensions to use in order to represent the exemplars. The number of dimensions that gave the best fit for the preschoolers varied across ages and measures (biological vs. psychological questions). For the adults, one-dimensional solutions had stress < 0.05 for all measures, which suggests that adult conceptions were best represented in one dimension (Kruskal & Wish, 1978). In order to (a) have a consistent format and (b) be able to compare the preschoolers to adults, I created all the plots in one dimension.[3] In this case, I did not use MDS to determine the true, underlying structure of the preschoolers' concept, but instead as a tool for creating a visual representation to see how adults and preschoolers were grouping the exemplars based on their *yes/no* responses.

The first MDS plot represented how adults treated the stimulus exemplars in relation to each other based on their *yes/no* responses to the three biological property questions. The adults' MDS plot illustrates how adults largely formed two groupings, animal and plant stimulus exemplars in one group and mobile and immobile stimulus exemplars in a separate group (see Figure 11a). I decided to create two MDS plots on the preschoolers responses, one when the preschoolers were younger (pre-median age split) and one when the preschoolers were older (post-median age split) in order to visually examine how their response patterns changed with age. Figure 11b and 11c represent how the preschoolers treated the stimulus exemplars in relation to each other, when the preschoolers were younger and when the preschoolers were older, respectively.

The MDS plots helps to illustrate the change in preschooler response pattern to the three biological questions over time. At earlier ages, preschoolers evidenced a fair deal of spread

[3] MDS settings and specifications: Euclidian squared distance matrix; levels of measurement = ratio; conditionality = matrix; dimensions =1; S stress convergence = .001; minimum stress value = .005; minimum iterations = 30.

between all the stimulus exemplars without distinct groupings. However, even at earlier ages preschoolers were broadly distinguishing living things from nonliving things, with objects (mobile and immobile exemplars) on one end and living kinds (plants and animal exemplars) on the other end (see Figure 11b). While the exemplars were fairly evenly distributed along the dimension, mobile objects came first, followed by immobile, then by animals, and finally by plants with no overlap between the classes. With age preschoolers in this study evidenced increased grouping of the exemplars with living kinds grouped distinct from objects (see Figure11c). The increased tightening of the living and nonliving groups can be characterized by the immobile objects moving closer to the mobile objects and the animals moving closer to the plants.

Phase 2: Psychological Process Questions

Preliminary HLM analyses revealed no significant association between a more adult-like response pattern to the psychological property questions in Phase 2 and preschoolers' gender, $t(27.590) = .188$, $p = .852$, 95% CI [-8.567, 10.299]; ethnicity, $t(27.493) = -.777$, $p = .444$, 95% CI [-12.528, 5.641]; parental education, $t(26.957) = -.109$, $p = .914$, 95% CI [-13.276, 11.940] or income, $t(26.899) = -.188$, $p = .852$, 95% CI [-19.344, 16.096]. Preschoolers' intercepts significantly varied when all of these predictor variables were centered at zero (female, minority, graduate degree and high income), Wald $Z = 2.547$, $p = .005$, var = 109.652. Consequently, I eliminated these variables from further Phase 2 Psychological analyses.

Model comparisons for psychological response patterns. To characterize how preschoolers' response pattern to the three psychological property questions changed in relation to the adult model over the course of the year-long study, I employed HLM analysis (see Table 8 for the absolute difference between preschoolers' and the adult models psychological responding, means and standard deviations). Results revealed that over one year, preschoolers' response pattern did *not* move significantly closer to the adult model, $t(119.932) = -.606$, $p = .545$, $b = -.005$. Given the structure of the adults' psychological difference matrix, the potential minimum that a preschooler's psychological difference matrix could differ from the adult model was 8.85, with a potential maximum difference from the adult model of 105.99, resulting in a range of 97.14. Although non-significant, the model indicates that, on average, preschoolers in this study moved 1.825 units closer to the adult model over the course of one year, approximately 2%. In addition, preschoolers' intercepts significantly varied in regard to how similar preschoolers' response pattern was to the adult model when preschoolers' response pattern was centered at the mean age, Wald $Z = 2.508$, $p = .006$, var = 85.494, indicating that the standard deviation of preschoolers' intercepts at the mean age was 9.25 units.

Although preschoolers' psychological responding did not move significantly closer to the adult model as they got older, was their responding significantly different than chance responding at each testing session? To answer this question, I used the same process described in the biological property questions section and found that the expected difference from the adult model measured from chance was 74.67 over the three psychological processes questions. At all testing sessions, preschoolers' response patterns were significantly closer to the adult model than chance, TS1, $t(34) = -2.863$, $p = .007$, 95% CI [-12.336, -2.093]; TS2, $t(34) = -5.568$, $p < .001$, 95% CI [-17.148, -7.977]; TS3, $t(31) = -3.981$, $p < .001$, 95% CI [-19.080, -6.152]; TS4, $t(30) = -2.567$, $p = .015$, 95% CI [-16.056, =1.827].

How did the other proposed hypothetical models fare in characterizing preschoolers' response patterns across the four testing sessions? To answer this question, I took the absolute difference of preschoolers' response pattern to the three psychological property questions at each testing session relative to the adult model and to the three hypothetical models (see Figure 12). All pairwise comparisons were conducted at each testing session. Paired sample *t*-tests revealed that at each testing session preschoolers' response patterns were significantly closer to the adult model than to any of the hypothetical models (see Table 8 for means, standard deviations and significant differences between models).

Spatial representation of change in preschoolers' psychological response pattern. Although there was not a significant change in the degree of similarity between preschoolers' psychological responding and the adult model over the course of the study, I visually examined preschoolers' organization compared to adults' organization at pre and post median age split via MDS plots to confirm that no reorganization had taken place in preschoolers' psychological responding. Figure 13a represented how adults' treated the stimulus exemplars in relation to each other based on their *yes/no* responses to the three psychological property questions. The adults' MDS plot illustrates how adults largely formed two groupings, animal stimulus exemplars in one group, and plant, mobile and immobile stimulus exemplars in a separate group. Figures 13, plots b and c, represent how the preschool sample treated the stimulus exemplars in relation to each other when the preschoolers were younger (pre-median age split) and when they were older (post-median age split), respectively.

The MDS plot helps to illustrate the change in preschoolers' response pattern to the three psychological questions over time. At the earlier ages preschoolers evidenced a fair deal of spread between the all stimulus exemplars yet broadly distinguished living things from nonliving things with the nonliving exemplars at one end and living kind exemplars (plants and animals) on the other (see Figure 13b). With increased age, there was still no overlap between living and nonliving things, though preschoolers appeared to shift the plant exemplars closer to the nonliving kinds (see Figure 13c).

Within Phase Analyses: Phase 2 Biological Property Questions with Phase 2 Psychological Property Questions

To investigate the relation between a more adult-like response pattern to the biological property questions in Phase 2 and a more adult-like response pattern to the psychological property questions in Phase 2, I employed HLM analyses. These analyses targeted the following question: Did preschoolers who responded in more adult-like fashion to the biological questions in Phase 2 also respond in more adult-like fashion to the psychological questions in Phase 2? Results revealed that a more adult-like response pattern to the three biological property questions in Phase 2 predicted a significantly *less* adult-like response pattern to the three psychological property questions in Phase 2, $t(130.920) = 3.452$, $p < .001$, $b = .227$. The slope of .227 indicates that, on average, for each unit that, on preschoolers' biological difference matrix became more similar to adults' biological difference matrix, there is a .277 unit (out of the possible 97.14 range) *decrease* in the similarity of preschooler's psychological difference matrix to the adults' psychological difference matrix. In this model, intercepts of the psychological response pattern significantly varied across preschoolers when the biological response pattern was centered at the mean, Wald $Z = 2.255$, $p = .012$, var = 64.854.

Phase 3: Alive Question

Preliminary HLM analyses revealed no significant association between a more adult-like response pattern to the alive question in Phase 3 and preschoolers' gender, $t(28.520) = .537$, $p = .595$, 95% CI [-2.386, 4.084]; ethnicity, $t(28.412) = -.544$, $p = .590$, 95% CI [-3.943, 2.287]; parental education, $t(27.811) = .238$, $p = .813$, 95% CI [-3.818, 4.823] and income, $t(27.745) = -$

1.207, p = .238, 95% CI [-9.648, 2.497]. Preschoolers' intercepts significantly varied when all of these predictor variables were centered at zero (female, minority, graduate degree and high income), Wald Z = 2.435, p = .007, Var = 12.170. Consequently, I eliminated these variables from further Phase 3 alive analyses.

Model comparisons for alive response patterns. To characterize how preschoolers' response pattern to the alive questions changed in relation to the adult model over the course of the year-long study, I employed HLM analyses (see Table 9 for the absolute difference between preschoolers' and the adult models alive responding, means and standard deviations). Results revealed that over one year, preschoolers' response pattern linearly moved significantly closer to the adult model, $t(121.494) = -4.699$, $p < .001$, b = -.013. Given the structure of the adults' alive difference matrix, the potential minimum that a preschooler's alive difference matrix could differ from the adult model was 2.29, with a potential maximum difference from the adult model of 36.99, resulting in a range of 34.7. The model indicates that, on average, preschoolers in this study moved 4.745 units closer to the adult model over the course of one year, approximately 14%. In addition, preschoolers' intercepts significantly varied in regard to how similar preschoolers' response pattern was to the adult model when the preschoolers' response pattern was centered at the mean age, Wald Z = 2.526, p =.006, var= 8.917, indicating that the standard deviation of preschoolers' intercepts at the mean age was 2.99 units.

Based on a plot of the absolute difference of preschoolers' response patterns from adult model (see Figure 14) I was concerned that the significant effect could be due to four outliers. I re-ran the model without those four points, and without the preschoolers who contributed those four points, and in both cases the linear effect was still significant.

Although the preschoolers' alive response patterns did move significantly closer to the adult model as they got older, was their responding significantly different than chance responding at each testing session? To answer this question, I used the same process described in the biological questions section and I found that the expected difference from the adult model from chance response pattern on the alive question is 30.5 (see Table 9 for the absolute difference between preschoolers' and the adult models alive responding, means and standard deviations). At Testing Sessions 1 and 2, preschoolers' response pattern is significantly *further* from the adult model than chance responding, TS1, $t(34) = 5.697$, $p < .001$, 95% CI [1.571, 3.314]; TS2, $t(34) = 5.024$, $p < .001$, 95% CI [1.492, 3.519]. However, at Testing Sessions 3 and 4, preschoolers' response pattern was not significantly different from the adult model than chance, TS3, $t(31) = .003$, $p = .997$, 95% CI [-2.380, 2.388]; TS4, $t(30) = -1.141$, $p = .263$, 95% CI [-4.973, 1.408].

How did the other proposed hypothetical models fare in characterizing preschoolers' response patterns across the four testing sessions? To answer this question, I took the absolute difference of preschoolers' response pattern to the alive question at each testing session relative to the adult model and the three hypothetical models (see Table 9 for means and standard deviations). All pairwise comparisons were conducted at each testing session. Paired sample *t*-tests revealed that at Testing Sessions 1 and 2, there was no significant difference in preschoolers' response patterns from the to the animal model and the immobile object model, TS1, $t(34) = <.001$, $p = 1.000$, 95% CI [-3.763, 3.763]; TS2, $t(34) = -.168$, $p = .868$, 95% CI [-3.750, 3.178]. However, at Testing Sessions 3 and 4, preschoolers' response patterns was significantly closest to the *animal model*, TS3, $t(31) = 3.753$, $p = .001$, 95% CI [3.839, 12.981]; TS4, $t(30) = 2.501$, $p = .018$, 95% CI [1.208, 11.969] (see Figure 15).

Thus, at the first two testing sessions, preschoolers *yes/no* response pattern to the alive question was significantly further from the adult model than chance would predict and their response pattern was equally similar to both hypothetical models, the animal model and immobile object model. However, at the final two testing sessions, preschoolers *yes/no* response patterns to the alive question was not significantly closer to adult model than chance and their response patterns were significantly closer to the animal model than to the adult model or the other hypothetical models.

Spatial representation of change in preschoolers' alive response pattern. To further investigate how preschoolers' *yes/no* response patterns to the alive question changed over the course of the study, I created MDS plots. Figure 16a represents how adults' treated the stimulus exemplars in relation to each other based on their *yes/no* responses to the alive question. The adults' MDS plot illustrates how adults largely form two groupings, animal and plant stimulus exemplars in one group and mobile and immobile stimulus exemplars in a group distinct from the animal and plant exemplars. Figure 16b and 16c represent how the preschooler sample treated the stimulus exemplars in relation to each other when the preschoolers were younger (pre-median age split) and when the preschoolers were older (post-median age split), respectively.

The MDS plots help to illustrate the change in preschoolers' response pattern to the alive question over time. At the earlier ages preschoolers evidenced a fair deal of spread between all the stimulus exemplars (see Figure 16b). A degree of overlap between the stimulus exemplars was evident and immobile stimulus exemplars were at one end moving into the plant exemplars, followed by the mobile exemplars, followed by the then animal exemplars. Thus, it appeared that at earlier ages, preschoolers broadly distinguish the exemplars based on *mobility* with the immobile and plant exemplars treated more similarly relative to the mobile and animal exemplars. With age preschoolers no longer broadly distinguish the exemplars based on mobility but began to clearly treat the animal exemplars as separate from the other three classes of object (see Figure 16c).

Across Phase Analyses

In addition to examining preschoolers' response patterns at each phase and in each domain of understanding, I was interested in examining whether preschoolers' response patterns in one phase or in one area of understanding mapped onto responding in another phase or domain of understanding. If preschoolers' responding within a particular phase mapped onto responding in another phase, this would demonstrate some degree of structural organization in their living kinds conceptualization. Such findings would indicate that a conceptual framework is in place in the preschool period that can be applied by preschoolers when making statements about different classes of objects and when they answer questions about biological and psychological processes as well as attribute "alive" to different classes of objects. Thus, to more thoroughly investigate the structural organization of preschoolers' living kinds concept, I used HLM to determine whether responding in one phase or one domain of understanding predicted responding in another phase or domain of understanding.

