Parental reports of children’s biological knowledge and misconceptions

Simone P. Nguyen
University of North Carolina at Wilmington, USA

Karl S. Rosengren
University of Illinois at Urbana-Champaign, USA

Children’s misconceptions about five specific biological concepts—life, aging, reproduction, illness, and death—were investigated using a parent survey. Parents of 3- to 4-year-olds (N = 125) and parents of 5- to 6-year-olds (N = 145) completed a questionnaire about their child’s knowledge and misconceptions involving these concepts. Parents reported that misconceptions were common among 3- to 6-year-olds, particularly for reproduction and death. Parents reported a greater reluctance to talk with their children about death and reproduction and also thought their children should learn about these concepts at a later age than other biological concepts. One third of the misconceptions reported by parents occurred at the boundary between different domains, where information from another domain (i.e., physics or psychology) was incorrectly associated with the biological domain. Parents of 5- to 6-year-olds reported fewer misconceptions than parents of 3- to 4-year-olds, suggesting that these misconceptions are open to change and are eventually replaced by accurate biological knowledge.

Children’s understanding of biology has been the focus of many investigations over the past two decades. Although there is considerable debate regarding the age at which children can be judged to hold a distinctly biological theory (Carey, 1985; Keil, 1989; Wellman & Gelman, 1997), researchers generally agree that children have greater knowledge about biological phenomena than Piaget (1929) had earlier proposed.

For example, Inagaki and Hatano (1996) have found that many 5-year-olds recognise that plants and animals share a number of properties and that these properties distinguish both of them from inanimate objects. Other researchers have shown that even young preschoolers have a rudimentary understanding of growth (Rosengren, Gelman, Kalish, & McCormick, 1991) and that a living thing will grow to manifest properties that are characteristic of its species (Gelman & Wellman, 1991). Young children have also been shown to understand aspects of reproduction (Hickling & Gelman, 1995; Springer, 1995). Specifically, Hickling and Gelman have reported that by 4½ years of age, most children understand that plants grow from seeds. Likewise, Springer (1995) has found that young children understand that babies grow inside a woman and that important properties or characteristics are passed from the mother to the child.

Research also supports the notion that children understand the causal mechanisms involved in illness to a greater extent than Piaget proposed (Hansdottir & Malcarne, 1998; Kalish, 1996; Keil, 1992, 1994; Nguyen & Rosengren, in press; Springer & Ruckel, 1991). For example, found that 4- to 5-year-olds reject the idea that illness can be attributed to people’s misbehaviour or immanent justice (e.g., a boy gets sick from eating a stolen apple). Keil has also shown that even preschoolers can readily distinguish biological (e.g., viruses) from nonbiological disease-causing agents (e.g., poisons). In addition, if children are told that a “thing” causes illness, they will reason that the “thing” is alive, has insides, and can move on its own (Keil, 1992, 1994).

Children have even been found to have a better understanding of death than was previously reported. For example, Speece and Brent (1984, 1992, 1996) have found that children begin to gain an understanding of death during the preschool years. A similar finding has also been reported by Slaughter, Jaakola, and Carey (1999), who found improvements in children’s understanding of death between the ages of 4 and 6 years. In a study examining children’s understanding of death (inevitability, universality, causality, and finality), Nguyen and Gelman (2002) found that by 6 years of age, most children understand all of these subconcepts. Taken together, these studies suggest that young children have a fairly sophisticated understanding of biological concepts.

Although this body of research appears to support the notion that children have relatively coherent and more advanced knowledge of biological phenomena than was once presumed, there is a substantial amount of literature that has documented children’s biological misconceptions (Arnaudin & Mintzes, 1985; Billeh & Pella, 1970; Browning & Lehman, 1988; Bumby, 1984). Much of this work has been conducted in the context of children’s learning of biological concepts in the classroom. For example, in a teacher survey, Pine, Messer, and St John (2001) asked teachers to provide examples of misconceptions that their elementary school students hold about science. A third of the misconceptions pertained to “life processes and living things.” For example, teachers reported that children often believe that “everything in the ground grows,” “plants die if they are not kept on a windowsill,” and “taller people must be older than shorter people.”
The idea that children hold misconceptions regarding certain biological phenomena contrasts with the perspective that even young preschool children have a relatively sophisticated understanding of basic concepts in biology. Thus, two parallel and independent bodies of research appear to exist; one that supports the notion that children hold misconceptions regarding biological phenomena, and another that supports the notion that children have a relatively sophisticated understanding of biology. To some extent, the differences in these viewpoints can be attributed to the fact that researchers in different fields focus on different aspects of children’s knowledge. Researchers in education have often focused explicitly on misconceptions that might interfere with classroom instruction. In contrast, researchers in developmental psychology, in response to Piaget’s characterisation of the limitations of young children’s biological knowledge, have often focused on cataloguing children’s early competencies. In addition, developmental psychologists have primarily examined young preschool children and their basic understanding of biological concepts such as life, growth, illness, and death, while educators have tended to focus on older, school-age children and more complex concepts such as inheritance and evolution. This is not to say that developmental psychologists have asserted that young children have a perfect understanding of biology in all of its complexities. Rather, it is to say that their research focus has been on the biological concepts children understand as opposed to the concepts children misunderstand.

In fact, an examination of research findings from a variety of studies, even those where the focus is on an early understanding of biological concepts, reveals that young children hold quite a few biological misconceptions. By biological misconception we mean conceptions that are either inaccurate or contrast with the accepted scientific viewpoint. It does not mean a lack of knowledge as in the case of a child who “does not understand reproduction.” Examples of misconceptions from this body of studies include the idea held by some young children that babies “always existed” or were manufactured or purchased at a store (Bernstein & Cowan, 1975; Springer, 1995) and the idea that “plants are not alive” (Hatano, Siegler, Richards, Inagaki, Stavy, & Wax, 1993; Richards & Siegler, 1986).

In this investigation we probe children’s knowledge of five different biological concepts, namely life, aging, reproduction, illness, and death, using a parental survey approach. We chose these concepts because they are all central to a distinctly biological theory. The primary focus of this investigation was discovering information from parents about the misconceptions that children might have regarding these concepts. Examining children’s misconceptions may be fruitful because it can help us to understand the origins and limits of children’s knowledge. Specifically, we may be able to determine the extent to which these misconceptions are constructed by the child or are derived from a mismatch between the child’s intuitive models and those presented by parents and the culture at large (Vosniadou & Brewer, 1992).

By investigating misconceptions we may also be better able to understand how children’s domain-specific knowledge is structured. There is considerable evidence that children develop a set of naive theories for the domains of physics, psychology, and biology based on their interactions in the world (see Wellman & Gelman, 1992, 1997, for a review). It may be the case that children have more misconceptions at the boundaries between domains of knowledge. That is, misconceptions may result to some extent when information from one domain (such as naive psychology) is associated with information from another domain (such as naive biology). For example, Carey (1985) argued that children’s reasoning about biology is framed by naive psychology, rather than any distinctly biological theory. She reported that many 4-year-olds think of biological processes such as growth, death, and reproduction in terms of what a person wants or thinks.

Additional research suggests that children may have difficulty with other domain boundaries. Specifically, Simons and Keil (1995) reported that a sizeable number of 3- and 4-year-olds think that animals have “machine insides.” This mechanistic view of living things is also captured in Au and Romo’s (1999) suggestion that children reason about germs and illness in a mechanistic manner. These results suggest that children may have some difficulty negotiating the boundary between biology and physics.

Misconceptions may also arise at boundaries within a domain. For example, information from one type of biological organism (animals) may be associated with different biological organisms (plants). A number of researchers have reported that children (and sometimes adults) misapply human properties to other animals (Coley, 1995; Inagaki & Hatano, 1987). Specifically, Inagaki and Hatano reported that 40% of kindergarteners believe that a tulip can “feel happy” and 72% believe that a tulip can “feel pretty”.

The purpose of the present investigation was to examine children’s biological knowledge and misconceptions. Specifically, we were interested in determining whether children’s misconceptions occur with respect to certain biological concepts and whether these misconceptions arise at the boundaries of various domains. We explored 3- to 6-year-old children’s misconceptions regarding the concepts of life, aging, reproduction, illness, and death. We focused on these ages because current research has shown that children acquire many key biological concepts during this time period (e.g., see Wellman & Gelman, 1997, for a review). We surveyed parents as an initial attempt to examine young children’s biological knowledge and misconceptions. In particular, we examined parental reports of (1) children’s experiences with a specific biological concept, (2) children’s discussion about a specific biological concept, (3) parents’ comfort discussing a specific biological concept, (4) preference of what age children should learn about a specific biological concept, (5) preference for how children should learn about a specific biological concept, (6) children’s difficulty understanding a specific biological concept, and (7) children’s misconceptions about a specific biological concept.