Across Phase Analyses: Phase 1 Statements Generated with Phase 2 Biological Property Questions

To investigate the relationship between the absolute count of "correct" type statements made in Phase 1—biological statements for animal and plant classes and functional statements for mobile and immobile classes—and a more adult-like response pattern to the biological property questions in Phase 2, I employed HLM analyses. These analyses targeted the following questions: Did preschoolers who appropriately applied biological statements to the animal or plant classes in Phase 1 also respond in more adult-like fashion to the biological processes questions in Phase 2? Did preschoolers who appropriately applied functional statements to the mobile or immobile classes in Phase 1 also respond in more adult-like fashion to the biological questions in Phase 2? Results revealed that increases in the absolute count of biological type statements made about the *plant class* in Phase 1 predicted a more adult-like response pattern to the biological property questions in Phase 2, $t(115.828) = -3.459$, $p = .001$, $b = -2.815$. The slope of -2.815 indicates that for each additional biological statement made for the plant class in Phase 1, there was an average increase of 2.185 (out of the possible 95.53 range) units towards a more adult-like response pattern to the biological property questions in Phase 2. No additional associations were significant: biological statements for animals, $t(125.547) = .431$, $p = 667$, $b = .164$; functional statements for mobiles, $t(116.339) = -.596$, $p = .570$, $b = .-543$; functional statements for immobiles, $t(127.208) = .511$, $p = .610$, $b = .4233$. In this model, the biological response pattern intercepts significantly varied across preschoolers when the number of correct type statements was centered at the mean for each object class, Wald $Z = 2.067$, $p = .019$, var= 86.490.

Next, I looked at the relationship between "incorrect" type statements made in Phase 1—biological statements for mobile and immobile classes and functional statements for animal and plant classes—and a more adult-like response pattern to the biological property questions in Phase 2. These analyses targeted the following questions: Did preschoolers who inappropriately applied biological statements to the mobile or immobile classes in Phase 1 also respond in less adult-like fashion to the biological processes questions in Phase 2? Did preschoolers who inappropriately applied functional statements to the plant class in Phase 1 also respond in less adult-like fashion to the biological questions in Phase 2? HLM analyses revealed no significant associations: functional statements for animals, $t(111.467) = .424$, $p = .672$; functional statements for plants, $t(118.711) = .561$, $p = .576$; biological statements for mobiles, $t(121.153) = -.100$, $p = .920$; biological statements for immobiles, $t(127.924) = -488$, $p = .626$. In this model, the biological response pattern intercepts significantly varied across preschoolers when the number of incorrect type statements was centered at the mean for each object class, Wald $Z = 2.109$, $p = .018$, var= 102.337.

Across Phase Analyses. Phase 1: Statements Generated with Phase 2: Psychological Property Questions

To investigate the relationship between the absolute count of "correct" type statements made in Phase 1—biological statement for animal and plant classes and functional statements for mobile and immobile classes—and a more adult-like response pattern to the psychological property questions in Phase 2, I employed HLM analyses. These analyses targeted the following questions: Did preschoolers who appropriately applied biological statements to the animal or plant classes in Phase 1 also respond in more adult-like fashion to the psychological processes questions in Phase 2? Did preschoolers who appropriately applied functional statement to the mobile or immobile classes in Phase 1 also respond in more adult-like fashion to the psychological questions in Phase 2? Results revealed that an increase in the absolute count of biological type statements made for the *animal class* in Phase 1 predicted a more adult-like response patterns to the biological property questions in Phase 2, $t(118.790) = -2.302$, p .023, $b = -.688$. The slope of -.688 indicates that for each additional biological statement made for the animal class in Phase 1, there was an average increase of .688 (out of the possible 97.14 range) units towards a more adult-like response pattern to the psychological property questions in Phase

2. No additional associations were significant: biological statements for plants, $t(108.524) = -1.110$, $p = .269$; functional statements for mobile, $t(108.913) = .304$, $p = .762$; functional statements for immobile $t(121.676) = 1.023$, $p = .308$. In this model, the psychological response pattern intercepts significantly varied across preschoolers when the number of correct type statements was centered at the mean for each object class, Wald $Z = 2.672$, $p = .004$, var = 99.376.

Next, I looked at the relationship between “incorrect” type statements made in Phase 1—biological statements for mobile and immobile classes and functional statements for animal and plant classes—and a more adult-like response pattern to the psychological property questions in Phase 2. These analyses targeted the following questions: Did preschoolers who inappropriately applied biological statements to the mobile or immobile classes in Phase 1 also respond in less adult-like fashion to the psychological processes questions in Phase 2? Did preschoolers who inappropriately applied functional statements to the animal or plant classes in Phase 1 also respond in less adult-like fashion to the psychological questions in Phase 2? HLM analyses revealed that an increase in the absolute count of functional type statements made for the *animal class* in Phase 1 predicted *less* adult-like response pattern to the psychological property questions in Phase 2, $t(105.858) = 2.138$, $p = .035$, $b = 6.456$. The slope of 6.456 indicates that for each additional functional statement made for the animal class in Phase 1, there is an average decrease of 6.456 (out of the possible 97.14 range) units towards a *less* adult-like response pattern to the psychological property questions in Phase 2. No other significant associations emerged: functional statements for plants, $t(111.464) = -.853$, $p = .395$; biological statements for mobiles, $t(113.468) = -1.463$, $p = .146$; biological statements for immobiles, $t(124.697) = -1.256$, $p = .211$. In this model, the psychological response pattern intercepts significantly varied across preschoolers when the number of incorrect type statements was centered at the mean for each object class, Wald $Z = 2.831$, $p = .002$, var = 108.474.

Across Phase Analyses. Phase 1: Statements Generated with Phase 3: Alive Question

To investigate the relationship between the absolute count of "correct" type statements made in Phase 1—biological statements for animal and plant classes and functional statements for mobile and immobile classes—and a more adult-like response pattern to the alive question in Phase 3, I employed HLM analyses. These analyses targeted the following questions: Did preschoolers who appropriately applied biological statements to the animal or plant classes in Phase 1 also respond in more adult-like fashion to the alive question in Phase 3? Did preschoolers who appropriately applied functional statements to the mobile or immobile classes in Phase 1 also respond in more adult-like fashion to the alive question in Phase 3? HLM analyses revealed that increases in the absolute count of functional type statements made for the *mobile class* in Phase 1 predicted a more adult-like response pattern to the alive question in Phase 3, $t(113.700) = -2.246$, $p = .027$, $b = -.616$. The slope of -.616 indicates that for each additional functional statement made for the mobile class in Phase 1, there was an average increase of .616 (out of the possible 34.70 range) units towards a more adult-like response pattern to the alive question in Phase 2. No other significant associations emerged: biological statements for animals, $t(122.965) = 1.404$, $p = .163$; biological statements for plants, $t(113.276) = -.571$, $p = .569$; functional statements for immobile, $t(125.229) = .725$, $p = .470$, the alive response pattern intercepts significantly varied across preschoolers when the number of correct type statements was centered at the mean for each object class, Wald $Z = 2.492$, $p = .006$, var= 10.042.

Next, I looked at the relationship between "incorrect" type statements made in Phase 1—biological statements for mobile and immobile classes and functional statements for animal and plant classes—and a more adult-like response pattern to the alive question in Phase 3. These analyses targeted the following questions: Did preschoolers who inappropriately applied biological statements to the mobile or immobile classes in Phase 1 also respond in less adult-like fashion to the alive question in Phase 3? Did preschoolers who inappropriately applied functional statements to the animal or plant classes in Phase 1 also respond in less adult-like fashion to the alive question in Phase 3? HLM analyses revealed that an increase in the absolute count of biological statements made for the *mobile class* in Phase 1 predicted a *less* adult-like response pattern to the alive question in Phase 3, $t(120.424) = 2.068$, $p = .041$, $b = .609$. The slope of .609 indicates that for each additional biological statement made for the mobile class in Phase 1, there is an average decrease of .609 (out of the possible 34.70 range) units towards a less adult-like response pattern to the alive question in Phase 2. No other significant associations emerged: functional statements for animals, $t(111.262) = -.836$ $p = .405$; functional statements for plants, $t(118.091) = .843$, $p = .401$; biological statements for immobiles, $t(127.998) = -.127$, $p = .899$, the alive response pattern intercepts significantly varied across preschoolers when the number of incorrect type statements was centered at the mean for each object class, Wald $Z = 2.270$, $p = .012$, var = 8.656.

In summary, analyses mapping preschoolers' responding in Phase 1 with their responding in Phases 2 and 3 revealed the following general results: 1) preschoolers who made more biological statements for the plant class in Phase 1 also responded in more adult-like fashion to the biological property questions in Phase 2; 2) preschoolers who made more biological statements for the animal class in Phase 1 also responded in more adult-like fashion to the psychological property questions in Phase 2; 3) preschoolers who made more functional statements for the animal class in Phase 1 responded in a *less* adult-like fashion to the psychological property questions in Phase 2; 4) preschoolers who made more functional statements for the mobile class in Phase 1 responded in a more adult-like fashion to the alive question in Phase 3; and finally 5) preschoolers who made more biological statements for the mobile class in Phase 1 responded in a *less* adult-like fashion to the alive question in Phase 3.

Across Phase Analyses. Phase 2: Biological Property Questions with Phase 3: Alive Question

To investigate the relationship between a more adult-like response pattern to the biological property questions in Phase 2 and a more adult-like response pattern to the alive question in Phase 3, I employed an HLM analysis. This analysis targeted the following question: Did preschoolers who responded in more adult-like fashion to the biological questions in Phase 2 also respond in more adult-like fashion to the alive question in Phase 3? HLM analysis revealed that a more adult-like response pattern to the three biological property questions in Phase 2 predicted a more adult-like response pattern to the alive question in Phase 3, $t(130.944) = 4.945$, $p < .001$, $b = -.112$. The slope of .112 indicates that for each unit the average preschoolers' biological difference matrix became more similar to adults' biological difference matrix there is a .112 unit increase (out of the possible 34.70 range) in the similarity of the average preschoolers' alive difference matrix to the adults' alive difference matrix. In this model, the alive response pattern intercepts significantly varied across preschoolers when biological response pattern was centered at the mean for each object class, Wald $Z = 2.146$, $p = .016$, var = 6.639.

Across Phase Analyses. Phase 2: Psychological Property Questions with Phase 3: Alive Question

To investigate the relationship between a more adult-like response pattern to the psychological property questions in Phase 2 and a more adult-like response pattern to the alive question in Phase 3, I employed an HLM analysis. This analysis targeted the following question: Did preschoolers who responded in more adult-like fashion to the psychological questions in Phase 2 also respond in more adult-like fashion to the alive question in Phase 3? HLM analysis revealed that a more adult-like response pattern to the three psychological property questions in Phase 2 did *not* predict a more adult-like response pattern to the alive question in Phase 3, $t(129.571) = 1.524$, $p = .130$, $b = .047$. Although nonsignificant, a change in slope of .047 indicates that for each unit the average preschoolers' psychological difference matrix became more similar to adults' psychological difference matrix there was a .047 unit decrease (out of the possible 34.70 range) in the similarity of the average preschoolers' alive difference matrix to the adults' alive difference matrix. In addition, alive response pattern intercepts significantly varied across preschoolers when psychological response pattern was centered at the mean for each object class, Wald $Z = 2.137$, $p = .016$, var = 8.290.

In summary, analyses mapping preschoolers' responding in Phase 2 with their responding in Phase 3 revealed the following general results: 1) preschoolers who responded in more adult-like fashion to the biological property questions in Phase 2 also responded in more adult-like fashion to the alive question in Phase 3, and 2) preschoolers who responded in more adult-like fashion to the psychological property questions did *not* respond in more adult-like fashion to the alive question in Phase 3.

Qualitative Data

I randomly assigned ten preschoolers to the qualitative condition which involved my asking these preschoolers an additional eight open-ended questions in order to gain insight into the reasoning behind their responses in Phases 2 and 3. I asked six questions—"How do you know something needs water?" "How do you know something can grow?" "How do you know something needs food?" "How do you know something can feel happy?" "How do you know something can remember yesterday?" and "How do you know something can think thoughts?"—in a random order after Phase 2 at each testing session. I asked two questions—"How do you know something is alive?" and "Can you list some things that are alive?"— after Phase 3 at each testing session.

The same four trained research assistants that coded Phase 1 statements also coded the preschoolers' responses to the qualitative questions. Upon completion of Testing Session 1, the four research assistants and I created a coding scheme that best captured the type of answers given to the qualitative questions. Upon completion of each additional testing session, the research assistants met and I to determine if the coding scheme required updating based on the answers given to the qualitative questions. When the coding scheme was updated, coders reevaluated their previously assigned codes based on the updated coding scheme. One research assistant, extensively trained in coding, checked all the codes assigned by the other three research assistants. When disagreements arose, the research assistants met to discuss and come to agreement as to what code best characterized the statement.

Comparing the qualitative subsample to the larger sample

To ensure that there was not a significant difference between the qualitative subsample of preschoolers and the non-qualitative sample, I examined whether there was a significant difference in the number of Phase 1 statements generated at each testing session (See Table 10 for means and standard deviations). At each testing session, there was no significant difference between the number of statements made in Phase 1 by the qualitative and non-qualitative subsamples. TS1, $t(33) = -.405$, $p = .656$, 95% CI -10.390, 6.625]; TS2, $t(33) = -.073$, $p = .942$, 95% CI -8.660, 8.060]; TS3, $t(30) = -.555$, $p = .583$, 95% CI [-15.020, 8.590]; TS4, $t(29) = -1.118$, $p = .273$, 95% CI [-15.873, 4.656].

Next, I examined whether there was a significant difference between the qualitative subsample of preschoolers and the non-qualitative preschoolers in the degree of correspondence to the adult model in Phases 2 and 3 and found no significant differences. See Table 11 for the absolute difference between preschoolers' and adults' response patterns to the biological, psychological and alive questions, means and standard deviations. Thus, the qualitative subsample of preschoolers was representative of the entire sample and participating in the qualitative condition did not influence or alter the preschoolers' response pattern in Phases 1, 2 or 3.

Qualitative results

In response to the qualitative questions, preschoolers overwhelmingly offered answers of two general types. For the Exemplar-Type of answer, preschoolers offered an example of an object that engages in the process being asked about. For example, given the question "How do you know something needs water?" an Exemplar-Type answer would be "a plant does." For the Reference-Type of answer, preschoolers referred to an aspect of an object that can be considered biological or psychological. For example, given the question "How do you know something can grow?," a biological Reference-Type answer would be:, "because it can die" (biological property), "because it growls" (biological action), or "its leaves can grow" (biological part of an object), A psychological Reference-Type answer would be, for example, “because it has imagination,” or “because it wants to scare people,” or any statement that involves emotions, thoughts, memories, or intentions. Figure 17 presents the type of answers offered by the preschoolers in the qualitative condition.

I examined the number of the two types of answers offered by the preschoolers in the qualitative condition at each testing session (see Figures 18 – 21). I was also interested in comparing how preschoolers answered the qualitative questions compared to how the adult sample answered the same qualitative questions (see Figure 22 for the number of the types of answers offered by adults to the qualitative questions).

Answers to the biological qualitative questions. Two general patterns emerged after examining the different types of answers preschoolers offered to the biological qualitative questions at each testing session. First, preschoolers offered “plants” as exemplars for the biological qualitative questions at a higher rate than they did for the psychological, alive or alive list qualitative questions which indicated that preschoolers in my sample understood plants as biological entities but did not construe plants as psychological entities or as entities that are alive. Similarly, the adult sample offered “plants” as exemplars for the biological and alive qualitative questions at higher rates than the psychological qualitative questions.

Second, preschoolers offered “animals” as exemplars for the biological qualitative questions at a higher rate than they did for the psychological qualitative questions at the first two testing sessions. However, at Testing Sessions 3 and 4, preschoolers offered “animals” more equally for both the biological and psychological qualitative questions, which indicated that preschoolers in my sample initially understood animals as biological entities and only later understood animals as also psychological entities. In contrast, the adult sample equally offered "animals" as exemplars of biological and psychological entities.

Answers to the psychological qualitative questions. Two general themes emerged after examining the different types of answers preschoolers offered to the psychological qualitative questions at each testing session. First, preschoolers offered "humans" as exemplars for the psychological qualitative questions at a higher rate than they did for the biological qualitative questions at the first two testing sessions. However, at Testing Session 3 preschoolers dramatically reduced the number of "humans" offered as exemplars (from 9 to 1) and at Testing Session 4 did not offer "human" as exemplars for the psychological qualitative questions. These results indicated that initially preschoolers in the qualitative subsample understood humans as psychological entities but with age did not offer humans as examples of psychological entities. In contrast, the adult sample offered "humans" as examples of both biological and psychological entities.

Second, it was not until Testing Session 2 that preschoolers began referencing psychological properties when asked the three psychological qualitative questions. In contrast, the preschoolers never referenced psychological properties when answering the biological qualitative questions. These results indicated that preschoolers broadly distinguish psychological processes from biological processes. Adults also referenced psychological properties when answering the psychological qualitative questions but did not when answering the biological qualitative questions.

Answers to the alive qualitative question. A general theme emerged after examining the different types of answers preschoolers offered to the alive qualitative question at each testing session. At the first three testing sessions, preschoolers offered both Exemplar and

Reference-type statements when asked the alive qualitative question. However, by Testing Session 4, preschoolers no longer offered Exemplar-type statements for the alive qualitative question and only offered Reference-type statements. Referencing biological or psychological processes as an answer to, "How do you know something is alive?" is a more appropriate type of answer than to offer exemplars that are alive. The adult sample overwhelmingly (35 vs. 7, see Figure 22) made Reference-type statements in response to the alive qualitative questions. These results indicated that preschoolers in my sample demonstrated an increased sophistication in their understanding of alive by appropriately applying only Reference-Type answers to the alive question at the final testing session.

Answers to the alive list question. Two general themes emerged after examining the different types of answers preschoolers offered to the alive list qualitative question at each testing session. First, at the first three testing sessions, preschoolers offered both Exemplar-type and Reference-type statements when asked the alive list qualitative question. However, by Testing Session 4, preschoolers no longer offered Reference-type statements for the alive list qualitative question and only offer Exemplar-type statements. Offering exemplars of objects that are alive when asked, "Can you list some things that are alive?" is a more appropriate type of answer than to reference a biological or psychological process. The adult sample overwhelmingly (107 vs. 1, see Figure 22) made Exemplar-type statements in response to the alive list qualitative questions. These results indicate that preschoolers in my sample demonstrated an increased sophistication by appropriately applying only Exemplar-type answers to the alive list qualitative question by the final testing session.

Second, at each testing session, preschoolers overwhelmingly offered "animals" as exemplars when asked to list things that are alive (followed by humans, plants, person-made objects, ambiguous items, and fictional characters). Interestingly, there was a dramatic increase in number of "animal" exemplars offered at Testing Session 4 (from 17 at Testing Session 3 to 34 at Testing Session 4, see Figures 20 and 21). In addition, preschoolers offered "humans" as exemplars of objects that are alive pretty equally across each testing session. At the first three testing sessions, preschoolers offered "plants" as exemplars of objects that are alive; however, preschoolers did not offer "plants" as exemplars of objects that are alive at Testing Session 4. These results indicate that preschoolers initially understood "animals" as alive and with age increasingly conceptualized animals as alive. At the same time, preschoolers understood that "humans" are alive but there did not appear to be a shift in this understanding with age. Preschoolers also initially understood plants as alive but did not list plants as objects that are alive at the last testing session. The majority of things listed by the adult sample as alive were animals, followed by plants then humans.

Discussion

This study was designed to examine the structural organization of preschoolers' living kinds concept and the nature of developmental change in that concept from roughly 3.5- to 4.5-years-old. To what extent is preschoolers' living kinds conceptualization structured and to what extent does this organization undergo structural change during the preschool period? Through the use of a longitudinal design, alternate means of indexing preschoolers' conceptualization, and converging statistical analyses, the current study offers more comprehensive evidence regarding the nature of developmental change in preschoolers' living kinds concept. The first analytic strategy I employed involved examining preschoolers' responding within different testing contexts and domains of living kinds understanding over developmental time. The second analytic strategy I employed involved examining interrelations among preschoolers' responding across testing contexts and domains of understanding, but collapsed across age in the sample. Both analytic strategies yielded the same overall conclusion and, in general, support the core competence approach, suggesting that certain aspects of the biological framework are already in place early in the preschool period. However, my findings also qualify the core competence approach by demonstrating that conceptual reorganization does indeed occur during the preschool period and that, therefore, cognitive development is not simply the elaboration of an existing skeletal conceptual framework. More specifically, I found that in different testing contexts, preschoolers demonstrated different levels of understanding and that the pattern of development observed involved both progressive elaboration of an existing biological framework *and* organizational restructuring. In other words, the understanding that preschoolers between 3.5 and 4.5 years evidenced in different testing contexts and different domains (biological, psychological) had not yet fully integrated into an organizationally structured living kinds conceptualization, suggesting that qualitative reorganization characterizes aspects of preschoolers' living kinds conceptual development.

Different Testing Contexts, Differential Developmental Patterning and Levels of Understanding

By examining preschoolers' responding in different testing contexts and tracing the development in each context over the course of the year-long study, I found that depending on the methodology employed, preschoolers demonstrated different levels of understanding and that the type of development (elaboration of an existing mature framework or conceptual reorganization) that occurred largely depended on what domain of understanding (biological, psychological) was under investigation. This study employed two primary means of indexing preschoolers living kinds conceptualization—asking preschoolers to generate information (Phase

1 and Qualitative responding) and asking preschoolers *yes/no* questions (Phases 2 and 3 responding). When asked to generate information, children demonstrated that they largely distinguish living things from nonliving things, which suggests that a biologically based skeletal framework is in place early in the preschool period. However, gaps in preschoolers' thinking were also evident, suggesting that aspects of a biologically based skeletal framework have not yet been constructed during the preschool period. Furthermore, when preschoolers were asked *yes /no* questions about objects of different classes, they showed even more dramatically the extent to which living kinds conceptual development in the preschool period involves qualitative reorganization, not just quantitative elaboration of a core conceptual framework.

Phase 1 results revealed that preschoolers applied biological statements to the animal and plant classes and applied functional statements to the immobile class at each testing session; however, preschoolers were less clear on what type of statements should be applied to the mobile class. Thus, when generating information about different classes of objects, preschoolers demonstrated a broad distinction between living and nonliving kinds by appropriately applying biological statements to living kinds and appropriately applying functional statements to nonliving immobile kinds. These results largely support the core competence view and disconfirm Carey's (1985) assertion that preschoolers do not possess a biologically based skeletal framework for understanding the living world. In addition, the finding that preschoolers applied biological statements to plants which were displayed motionless does not support Piaget's (1929) theory because plants appearing motionless did not hinder preschoolers' understanding of plants as biological entities. However, the distinction preschoolers made between living and nonliving kinds broke down when they were asked to consider mobile objects for which they made a similar number of biological and functional statements at Testing Sessions

1, 2 and 4. This result lends some support to Piaget's (1929) theory that preschoolers conflate livingness with motion because preschoolers, in general, did make more biological statements when viewing mobile artifacts than immobile artifacts, as if the motion displayed by the mobile objects caused children to think about them in more biological terms than the immobile objects that were displayed motionless. Yet, at testing session 3, preschoolers made more functional statements than mobile statements for the mobile object. Although, this shift in the type of statements generated for mobile objects was not evident at the final testing session (possibly reflecting a bit of regression following a transition) it still points to the possibility that structural reorganization in thinking about mobile objects occurred by the latter testing sessions.

The qualitative results revealed that the subsample of preschoolers—who were asked eight open-ended questions in order to examine how they know whether an object engages in biological and psychological properties or is alive—appropriately offered Exemplar-type statements or Reference-type statements at each testing session. Preschoolers predominately referenced animals, plants and humans as examples of objects that are alive. Preschoolers also referenced artifacts (i.e., a chair) as examples of an object that is *not* biological, psychological or alive. In addition, preschoolers predominately referenced other biological or psychological properties when asked how they know an object engages in biological, psychological properties or is alive. Furthermore, at the final testing session preschoolers offered only Reference-type statements to the question, "How do you know something is alive?" and only offered Exemplar-type statements to the question, "Can you list things that are alive?" This pattern of answers to the qualitative questions that preschoolers displayed at the final two testing sessions is strikingly similar to the pattern of answers offered by our adult sample. By appropriately offering Exemplar-type and Reference-type statements and by differentially offering the most appropriate type of statements to the alive qualitative questions at the final testing session, preschoolers demonstrated that when they are given the opportunity to generate information they do broadly distinguish between living and nonliving kinds, which supports the core competence view. However, these results also point to a structural reorganization occurring in preschooler's living kinds concept occurring between the third and fourth testing session, specifically in preschoolers' understanding of "alive."

Thus, preschoolers showed that they largely distinguish between living and nonliving kinds when given the opportunity to generate statements but also demonstrated some confusion in fully demarcating the division between the living and person-made objects. In the context of preschoolers' responses to *yes/no* questions about objects' biological and psychological properties, preschoolers showed even greater variability and marked deviations from adult living kinds conceptualization. Specifically, preschoolers in Phase 2 ran the gamut from exhibiting organizationally stable conceptualization across developmental time, progressive elaboration of an existing biological framework, and robust conceptual reorganization between 3.5 and 4.5 years.

With respect to preschoolers' biological property understanding over the course of the study, the developmental patterning that emerged can be characterized as *both* conceptual reorganization and a progressive elaboration of an existing, biologically based skeletal framework. Preschoolers' understanding of biological properties did become increasingly adult-like over the four testing sessions but also transitioned from chance level responding at the first two testing sessions to significant departures from chance and closer alignment with the adult model at the final two testing sessions. This suggests a potential conceptual reorganization between the first and second pairs of testing sessions—going from reduced, inconsistent evidence for a biologically based framework (via chance level responding) to clear evidence for a biologically based framework (moving closer to the adult model than chance). MDS results, however, indicate that preschoolers' biological property understanding involves the progressive elaboration of a biologically based skeletal framework between 3.5 and 4.5 years. The MDS plots, before and after the median age split (see Figure 11), demonstrate that even at the earliest ages studied, preschoolers were broadly distinguishing living things from nonliving things and that with age preschoolers more clearly distinguished living things from nonliving things, suggesting that a biologically oriented skeletal framework is already in place early in the preschool years. Nonetheless, preschoolers' understanding of biological properties at the first two testing sessions equally mapped onto both the adult model and the animal model of responding, transitioning to being similar only to the adult model by the final two testing sessions. This suggests that preschoolers' biological property understanding does undergo some degree of reorganization between 3.5 and 4.5 years, evidenced by a shift from an understanding that only animals engage in biological properties and that plants, mobile and immobile objects do not toward a more adult-like conception of biological properties which positions both animals and plants as engaging in biological processes, in contrast to both mobile and immobile objects. That preschoolers broadly distinguished living things from nonliving things in terms of biological processes by grouping animals and plants together and contrasting them with mobile and immobile objects does not support Piaget's (1929) theory that preschoolers conflate livingness with mobility, at least in terms of biological properties. These results also do not support Carey's (1985) theory that preschoolers lack a biologically based framework for understanding living kinds. However, these results do point to some form of qualitative reorganization taking place in preschoolers' living kinds conceptualization between 3.5 and 4.5 years.