Within the field of cognitive development, parental reports have been used as important sources of data on infants and children. For example, parental reports have been used to examine the development of memory in infancy (e.g., Ashmead & Perlmuter, 1980; Nelson & Ross, 1980), causal reasoning (e.g., Callanan & Oakes, 1992), and magical beliefs in young children (e.g., Rosengren, Kalish, Hickling, & Gelman, 1994). Of course, the use of parental reports of children’s biological misconceptions may have a number of potential limitations: (1) they are highly subjective, with parents often providing an overly competent picture of their children, (2) parents may report only those misconceptions that are highly salient and perhaps unusual, (3) parents may not construe a child’s particular belief to be a misconception, and (4) children may not articulate their misconceptions to...
their parents. However, if any of these are the case, we can assume that the misconceptions we find in our present study are actually conservative estimations of misconceptions held in the general child population.

There are indeed a number of reasons why we might not want to discount parental reports entirely. Researchers have argued that parents are quite accurate at reporting their children’s cognitive abilities. Parents are valuable informants in that they spend a lot of time with their children and are likely to know their children better than the experimenter. For example, Waschbush, Daleiden, and Drabman (2000) found a relationship between parental reports of their children’s cognitive abilities and children’s actual performance on cognitive measures.

It is also the case that parental input plays a very important role in the development of children’s knowledge of certain biological phenomena. Indeed, a number of studies have situated the study of children’s biological knowledge in the social context of families (e.g., Perez-Granados & Callanan, 1997; Tenenbaum, Callanan, Alba-Speyer, & Sandoval, 2002). Specifically, given that some biological processes are either relatively rare (occurring once in a lifetime) or difficult to directly observe, it may be the case that certain biological concepts develop in much the same way as metaphysical concepts that are passed on to children through cultural transmission (Harris, 2000). Information provided by parents may interact with children’s direct observations of biological phenomena, leading to the emergence of synthetic models that may contrast with the scientific views of biological phenomena.

In summary, the present study examined parental reports of children’s knowledge and misconceptions about five biological concepts: life, ageing, reproduction, illness, and death. The goal of this study was to provide a better understanding of the origins and limits of children’s knowledge and how children’s domain-specific knowledge might be structured.

Method

Participants

Initially, 600 parents of 3- to 4-year-olds and 5- to 6-year-olds were contacted regarding participation in this study. Parents were contacted from a database of families who expressed interest in participating in research at a University in the Midwestern United States. Parents were also contacted at local and University-sponsored schools. The response rate was relatively high in that approximately 45% or 270 parents completed the questionnaire: 125 parents of 3- to 4-year-olds ($M$ age = 4.2) and 145 parents of 5- to 6-year-olds ($M$ age = 5.9). Eighty-nine per cent of the parents were mothers, 10% fathers, and 1% another relative. Overall, the mean age of parents was 35 years with a range of 22 to 58 years. Seventy-six per cent of the parents had a college or advanced degree.

Parents reported the following information regarding their children. Across both age groups, the ethnic breakdown of the children was: 69% European-American; 8% Asian-American; 8% African-American; 7% Native-American; 4% Mexican-American; and 4% Other or Mixed Ethnicity. Also, across both age groups parents reported that 83% of children were interested in plants and 64% of children had a garden. Similarly, parents reported that 97% of children were interested in animals and 59% had a pet.

Materials

The questionnaire included questions about five biological concepts: life, reproduction, ageing, illness, and death. The questions focused on seven content areas: (1) children’s experiences with a specific biological concept, (2) children’s discussion about a specific biological concept, (3) parents’ comfort discussing a specific biological concept, (4) the age at which children should learn about a specific biological concept, (5) how children should learn about a specific biological concept, (6) children’s difficulty in understanding a specific biological concept, and (7) children’s misconceptions (conceptions that are either inaccurate or contrast with the accepted scientific viewpoint) about a specific biological concept. See Appendix for a complete list of the questions and possible responses.

Procedures

Parents received questionnaires in the mail or through their child’s school. Attached were directions explaining that participation would take approximately 15 to 20 minutes. Parents were instructed to answer the questions with their oldest child in mind if they had more than one child in the age range of 3 to 6 years. Parents were asked to return completed questionnaires in a self-addressed envelope to our laboratory or to their child’s school. At the end of the study, 2 parents were randomly selected to receive a $50 gift certificate to a store of their choice.

Coding

We coded the misconceptions that parents reported on a variety of dimensions. The first dimension, content, captured the subject of the misconception, and included five codes: animal/insect; plants; self; other human; and living things in general. The second dimension, theme, captured the theme of the biological process (e.g., illness, death). The examples in parentheses were actual examples of misconceptions that parents provided. For life processes, we coded the misconceptions for dealing with life in general. For reproduction, we coded whether the misconception dealt with causes (e.g., “Thinks that parents hugging each other can make a baby”) or outcomes (e.g., “When I was a baby, I was a puppy”). For ageing, we coded whether the misconception dealt with causes of ageing (e.g., “People can grow up to be giants if they eat really good”); outcomes of ageing (e.g., “She will become a baby again after old age”); and appearance/reality distinction in ageing (e.g., “The tallest people are the oldest”).

For illness, we coded whether the misconception concerned the causes of illness (e.g., “Eating too many sweets causes most things from colds to nosebleeds”); symptoms of illness (e.g., “Hands smell metallic”); remedies of illness (e.g., “Going to the hospital can fix anything”); and outcomes of illness (e.g., “All sick people die”). Finally, for misconceptions concerning death, we coded whether the misconception involved universality/inevitability of death (e.g., “Doesn’t realise that young people can die” and “The magic age to die is 100”); finality of death (e.g., “Thinks some things will come back to life”); and causes of death (e.g., “Being naughty”).

Finally, two coders examined all of the misconceptions with respect to whether they occurred at a boundary within a domain, or at the boundary between domains. For example, if a mother reported that her child had a misconception that
misapplied a property of animals to plants, we coded it as a misconception at a boundary within the domain of biology (e.g., “My daughter thinks babies grow from seeds like plants”). Misconceptions that involved treating biological organisms in a manner similar to inanimate physical objects, artifacts, or machines were coded as misconceptions at the boundary of biology and physics (e.g., “Cars are alive because they move”). Misconceptions that involved a confusion of biological and psychological processes or properties were coded as misconceptions at the boundary of biology and psychology. These included examples where children were reported to equate death with sleep, had difficulty distinguishing pretence and reality, or where they believed that psychological properties persisted after death (e.g., “Dead goldfish is sleeping”).

Misconceptions involving religion and biology were coded if there was any discussion of religion or any religious entities. Misconceptions involving religion were based on the parents’ responses to our request for misconceptions. Thus, these do not involve any judgment of ours regarding whether a particular religious belief is a misconception. For example, in response to the question asking whether their children had misconceptions concerning death, a number of parents reported that their child had some beliefs that violated the finality of death (e.g., “Spiritual beings live forever” and “All dead things go to be with Jesus”).

Finally, we coded any response to the misconception questions that mentioned magic as being at the boundary of biology and magic. We only obtained one of these types of misconceptions and it involved reproduction. Specifically, one parent reported that her child “doesn’t understand how this [reproduction] works, she thinks they [babies] magically appear.”

In order to determine reliability on all of the coding categories, two experimenters coded 20% of the questionnaire data, resulting in an overall reliability of .76 (Cohen’s Kappa).

Results

Although the main focus of this investigation was on children’s biological misconceptions, we wanted to examine these misconceptions in the broader context of children’s biological knowledge, as reported by parents. For this reason the questionnaire given to parents asked a series of questions regarding children’s experiences with events related to specific biological concepts, discussion concerning these concepts, and parents’ comfort with discussing these concepts.

Experiences with events related to specific biological concepts

The majority of the parents reported that their children had influential and important experiences relating to life processes (89% of parents), aging (73% of parents), illness (71% of parents), and death (75% of parents). Only 48% of the parents reported that their children had experienced an important event related to reproduction. A 2 (age: 3 to 4, 5 to 6) by 5 (concept: life processes, ageing, reproduction, illness, death) repeated measures analysis of variance with concept as the repeated measure revealed a significant main effect of concept, $F(4, 268) = 42.90, MSE = 0.55, p < .001$, but not of age, nor was there an age by concept interaction. Tukey LSD post hoc comparisons confirmed that children in fact have less experience with the concept of reproduction than any of the other biological concepts examined ($p < .05$). No differences were found between the other concepts.