With respect to preschoolers' psychological understanding (Phase 2 responding) over the course of the study, the developmental patterning that emerged can be characterized as relatively stable and conceptually mature. At each testing session, preschoolers' psychological understanding was significantly closer to adults' psychological understanding than chance, was more similar to the adult model than to any of the hypothetical models, and did not evidence significant development over the course of this study, suggesting that a relatively mature skeletal conceptual framework is already in place at 3.5 years. The MDS plots on preschoolers' psychological understanding, before and after the median age split (see Figure 13), demonstrate that even at the earliest ages, preschoolers were broadly distinguishing living things from nonliving things and that with age preschoolers were assigning psychological properties to the animal class yet not to the plant, mobile or immobile classes. The MDS results further suggest that development in preschoolers' psychological understanding between 3.5 and 4.5 years is best characterized as progressive elaboration of a relatively mature skeletal framework, one which involves a broad distinction between classes of objects based on whether the class is alive or not and later becomes more adult-like by restricting the assignment of psychological properties to animals only, a subclass of living kinds.

With respect to preschooler's understanding of the concept "alive" (Phase 3 responding) over the course of the study, the developmental patterning that emerged can be characterized as conceptual reorganization. Preschoolers' understanding of "alive" became increasingly adult-like over the four testing sessions by going from significantly further from adults' responding than chance at the first two testing sessions to not significantly different than chance at the last two testing sessions, transitioning from clear evidence for a conceptual framework that was qualitatively distinct from an adult model (below chance level responding) toward no systematic evidence for a biologically based conceptual framework (chance level responding). More specifically, at the first two testing sessions, preschoolers' understanding of alive equally mapped onto the immobile model and the animal model yet at the final two testing sessions mapped predominantly onto the animal model. In addition, the MDS plots on preschoolers' understanding of alive, before and after the median age split (see Figure 16), demonstrate that at the earliest ages, preschoolers were broadly distinguishing the object classes based on *mobility* by grouping mobile things (animals and mobile objects) as distinct from immobile things (plants and immobile objects). With age, preschoolers no longer broadly distinguished the classes based on mobility and instead began to clearly treat the animal exemplars as separate from the other three classes of objects. Taken together, these results underscore the conceptual reorganization that takes place in the development of preschoolers' understanding of alive between 3.5 and 4.5 years, characterized by shifting from a framework in which things that move are alive toward a framework in which animals are alive but plants, mobile and immobile objects are not. These results lend some support to Piaget's (1929) theory because they suggest that at younger ages, preschoolers broadly distinguish living and nonliving kinds' exemplars based on *mobility*; by the last two testing sessions, preschoolers had corrected this error and had begun to group the mobile objects with the immobile objects, no longer distinguishing exemplars based on mobility. But even by 4.5 years, preschoolers were still appealing to an animal model in their understanding of "alive," suggesting that further conceptual reorganization needs to take place before a biologically based framework is in place for the concept of alive.

Depending on the methodology employed (statement generation vs. *yes/no* responding), preschoolers demonstrated different levels of understanding. When asked to generate information in response to seeing an object (Phase 1 responding) children demonstrated that they broadly distinguish living things from nonliving things by grouping plants and animals and distinguishing them from immobile objects. However, preschoolers also demonstrated some conceptual confusion when asked to reason about mobile objects by not clearly grouping them with immobile objects and not clearly distinguishing them from living things. In addition, when asked open-ended questions about biological and psychological processes and livingness (Qualitative responding), preschoolers, in general, demonstrated organizationally structured understanding consistent with adult thinking. Yet, even when generating statements, some evidence for structural reorganization exists. In Phase 1, at testing session 3 preschoolers made a shift in the type of statements they made for the mobile objects by appropriately making more functional than biological statements. In the qualitative conditions, there is a clear transition in understanding between the third and fourth testing sessions in regard to the alive qualitative questions, demonstrated by the shift in the type of answers offered by preschoolers becoming more adult-like. Thus, even in the context of generating statements, structural reorganization in preschoolers' living kinds conceptualization is evident by shifts in the type of statements they make at the final testing sessions. When preschoolers were asked *yes/no* questions about objects of different classes (Phases 2 and 3 responding), results did not reveal the same level of conceptual development as when they generated information and even more strongly suggest that conceptual reorganization occurs in preschoolers' living kinds concept between 3.5 and 4.5 years old.

Furthermore, the type of development evidenced depends largely on the domain of understanding (biological or psychological) that is under investigation. When examining the domain of biological understanding by specifically examining preschoolers' understanding of biological properties (growth, needing water and food) and the property of alive, both conceptual reorganization as well as progressive elaboration of an existing biological framework is evidenced. In the domain of psychological understanding, preschoolers did *not* evidenced significant development; however, results indicate that by roughly 3.5-years-old, preschoolers' already possess a relatively mature skeletal framework. Thus, some aspects of preschoolers' living kinds conceptual development are characterized by progressive elaboration of an existing skeletal biological framework and other aspects of development are characterized by reorganization of conceptual structures. Overall, these findings suggest that a biological framework for understanding the living and nonliving kinds concept is still being developmentally constructed between the ages of roughly 3.5- to 4.5-years-old and that it is not until after 4.5 years that an organizationally structured and stable living kinds concept emerges across multiple contexts and domains of understanding.

Relations Across Testing Contexts and Domains of Understanding: Evidence for Both Structured Organization and Fragmentation

To further investigate the nature of structural organization in preschoolers' living kinds concept, I examined whether preschoolers' responding in one testing context or domain of understanding predicted responding in another testing context or domain of understanding, collapsed across developmental time. If preschoolers evidenced appropriately (e.g., adult-like) structured conceptual organization across testing contexts, this would lend some support to the core competence approach by indicating that a biologically based conceptual framework is in place and can be applied both when making statements about different classes of objects and when answering questions about biological and psychological processes as well as about whether an object is alive. If on the other hand, children's responding in one testing context or one domain of understanding was not related to their responding in another testing context or domain of understanding, this would suggest that preschoolers' understanding of the living world is fragmented and lacks broad structural organization, contrary to the core competence view. Furthermore, if children's responding in one testing context was related to responding in another but not in a way consistent with adult responding, this would suggest that preschooler's understanding of the living world is still qualitatively distinct in important ways from that of adults. Results from examining preschoolers' responding across testing contexts and domains of understanding reinforce the idea that preschoolers' living kinds concept is *both* appropriately organizationally structured and fragmented/qualitatively distinct in its structuring during the developmental period between 3.5 and 4.5 years.

Evidence for appropriately structured organization in preschoolers' living kinds concept came from the following results: (1) preschoolers who made more biological type statements for the plant class also had a *more* adult-like understanding of biological properties; (2) preschoolers who made more biological type statements for the animal class had a *more* adult-like understanding of psychological properties, and those who made more functional statements for the animal class had a *less* adult-like understanding of psychological properties; (3) preschoolers who made more functional statements for the mobile class had a *more* adult-like understating of alive, and those who made more biological statements for the mobile class had a *less* adult-like understanding of alive; and (4) preschoolers whose biological understanding was more adult-like also had a more adult-like understanding of alive. In contrast, evidence for conceptual fragmentation/qualitatively distinct structuring in preschoolers' living kinds concept came from the following results: (1) preschoolers who had a more adult-like understanding of biological properties had a *less* adult-like understanding of psychological properties; and (2) preschoolers whose psychological understanding was more adult-like did *not* have a more adult-like understanding of alive.

Thus, the different types of statements (biological or functional) preschoolers' generated for the four classes of objects in Phase 1 differentially mapped onto their understanding of biological, psychological and livingness understanding in Phases 2 and 3—with preschoolers understanding of plants in Phase 1 being related to their biological understanding in Phases 2, their understanding of animals in Phase 1 related to their psychological understanding in Phase 2, and their understanding of mobile objects in Phase 1 related to their alive understanding in Phase 3. Furthermore, preschoolers' understanding of biological properties in Phase 2 was not associated with their understanding of psychological properties in Phase 2, and their understanding of biological properties in Phase 2 mapped on to their understanding of alive in Phase 3, but their understanding of psychological properties in Phase 2 did not map on to their understanding of alive in Phase 3. Overall, these results lend some support to the core competence approach by indicating that a degree of structured conceptual organization is in place during the preschool period. However, these results also qualify the core competence approach by indicating that certain aspects of an adult-like biological framework are not yet in place during the preschool period.

To further examine the extent to which preschoolers' living kinds concept is structured and systematic, I looked at the rate of change that took place over the year-long study in each domain of understanding—biological and psychological. If the rate of change was relatively consistent across the two domains of understanding, this would lend further support to the view that a structured conceptual organization is present during the preschool period. If on the other hand, the rate of development differed between the two domains of understanding, this would lend support to the view that conceptualization fragmentation better characterizes the living kinds concept during the preschool period. In fact the rates of development during the course of the study varied depending on the domain under investigation. On average, preschoolers' biological property understanding became roughly 21% closer to adults' conceptualization while preschoolers' psychological property understanding became roughly 2% closer to adults' conceptualization. Thus, during this one year period, preschoolers' biological property understanding evidenced a greater rate of development relative to preschoolers' psychological property understanding, suggesting relative independence in the development of each domain of understanding between 3.5 and 4.5 years.

In summary, by examining preschoolers' responding across testing contexts and domains of understanding, as well as the rate of development within each domain of understanding, I found some evidence that a structured conceptual organization is in place, which supports the core competence view. However, I also found evidence that aspects of preschoolers' living kinds conceptualization are somewhat fragmented and lack integration across testing phases and domains of understanding, which lends support to the view that a biological framework is being constructed during this period rather than already in place.

Limitations and Future Directions

Perhaps the biggest limitations of the current study are its small sample size and limited number of testing sessions. These limitations require analyses to be conducted at the group level, with focus specifically on *inter*-individual variation, and thus can only speak to the average preschooler's living kinds conceptual development. For a true study of developmental change, one that taps into the central question of process—namely, *how* is a biologically based framework for understanding living and nonliving kinds constructed during childhood—*intra*-individual stability and change over time need to be the central focus of analysis. Furthermore, even with this study's more limited focus at the group level of analysis, its small sample size and limited number of testing sessions preclude systematic, quantitative efforts to chart actual growth functions in preschooler responding across time. And with respect to the second analytic strategy employed—namely, looking at the interrelations among indices and domains of conceptualization—insufficient sample size limited analyses to the sample as a whole, collapsed across age/testing sessions. Time simply could not be taken into consideration because the models failed to converge with the parameter of age included. To allow for *intra*-individual analyses and for a richer examination of the nature of developmental change in preschooler's living kinds concept (both at the group and individual levels), future work should include a larger sample size but more importantly, many more sampling points conducted with each child.

Another limitation of this study was the duration of the study. I tested preschoolers over the course of one year, beginning testing when they were roughly 3.5-years-old and completing testing when they were roughly 4.5-years-old. Had I began testing when children were younger, roughly 2.5-years old, I would have gained insight into the early developmental trajectories of different domains of living kinds understanding. Had I continued testing when the children were older, I would have been able to more fully map out the developmental trajectory of the living kinds concept. Future work should focus on developmentally extended longitudinal study of living kinds conceptualization in order to more fully elucidate the nature of both change and constancy in children's living kinds concept.

Conclusion

Despite these limitations, the current study extends previous research by offering a more complete assessment of the organizational structure in preschoolers' living kinds conceptualization and its potential developmental transformation, via (1) the utilization of a longitudinal design with four testing sessions conducted over the course of approximately one year; (2) the employment of a broad stimulus set and alternate indices of understanding; (3) inquiries of children to reason about different domains of the living kinds understanding (biological, psychological); (4) inquiries of a subset of preschoolers to gain insight into the reasoning behind their ascriptions of "alive" and particular biological or psychological properties to an object; (5) inquiries of children to generate a list of objects that are alive; and (6) employment of complementary analytic strategies. The design of the current study allowed me to investigate both developmental stability and transformation in the organizational structure of preschoolers' living kinds conceptualization between roughly 3.5 and 4.5 years of age and to evaluate the nature of its developmental patterning, comparing developmental models of both conceptual reorganization and elaboration of a core competence. Results both support and qualify the core competence approach to conceptual development by demonstrating that certain aspects of the biological framework are in place early in the preschool period while highlighting the fact that other aspects have not yet been constructed. My results further qualify the core competence approach by demonstrating that conceptual reorganization in living kinds conceptualization does indeed occur during the preschool period and is not simply the elaboration of an existing skeletal conceptual framework. Based on these results, I argue that a biologically based, skeletal framework for understanding the living world is being constructed during the preschool years and that for the field to move forward, we need to revise the current theoretical debate regarding the nature of developmental change in preschoolers' living kinds conceptualization. We need to move past asking whether living kinds conceptual development involves *either* progressive elaboration of an already mature, core skeletal conceptual frameworks *or* fundamental conceptual reorganization to instead appreciate how transformation and continuity, reorganization and elaboration, are complimentary processes that give rise to conceptual development.

Appendix A: Tables

Table 1

Procedure Summary

Phase	Stimuli	Question Type	Question	Response Types
1	16 objects (4/class)	Open Ended	What can you say about this thing?	Biological and functional type statements
2	12 objects (3/class)[a]	3 Biological Yes/No	"Does this one grow?" "Does this one need water?" "Does this one need food?"	Yes or no responses
		3 Psychological Yes/No	"Does this one think thoughts?" "Does this one feel happy?" "Does this one remember yesterday?"	
3	12 objects (3/class)[a]	1 Alive-Yes/No	"Is this thing alive?"	Yes or no responses
Qualitative[b]	N/A	3 Biological Open Ended (after phase 2)	"How do you know something can grow?" "How do you know something needs water?" "How do you know something needs food?"	Exemplar-type and Reference-type answers
		3 Psychological Open Ended (after phase 2)	"How do you know something can think thoughts?" "How do you know something can feel happy?" "How do you know something can remember?"	
		2 Alive Open Ended (after phase 3)	"How do you know something is alive?" "Can you list some things that are alive?"	

[a] The same 12 objects were used for both phase 2 and 3.
[b] Qualitative data was collected from the entire adult sample and a subset of the preschool sample.

Table 2
Number of Biological and Functional Statements Made by Preschoolers at Each Testing Session

	TS1(*N*=35)	TS2(*N*=35)	TS3(*N*=32)	TS4(*N*=31)
Animal				
Biological	240	290	344	309
Functional	6	1	3	5
Total	246	291	347	314
Plant				
Biological	135	185	188	192
Functional	16	8	0	9
Total	151	193	188	201
Mobile				
Biological	48	65	57	74
Functional	77	86	120	83
Total	125	151	177	157
Immobile				
Biological	27	33	19	13
Functional	90	147	152	147
Total	117	180	171	160
All Classes				
Biological	450	573	608	588
Functional	189	242	275	244
Total	639	815	883	832

Table 3

Phase 1: Total Biological and Functional Statements Made at Each Testing Session: Means and Standard Deviations

	TS 1		TS 2		TS 3		TS 4	
	M	SD	M	SD	M	SD	M	SD
Animal								
Biological	6.86	5.52	8.29	5.43	10.75	7.27	9.97	5.90
Functional	0.17	0.71	0.03	0.17	0.09	0.30	0.16	0.52
Total	7.03	5.48	8.31	5.42	10.84	7.38	10.13	5.80
Plant								
Biological	3.86	2.09	5.29	2.46	5.88	2.78	6.19	2.29
Functional	0.46	0.78	0.23	0.55	0.00	0.00	0.29	0.59
Total	4.31	2.45	5.51	2.42	5.88	2.78	6.48	2.43
Mobile								
Biological	1.37	1.61	1.86	1.38	1.78	1.29	2.39	2.30
Functional	2.20	2.18	2.46	1.98	3.75	2.64	2.68	1.80
Total	3.57	2.91	4.31	2.39	5.53	3.17	5.06	2.74
Immobile								
Biological	0.77	1.90	0.94	1.43	0.56	0.88	0.45	0.93
Functional	2.57	2.27	4.20	2.52	4.75	2.85	4.74	3.27
Total	3.34	2.83	5.14	2.79	5.34	2.98	5.16	3.23

Table 4
Phase 1: Comparing Number of Statements Preschoolers Made for the Object Classes: t's, p's, and CI's

	TS 1	TS 2	TS 3	TS 4
Animal vs. Plant				
t	(34) = 3.430	(34) = 4.026	(31) = 4.383	(30) = 4.317
p	0.002*	< .001*	< .001*	< .001*
95% CI	1.106, 4.322	1.387, 4.213	2.657, 7.281	1.921, 5.370
Animal vs. Mobile				
t	(34) = 4.899	(34) = 4.999	(31) = 5.467	(30) = 6.392
p	< .001*	< .001*	< .001*	< .001*
95% CI	2.023, 4.891	2.374, 5.626	3.330, 7.295	3.446, 6.683
Animal vs. Immobile				
t	(34) = 4.067	(34) = 4.019	(31) = 5.562	(30) = 6.676
p	<.001*	< .001*	< .001*	< .001*
95% CI	1.844, 5.528	1.568, 4.775	3.483, 7.517	3.448, 6.487
Plant vs. Mobile				
t	(34) = 1.886	(34) = 3.106	(31) = 0.597	(30) = 3.344
p	0.068	0.004*	0.555	0.002*
95% CI	-0.058, 1.543	.415, 1.985	-0.831, 1.519	.553, 2.286
Plant vs. Immobile				
t	(34) = 2.244	(34) = 0.929	(31) = 0.979	(30) = 2.791
p	0.031	0.359	0.335	0.009
95% CI	0.092, 1.851	-0.441, 1.184	-0.575, 1.638	.355,2.290
Mobile vs. Immobile				
t	(34) = 0.478	(34) = -2.079	(31) = 0.432	(30) = -0.190
p	0.636	0.045	0.669	0.85
95% CI	-0.743, 1.200	-1.683, -0.019	-0.698, 1.073	-1.136, 0.942

Note: *indicates significance at <.05 after Dunn's correction.

Table 5

Phase 1: Type of Statements Preschoolers Made at Each Testing Session: Means and Standard Deviations

	TS 1		TS 2		TS 3		TS 4	
Statement Type	M	SD	M	SD	M	SD	M	SD
Biological	12.86	7.71	16.37	8.58	19.00	9.65	18.97	8.89
Functional	5.40	4.86	6.91	4.00	8.59	5.18	7.87	4.65

Table 6

Phase 1: Comparing Type of Statements Preschoolers Made for the Object Classes: t's, p's, and CI's

	TS 1	TS 2	TS 3	TS 4
Animal Bio vs. Func.				
t	(34) = 7.000	(34) = 8.978	(31) = 8.414	(30) = 9.046
p	<.001*	<.001*	<.001*	<.001*
95% CI	4.745, 8.627	6.388, 10.126	8.073, 13.239	7.593, 12.020
Plant Bio vs. Func				
t	(34) = 10.117	(34) = 11.456	(31) = 11.957	(30) = 14.381
p	<.001*	<.001*	<.001*	<.001*
95% CI	2.717, 4.083	4.160, 5.954	4.873, 6.877	5.065, 6.742
Mobile Bio vs. Func				
t	(34) = -1.968	(34) = -1.462	(31) = -4.153	(30) = -.523
p	0.057	0.153	<.001*	0.605
95% CI	-1.684, .027	-1.434, .234	-2.936, -1.002	-1.424, .843
Immobile Bio vs. Func				
t	(34) = -3.462	(34) = -6.416	(31) = -7.814	(30) = -6.817
p	0.001*	<.001*	<.001*	<.001*
95% CI	2.856, -.744	-4.289, -2.225	-5.280, -3.095	-5.576, -3.005

Note: *indicates significance at <.05 after Dunn's correction.

Table 7

Phase 2: Absolute Difference Between Preschoolers' Biological Response Pattern and the Adult and Hypothetical Models at Each Testing Session: Means and Standard Deviations

	TS 1		TS 2		TS 3		TS 4	
	M	SD	M	SD	M	SD	M	SD
Adult Model	85.33a	13.05	83.67a	12.67	73.93a	25.07	64.78a	23.04
Animal Model	88.51a	12.32	87.80a	12.30	86.47b	17.57	82.55b	16.53
Mobile Model	101.17b	6.53	99.71b	7.10	101.66ce	5.14	100.39ce	7.15
Immobile Model	96.57c	9.81	97.29b	10.63	92.34de	9.55	96.23de	8.12

Note: Means in a column (testing session) with different subscripts were significantly different at the $p < .05$ level.

Table 8

Phase 2: Absolute Difference Between Preschoolers' Psychological Response Pattern and the Adult and Hypothetical Models at Each Testing Session: Means and Standard Deviations

	TS1		TS2		TS3		TS4	
	M	SD	M	SD	M	SD	M	SD
Adult Model	67.46a	14.91	62.11a	13.35	62.05a	17.93	65.73a	19.40
Animal Model	85.54b	17.73	80.91b	18.37	79.84b	18.01	80.97b	23.59
Mobile Model	103.69c	5.51	102.83c	5.88	100.66c	10.07	100.03c	8.26
Immobile Model	92.11d	10.02	91.89d	9.85	91.16d	9.65	93.71d	9.83

Note: Means in a column (testing session) with different subscripts were significantly different at the $p < .05$ level.

Table 9

Phase 3: Absolute Difference Between Preschoolers' Alive Response Pattern and the Adult and Hypothetical Models: Means and Standard Deviations

	TS 1		TS 2		TS 3		TS 4	
	M	SD	M	SD	M	SD	M	SD
Adult Model	32.94a	2.54	33.01a	2.95	30.50a	6.61	28.72a	8.70
Animal Model	28.97b	6.69	28.14b	5.78	22.09b	12.56	22.13b	12.28
Mobile Model	32.89a	4.99	31.66b	9.47	31.28a	6.33	30.94a	5.77
Immobile Model	28.97b	7.09	28.43b	6.71	30.78a	5.34	30.71a	5.26

Note: Means in a column (testing session) with different subscripts were significantly different at the $p < .05$ level.

Table 10

Comparing Number of Phase 1 Statements Made by the Qualitative Subsample Versus the Non-Qualitative Subsample of Preschoolers: Means and Standard Deviations

	TS 1		TS 2		TS 3		TS 4	
	M	SD	M	SD	M	SD	M	SD
Non-Qualitative	17.72	11.40	23.20	11.03	26.79	15.09	25.39	12.63
Qualitative	19.60	10.55	23.20	10.86	30.00	10.57	31.00	10.88

Table 11

Comparing Phases 2 and 3 Response Patterns in Relation to the Adult Model: Qualitative Subsample Versus the Non-Qualitative Subsample of Preschoolers: Means and Standard Deviations

	TS 1		TS 2		TS 3		TS 4	
	M	SD	M	SD	M	SD	M	SD
Biological								
Non-Qualitative	84.87	14.22	84.22	13.44	71.8	24.79	67.28	23.42
Qualitative	86.49	10.09	82.29	11.04	80.3	26.49	57.56	21.71
Psychological								
Non-Qualitative	66.23	16.01	59.99	12.61	61.80	19.74	64.84	19.94
Qualitative	70.53	11.89	67.4	14.35	62.82	11.94	68.29	18.78
Alive								
Non-Qualitative	32.78	2.49	32.89	3.18	30.29	7.12	28.12	9.93
Qualitative	33.34	2.74	33.30	2.41	31.13	5.15	30.44	3.16

Appendix B: Figures

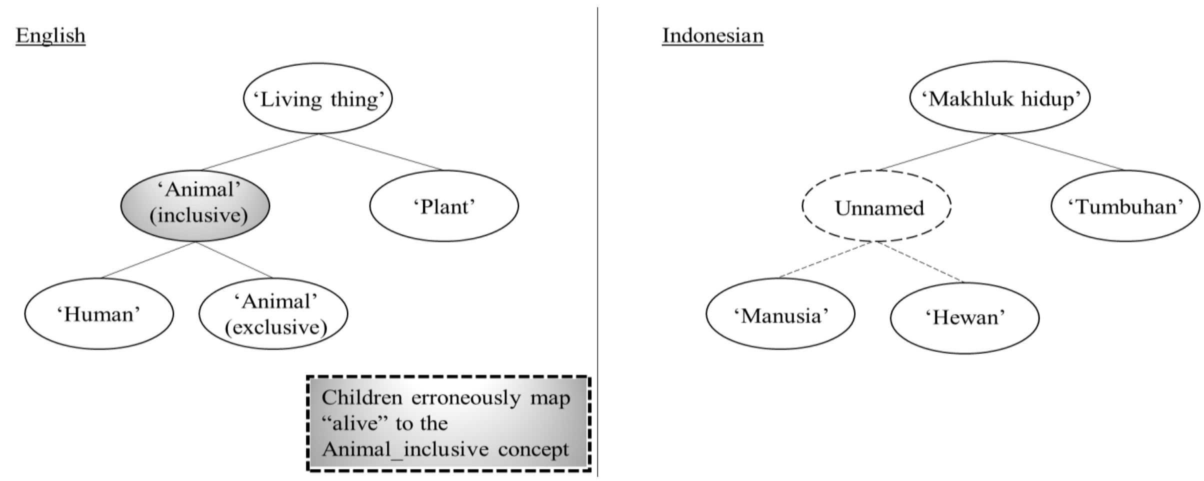

Figure 1. A schematic depiction of English and Indonesian names for fundamental biological concepts. Source: "Naming Practices and the Acquisition of Key Biological Concepts," by Anggoro, Waxman & Medin, 2008, *Psychological* Science, 19, 314-319. Copyright 2008 American Psychological Association. Note: dashed box and greying of 'Animal" circle was added by Margett-Jordan.

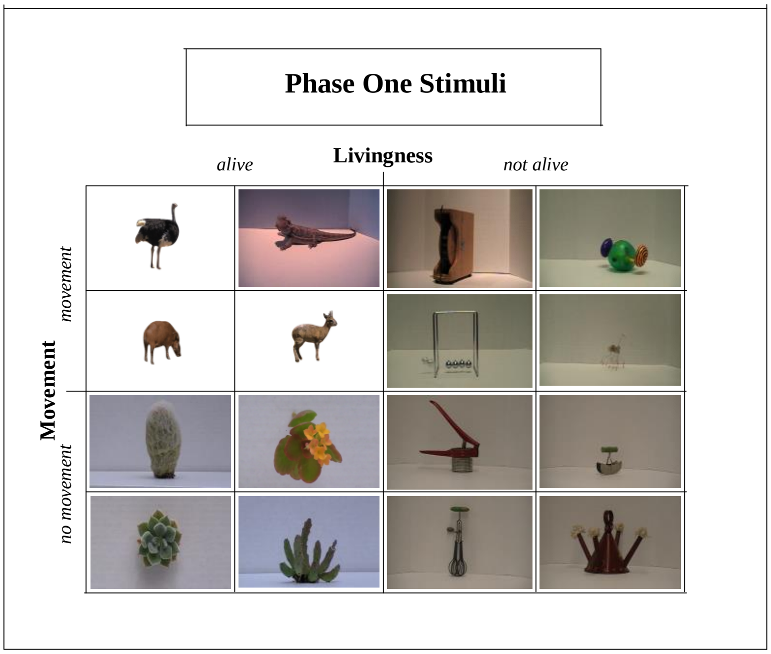

Figure 2. Stimuli shown for Phase 1.

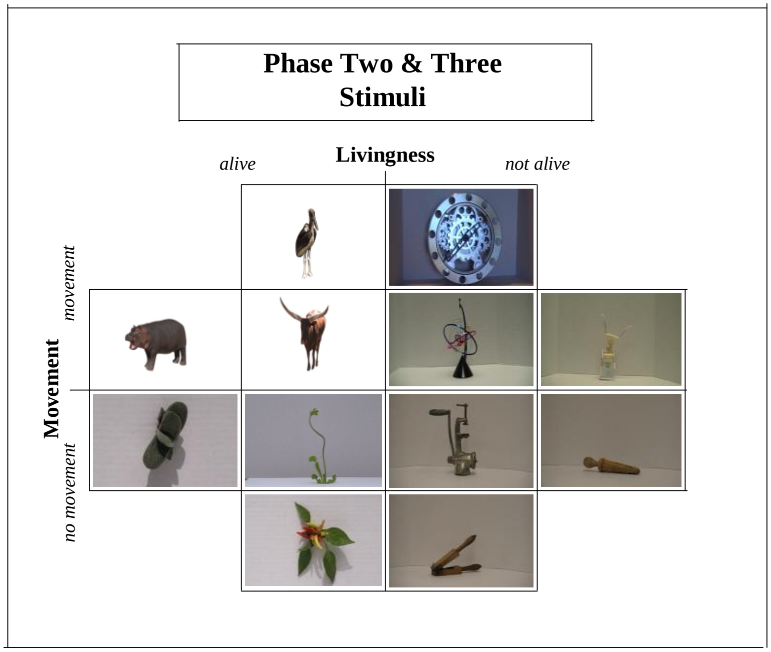

Figure 3. Stimuli shown for Phases 2 and 3.

	A 1	A 2	A 3	P 1	P 2	P 3	M 1	M 2	M 3	I 1	I 2	I 3
A 1		0	1	0	0	0	3	3	3	3	1	3
A 2			1	0	0	0	3	3	3	3	1	3
A 3				1	1	1	2	2	2	2	2	2
P 1					0	0	3	3	3	3	1	3
P 2						0	3	3	3	3	1	3
P 3							3	3	3	3	1	3
M 1								0	0	0	2	0
M 2									0	0	2	0
M 3										0	2	0
I 1											2	0
I 2												2
I 3												

Figure 4. Example of a preschooler's biological property difference matrix. A = animal, P = plant, M = mobile object, I = immobile object.

	A 1	A 2	A 3	P 1	P 2	P 3	M 1	M 2	M 3	I 1	I 2	I 3
A 1		0.002	0.002	0.073	0.051	0.064	2.782	2.836	2.836	2.729	2.729	2.782
A 2			0.000	0.089	0.063	0.077	2.945	3.000	3.000	2.890	2.890	2.945
A 3				0.089	0.063	0.077	2.945	3.000	3.000	2.890	2.890	2.945
P 1					0.003	0.001	2.386	2.440	2.440	2.349	2.349	2.387
P 2						0.001	2.508	2.563	2.563	2.467	2.467	2.508
P 3							2.467	2.522	2.522	2.427	2.427	2.467
M 1								0.001	0.001	0.002	0.002	0.002
M 2									0.000	0.002	0.002	0.001
M 3										0.002	0.002	0.001
I 1											0.000	0.001
I 2												0.001
I 3												

Figure 5. Adults' biological property difference matrix. Adults' matrix was created on the adults' average response pattern. A = animal, P = plant, M = mobile object, I = immobile object.

	A 1	A 2	A 3	P 1	P 2	P 3	M 1	M 2	M 3	I 1	I 2	I 3
A 1		0.002	0.998	0.073	0.051	0.064	0.218	0.164	0.164	0.271	1.729	0.218
A 2			1.000	0.089	0.063	0.077	0.055	0.000	0.000	0.110	1.890	0.055
A 3				0.911	0.937	0.923	0.945	1.000	1.000	0.890	0.890	0.945
P 1					0.003	0.001	0.614	0.560	0.560	0.651	1.349	0.613
P 2						0.001	0.492	0.437	0.437	0.533	1.467	0.492
P 3							0.533	0.478	0.478	0.573	1.427	0.533
M 1								0.001	0.001	0.002	1.998	0.002
M 2									0.000	0.002	1.998	0.001
M 3										0.002	1.998	0.001
I 1											2.000	0.001
I 2												1.999
I 3												

Figure 6. Absolute difference of a preschooler's biological difference matrix from the adults' biological difference matrix. A = animal, P = plant, M = mobile object, I = immobile object.

	A 1	A 2	A 3	P 1	P 2	P 3	M 1	M 2	M3	I 1	I 2	I 3
A 1		0	0	3	3	3	0	0	0	3	3	3
A 2			0	3	3	3	0	0	0	3	3	3
A 3				3	3	3	0	0	0	3	3	3
P 1					0	0	3	3	3	0	0	0
P 2						0	3	3	3	0	0	0
P 3							3	3	3	0	0	0
M 1								0	0	3	3	3
M 2									0	3	3	3
M 3										3	3	3
I 1											0	0
I 2												0
I 3												

Figure 7. Mobile model biological property difference matrix. A = animal, P = plant, M = mobile object, I = immobile object.

	A 1	A 2	A 3	P 1	P 2	P 3	M 1	M 2	M 3	I 1	I 2	I 3
A 1		0	0	3	3	3	3	3	3	3	3	3
A 2			0	3	3	3	3	3	3	3	3	3
A 3				3	3	3	3	3	3	3	3	3
P 1					0	0	0	0	0	0	0	0
P 2						0	0	0	0	0	0	0
P 3							0	0	0	0	0	0
M 1								0	0	0	0	0
M 2									0	0	0	0
M 3										0	0	0
I 1											0	0
I 2												0
I 3												

Figure 8. Animal model biological property difference matrix. A = animal, P = plant, M = mobile object, I = immobile object.

	A 1	A 2	A 3	P 1	P 2	P 3	M 1	M 2	M 3	I 1	I 2	I 3
A 1		0	0	0	0	0	0	0	0	3	3	3
A 2			0	0	0	0	0	0	0	3	3	3
A 3				0	0	0	0	0	0	3	3	3
P 1					0	0	0	0	0	3	3	3
P 2						0	0	0	0	3	3	3
P 3							0	0	0	3	3	3
M 1								0	0	3	3	3
M 2									0	3	3	3
M 3										3	3	3
I 1											0	0
I 2												0
I 3												

Figure 9. Immobile model biological property difference matrix. A = animal, P = plant, M = mobile object, I = immobile object.

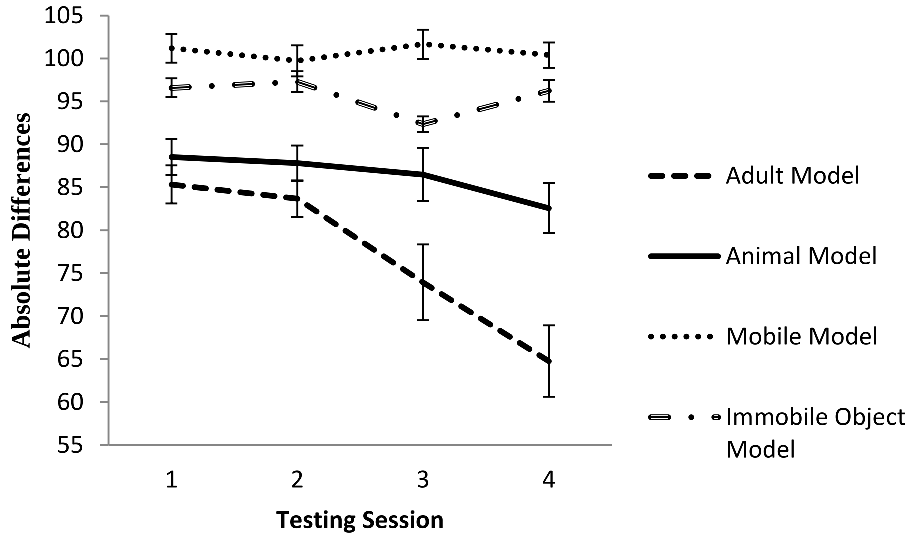

Figure 10. Preschoolers' biological response pattern in relation to the adult and hypothetical models. Standard errors are also provided.

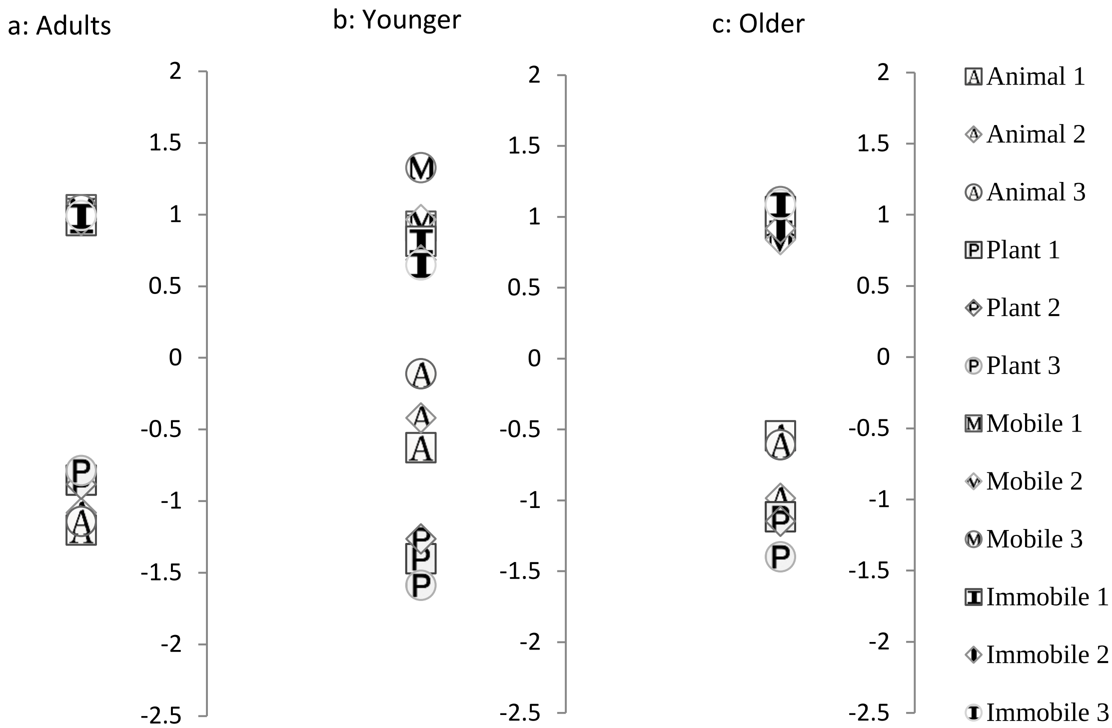

Figure 11. One dimensional MDS plot of (a) adults' biological responses, (b) preschoolers' biological responding before the median age split, and (c) preschoolers' biological responding after the median age split. MDS coordinates for the exemplars are as follows: (a) A1= -1.2046; A2= -1.0846; A3= -1.1443; P1= -0.8552; P2= -0.8848; P3= -0.7876; M1= 1.0324; M2= 0.9918; M3= 1.0324; I1= 0.9563; I2= 0.9563; I3= 0.992. (b) A1= -0.6295; A2= -0.4198; A3= -0.1079; P1= -1.4127; P2= -1.2719; P3= -1.5997; M1= 0.9319; M2= 0.9802; M3= 1.3447; I1= 1.0218; I2= 0.9042; I3= 1.0714. (c) A1= -0.5546; A2= -0.9933; A3= -0.6171; P1= -1.1235; P2= -1.1552; P3= -1.4046; M1= 0.9349; M2= 0.8241; M3= 1.092; I1= 1.0218; I2= 0.9042; I3= 1.0714.

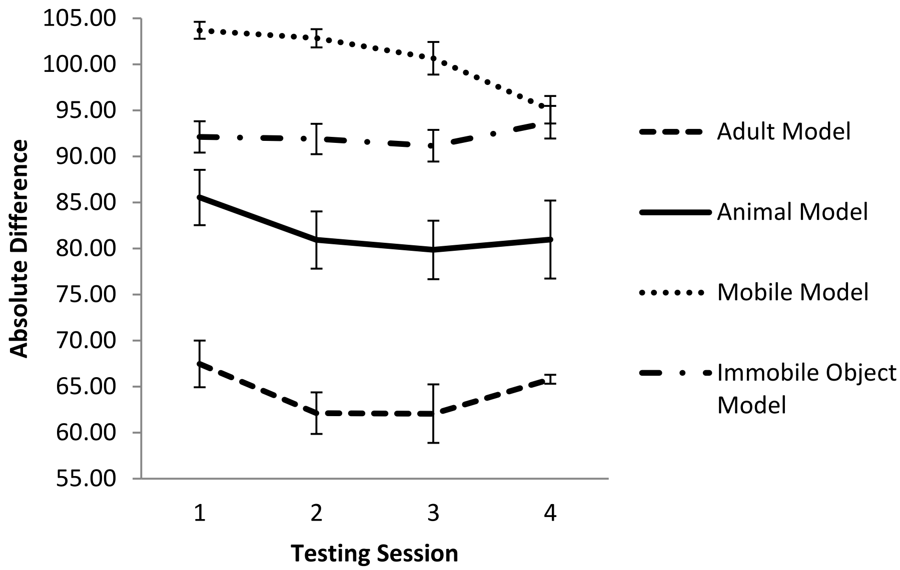

Figure 12. Preschoolers' psychological response pattern in relation to the adult and hypothetical models. Standard errors are also provided.

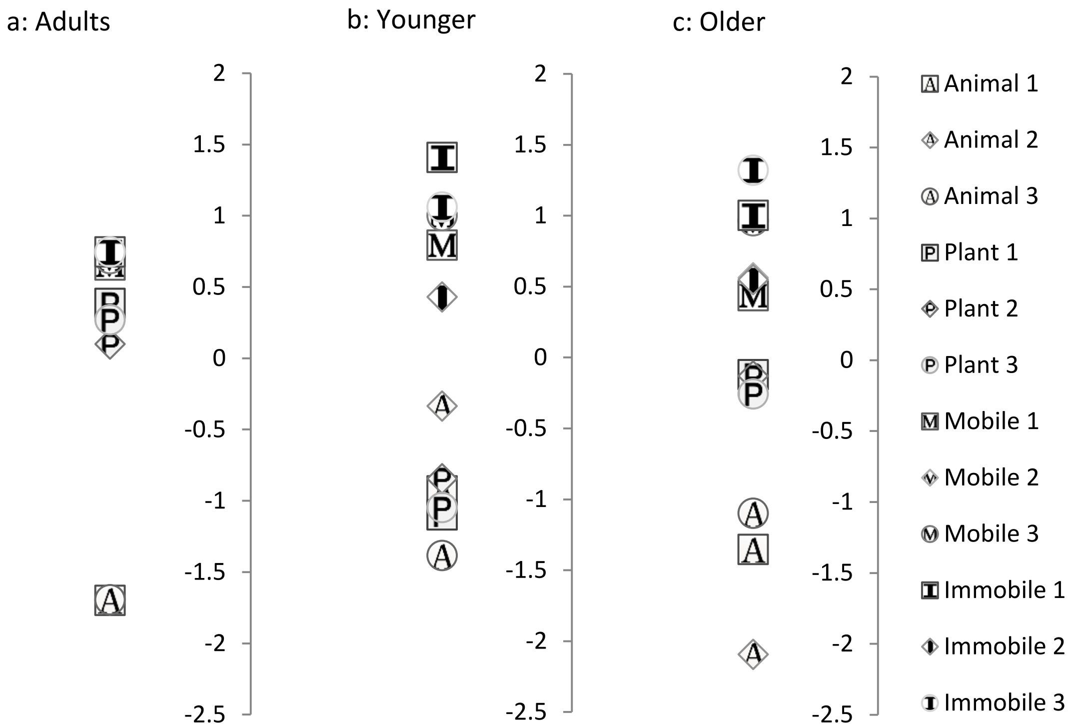

Figure 13. One dimensional MDS plot of (a) adults' psychological responses, (b) preschoolers' psychological responding before the median age split, and (c) preschoolers' psychological responding after the median age split. MDS coordinates for the exemplar are as follows: (a) A1= -1.6985; A2= -1.6956; A3= -1.6943; P1= 0.3846; P2= 0.1001; P3= 0.2691; M1= 0.6535; M2= 0.7458; M3= 0.6982; I1= 0.7458; I2= 0.7458; I3= 0.7458. (b) A1= -0.9412; A2= -0.3427; A3= -1.3973; P1= -1.1094; P2= -0.8563; P3= -1.0595; M1= 0.7929; M2= 1.0171; M3= 0.9986; I1= 1.4113; I2= 0.4262; I3= 1.0601.(c) A1= -1.3356; A2= -2.0748; A3= -1.08; P1= -0.1033; P2= -0.1117; P3= -0.2378; M1= 0.4536; M2= 0.5798; M3= 0.9829; I1= 1.0202; I2= 0.567; I3= 1.3397.

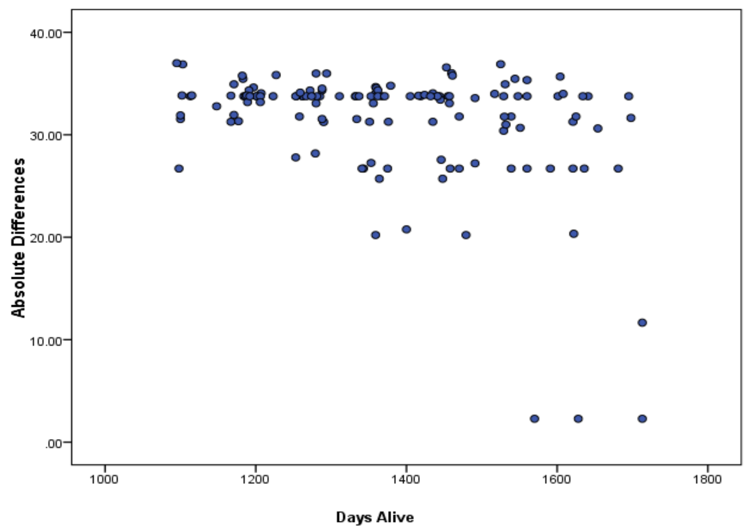

Figure 14. Absolute differences of preschoolers' response patterns from adults' response pattern for the alive question as the preschoolers aged.

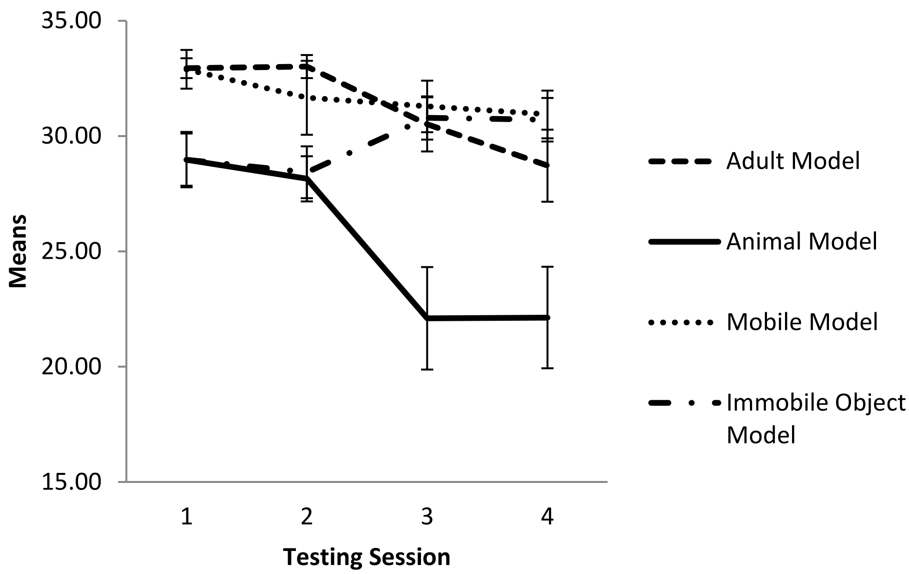

Figure 15. Preschoolers' alive response pattern in relation to the adult and hypothetical models. Standard errors are also provided.

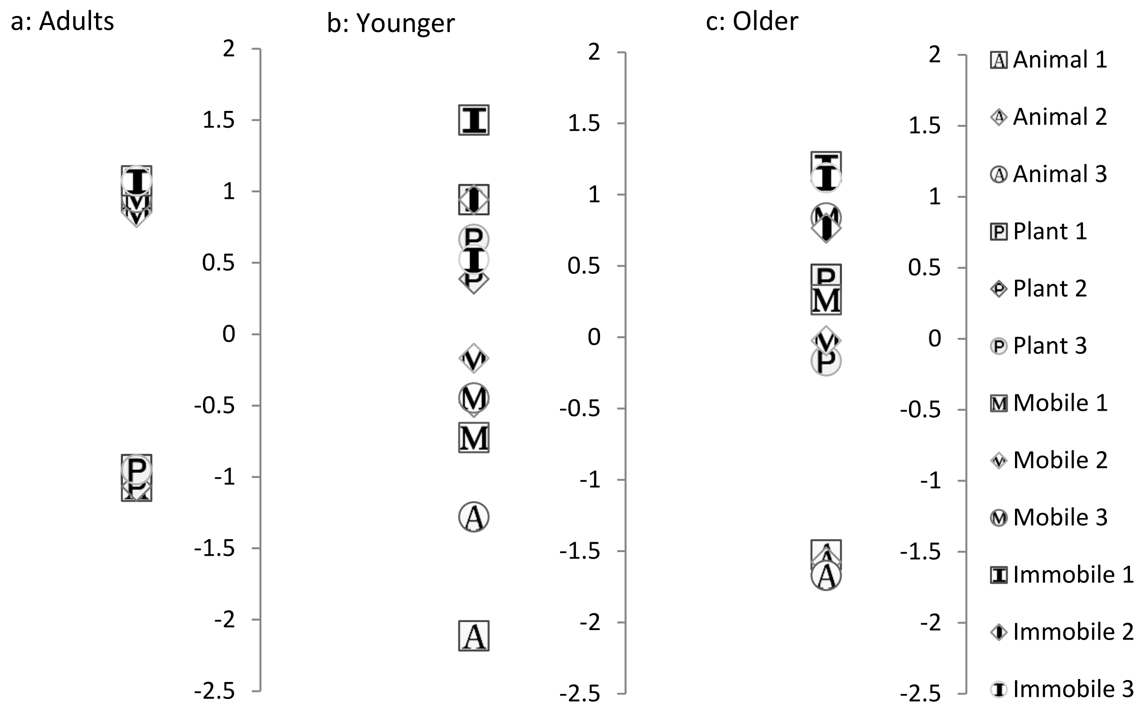

Figure 16. One dimensional MDS plot of (a) adults' alive responses, (b) preschoolers' alive responding before the median age split, and (c) preschoolers' alive responding after the median age split (a) A1= -1.6985; A2= -1.6956; A3= -1.6943; P1= 0.3846; P2= 0.1001; P3= 0.2691; M1= 0.6535; M2= 0.7458; M3=0.6982; I1= 0.7458; I2= 0.7458; I3= 0.7458. (b) A1= -2.0951; A2= -0.4581; A3= -1.2606; P1= 0.965; P2= 0.4086; P3= 0.6868; M1= -0.7042; M2= -0.1478; M3= -0.426; I1= 1.5213; I2= 0.965; I3= 0.5451. (c) A1= -1.5244; A2= -1.572; A3= -1.6682; P1= 0.418; P2= 0.2742; P3= -0.1575; M1= 0.2742; M2= -0.0136; M3= 0.8497; I1= 1.2094; I2= 0.7778; I3= 1.1324.

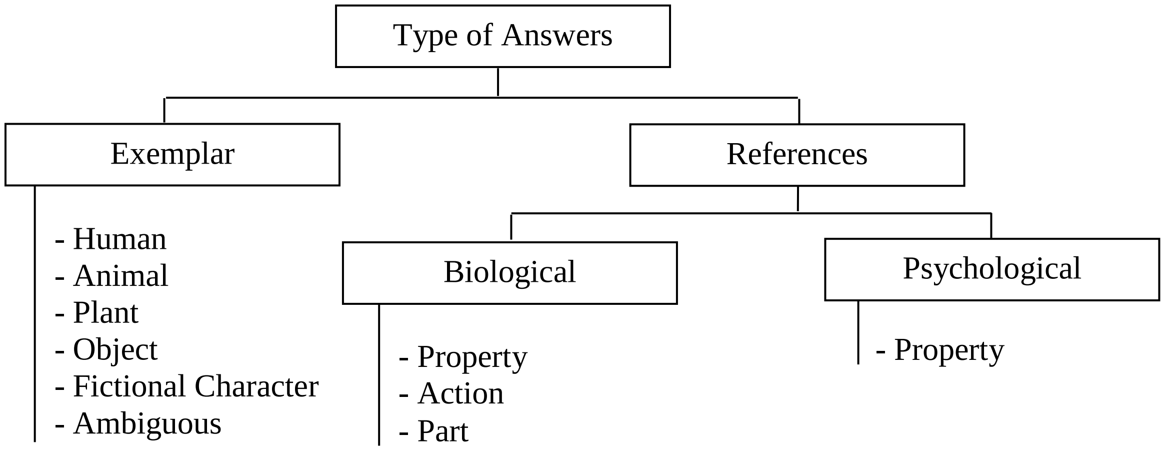

Figure 17. Type of answers offered by the preschoolers in the qualitative condition.

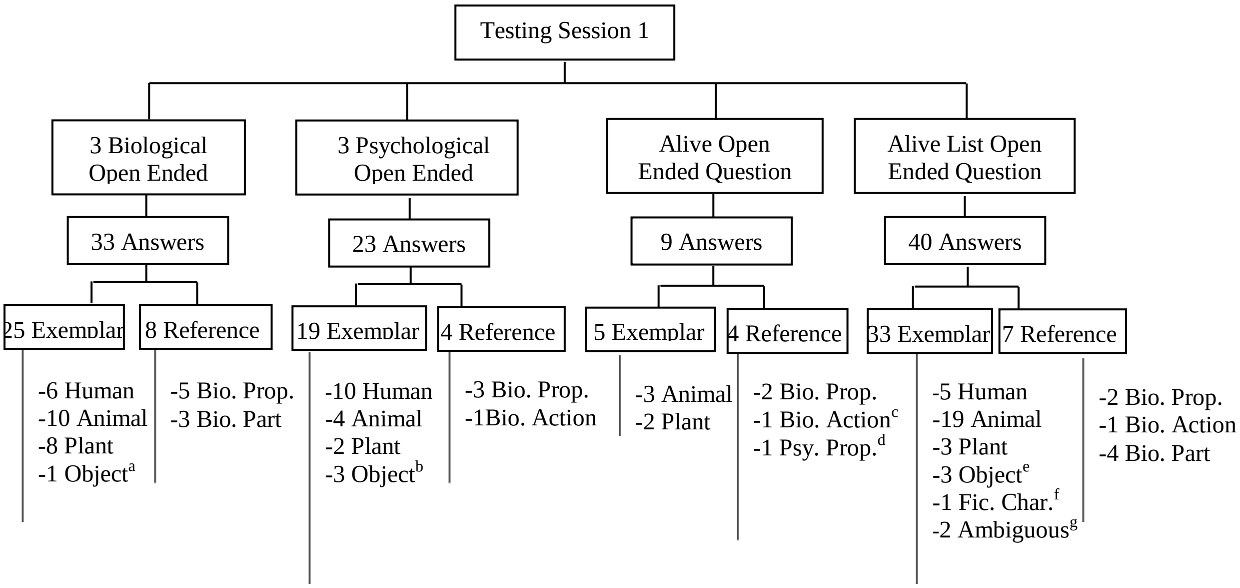

Figure 18. Number and types of answers offered by the preschoolers in the qualitative condition at Testing Session 1. [a] "not a robot," [b] "not a robot," "giant robot," "not a box," [c] "smile," [d] "they scare people," [e] "drawers," "computers," "motors" [f] "Ariel," [g] "clouds," "forest."

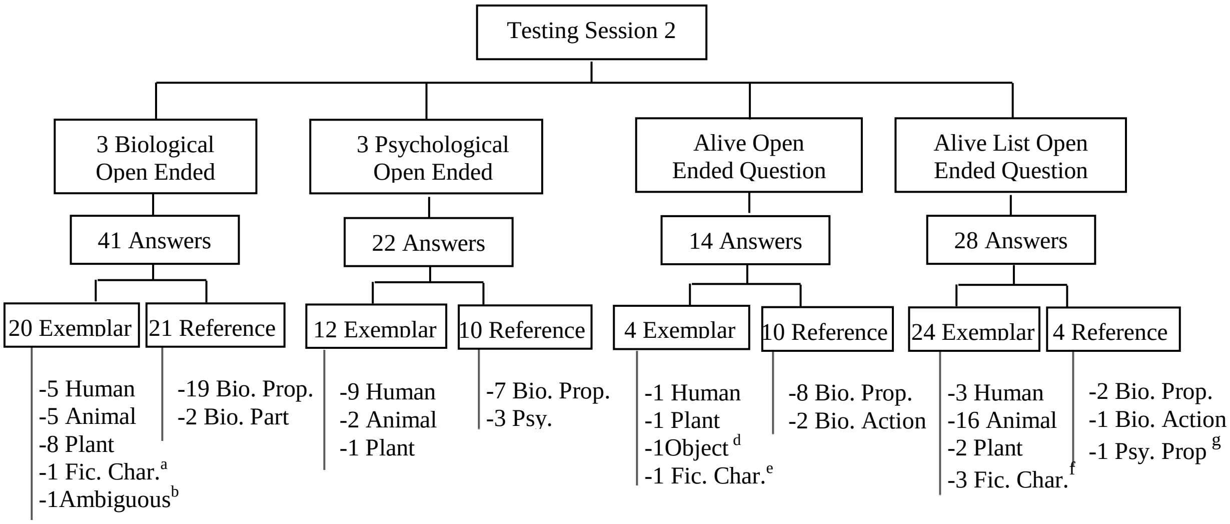

Figure 19. Number and types of answers offered by the preschoolers in the qualitative condition at Testing Session 2. [a] “Rapunzel,” [b] “all stuff,” [c] “in your dreams,” “remember,” “get sad,” [d] “a chair doesn’t,” [e] “monsters,” [f] “fairies,” “monster,” “princesses,” [g] “not mad.”

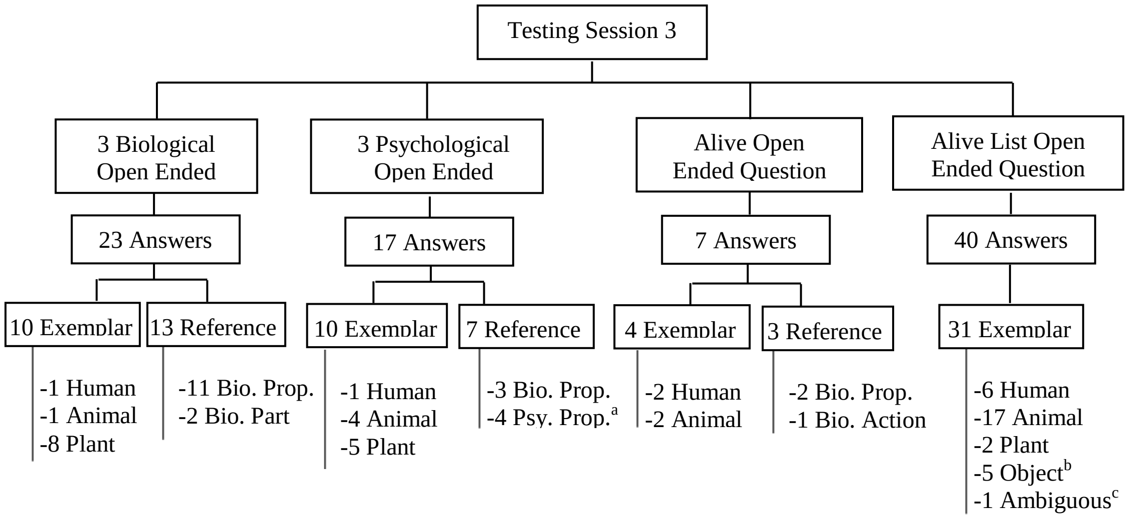

Figure 20. Number and types of answers offered by the preschoolers in the qualitative condition at Testing Session 3. [a] "when it's looking sad," "…bring blanket and cuddle up," "if it gets lonely," "using imagination" [b] "clock," "towels," "bracelet," "string," "shirt" [c] "storm clouds."

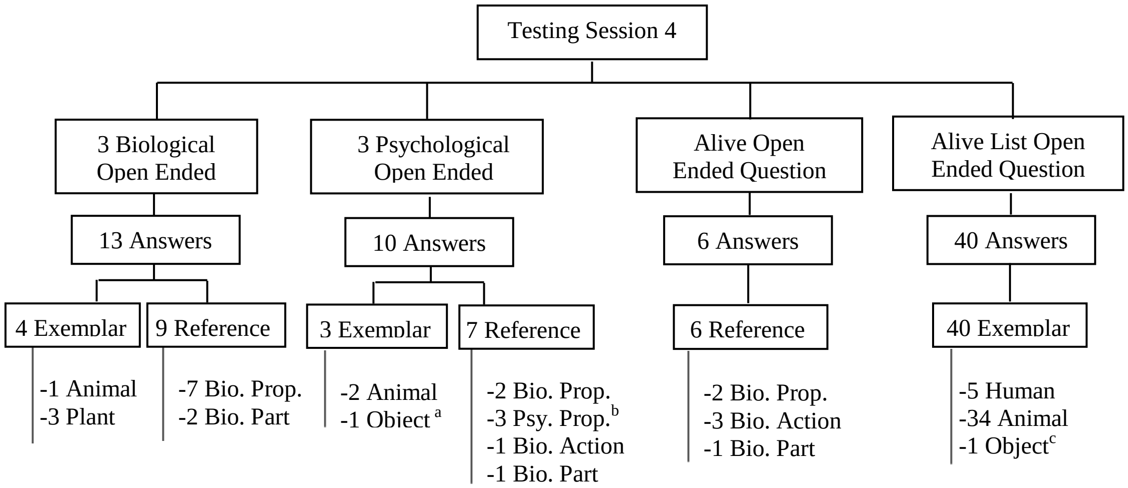

Figure 21. Number and types of answers offered by the preschoolers in the qualitative condition at Testing Session 4. [a] "pens," [b] "they'll have a dream," "they think," "'cause you're being nice." [c] "clock."

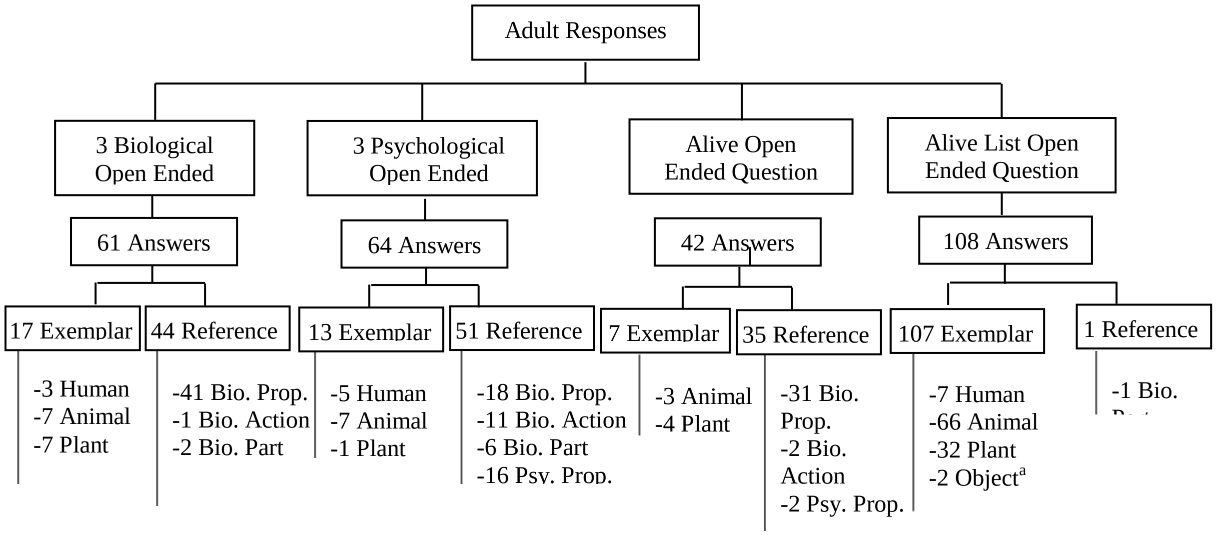

Figure 22. Number and types of answers offered by adults to the qualitative questions. [a] "not a man-made object," "a machine that can move without food/water."

References

Anggoro, F., Waxman, S., & Medin, D. L. (2008). Naming Practices and the Acquisition of Key Biological Concepts: Evidence from English and Indonesian. *Psychological Science,* 19(4), 314-319.

Brandone, A. C. & Gelman, S. A. (2013). Generic language use reveals domain differences in young children's expectation about animal and artifact categories. *Cognitive Development*, 29, 63-75.

Backscheider, A. G., Shatz, M., & Gelman, S. A. (1993). Preschoolers' ability to distinguish living kinds as a function of regrowth. *Child Development, 64*, 1242-1257.

Carey, S. (1985). *Conceptual change in childhood.* Cambridge, MA: MIT Press.

Einav, S., & Robinson, E. J. (2011). When being right is not enough: Four-year-olds distinguish knowledgeable informants from merely accurate informants. *Psychological Science,* 10, 1250-1253.

Erickson, J. E., Keil, F. C, & Lockhart, K. L. (2010). Sensing the coherence of biology in contrast to psychology: Young children's use of causal relations to distinguish two foundational domains. *Child Development,* 81, 390-409.

Greif, M. L., Kemler Nelson, D. G., Keil, F. C. & Gutierrez, F. (2006). What do preschoolers want to know about animals and artifacts? *Psychological Science*, *17,* 455-459.

Howell, D. C. (1987). *Statistical methods for psychology*. Boston: Duxbury.

Inagaki, K. & Hatano, G. (1996).Young children's recognition of commonalties between animals and plants. *Child Development,* 64, 1534-1549.

Inagaki, K. & Hatano, G. (2002). *Young preschoolers' naïve thinking about the biological* world. New York: Psychology Press.

Inagaki, K. & Hatano, G. (2006). Young children's conception of the biological world. Current Directions in Psychological Science, 15, 177-181.

Jipson, J. L, & Gelman, S. A. (2007). Robots and rodents: Preschoolers' inferences about living and nonliving kinds. *Child Development, 78*, 1675-1688.

Keil, F. C. (1992). The origins of an autonomous biology. In M.R. Gunnar & M. Maratsons (Eds). *Modularity and constraints in language and cognition. The Minnesota Symposia on Child Psychology* (Vol. 25, pp. 103-137). Hillsdale, NJ: Erlbaum.

Keil, F. C. (1994). The birth and nurturance of concepts by domain: The origins of concepts of living things. In L. A. Hirshfeld & S. A. Gelman (Eds.). *Mapping the mind; Domain specificity in cognition and culture* (pp. 234-254). New York: Cambridge University Press.

Keil, F. C., Levin, D. T., Richman, B. A., & Gutheil, G. (1999). Mechanism and explanation in the development of biological thought: The case of disease. In D. Medin & S. Atran (Eds.), *Folkbiology* (pp. 233-284). Cambridge, MA: MIT Press.

Kemler Nelson, D. G., Egan, C. L. & Holt, M. B. (2001). When preschoolers ask, "what is it?" what do they want to know about artifacts. *Psychological Science, 15*, 384-389.

Kruskl, J. & Wish, M. (1978). Multidimensional Scaling. Sage University Paper series on Quantitative Applications in the Social Sciences, series no. 07-001. Beverly Hills and London: Sage Publications.

Leddon, E., Waxman, S. R., & Medin, D. L. (2008). Unmasking "Alive." Children's appreciation of a concept linking all living things. *Journal of Cognitive Development.* 9(4), 461-473.

Margett, T. E. & Witherington, D. C. (2011) The nature of preschoolers' concept of living and artificial objects. *Child Development*, 82, 2067-2082.

Meunier, B. & Cordier, F. (2004). The plant category: when does it come to be organized? *Enfance*, *56*, 163-185.

Nguyen, S. P., & Gelman, S. A. (2002). Four and 6-year olds' biological concept of death: the case for plants. *British Journal of Developmental Psychology*, 20, 495-513.

Opfer, J. E. & Gelman, S. A. (2001). Preschoolers' and adults' models for predicting teleological action: the development of a biology model. *Child Development*, *72*, 1367-1381.

Opfer, J. E., & Siegler, R. S. (2004). Revisiting preschoolers' living things concept: a microgenetic analysis of conceptual change in basic biology. *Cognitive Psychology*, *49*, 301-332.

Piaget, J. (1929). *The child's conception of the world.* London: Routledge & Kegan Paul.

Piaget, J. (1947). *The Psychology of Intelligence.* London: Routledge and Kegan Paul.

Povinelli, D. J., Landau, K. R., & Perilloux, H. (1996). Self-recognition in young children using delayed versus live feedback: evidence of a developmental asynchrony. *Child Development*, *67*, 1540-1554.

Povinelli, D. J., Landry, A. M., Theall, L. A., Clark, B.R., & Castille, C. M. (1999). Development of young children's understanding that the recent past is causally bound to the present. *Developmental Psychology*, *34*, 1426-1439.

Povinelli, D. J., & Simon, B. B. (1998). Young children's understanding of briefly versus extremely delayed images of the self: emergence of the autobiographical stance. *Developmental Psychology*, 34, 188-194

Richards, D. D., & Siegler, R. S. (1984). The effects of task requirements on children's life judgments. *Child Development*, 55, 1687–1696.

Rosengren, K. S, Gelman, S. A., Kalish, C. W., & McCormick, M. (1991). As time goes by: children's early understanding of growth in animals. *Child Development*, 62, 1302-1320.

Wellman, H. M., Cross, D., & Watson, J. (2001). Meta-Analysis of theory-of-mind development: the truth about false belief. *Child Development*, 72, 655-684.

Waxman, S. R. (2005). Why is the concept "living thing" so elusive? Concepts, languages, and the development of folk biology. In Ahn, W, Goldstone, R. L., Love, b. C., Markman, A. B., & Wolff, P. (Eds.) *Categorization inside and outside the laboratory: essays in honor of Douglas L. Medin* (pp. 49-67). Washington, DC: APA.