Discussion concerning biological concepts

Parents were asked whether their children had questions or talked about concepts related to life processes, aging, illness, death, and reproduction, using a 4-point scale (1 = never, 2 = occasionally, 3 = once or twice a week, and 4 = daily). Parents reported that their children often asked questions or talked about reproduction and death ($M = 3.10$). Parents reported that children asked questions or talked about concepts related to life processes, aging, and illness only occasionally ($M_{s} = 2.60, 2.60, 2.80$, respectively). A 2 (age: 3 to 4, 5 to 6) by 5 (concept: life processes, aging, reproduction, illness, death) repeated measures analysis of variance with concept as the repeated measure and subsequent post hoc comparisons confirmed that children were reported to talk significantly more about concepts related to death and reproduction than the other concepts, $F(4, 956) = 22, p < .01$. A significant age by concept interaction was also obtained, $F(4, 956) = 2.40, p < .05$. Post-hoc comparisons revealed that parents reported that their 3- to 4-year-olds and 5- to 6-year-olds discuss life, illness, and death with similar frequency, but that 5- to 6-year-olds discuss reproduction more frequently than 3- to 4-year-olds.

Parents’ comfort with discussing these concepts

Parents were asked whether they felt comfortable discussing issues related to life processes, aging, reproduction, illness, and death using a 3-point scale (1 = they feel comfortable, 2 = they feel somewhat comfortable, and 3 = they do not feel comfortable). To examine whether parents felt more comfortable discussing certain concepts and whether this varied with the age of the child, we conducted a 2 (age: 3 to 4, 5 to 6) by 5 (concept: life processes, aging, reproduction, illness, death) repeated measures analysis of variance with concept as the repeated measure. A significant main effect of concept was obtained, $F(4,268) = 47.70, MSE = 0.47, p < .001$. Post hoc comparisons revealed that parents felt the least comfortable talking about reproduction ($M = 1.38$) and death ($M = 1.29$). Parental comfort level was significantly different for these two concepts. In addition, the parental comfort level for these two concepts was significantly lower than those for each of the remaining concepts ($M_{life\ processes} = 1.08; M_{aging} = 1.08, M_{illness} = 1.07$). There was not a significant effect of age or a significant interaction between age and concept for parental comfort with discussing the concepts.

When children should learn about specific biological concepts

Additional questions asked the parents about when they thought their children should learn about specific biological concepts, how children should learn about these concepts, and

---

1 The scales for some of the items in the questionnaire were designed to represent a continuum. Thus, for the ANOVAs, linearity was assumed and the rank data were treated as continuous data.
whether children have difficulty understanding a particular biological concept.

To examine whether parents felt that certain concepts should be learned by their children at different ages we conducted a 2 (age: 3 to 4, 5 to 6) by 5 (concept: life processes, aging, reproduction, illness, death) repeated measures analysis of variance with concept as the repeated measure. Parents were given the choices of ages 3–4, 5–6, 7–8 years or they could specify a particular age. A significant main effect of concept was obtained, $F(4, 197) = 63.10, MSE = 1.15, p < .001$. Post hoc comparisons revealed that parents felt that children should learn about reproduction and death by ages 5 to 6 years, while they felt that children should learn about the other concepts at an earlier age (3 to 4 years). No other effects were significant.

**How children should learn about specific biological concepts**

In response to the question asking parents if their children should learn about specific concepts from parents, direct experience, school, the media, or peers, a vast majority of parents (97%) preferred that their child learn about biological concepts through parents. Many of the parents also said that their child should learn about biological concepts through school (80%), direct experience (71%), and the media (64%). Only 15% of parents reported that they prefer their child to learn about biological concepts through peers.

**Difficulty understanding a particular biological concept**

We asked parents to rate the difficulty their child has in understanding specific biological concepts with respect to plants, animals, and humans, using a 3-point scale (1 = easy, 2 = medium, 3 = hard). We conducted a 2 (concept: life processes, aging, reproduction, illness, death) × 3 (type: plants, animals, humans) × 2 (age: 3 to 4, 5 to 6) repeated measures ANOVA with concept and type of living thing as repeated measures. Overall, parents reported that life processes, aging, illness, and death were more easily understood than reproduction, $F(4, 956) = 18, p < .01$. However, there was a concept by type interaction, $F(6, 1596) = 18, p < .01$. Parents suggested that their children understood concepts related to life, reproduction, and aging at a similar level for plants, animals, and humans. However, parents reported that it was easier for their children to understand concepts of illness with respect to humans rather than for animals or plants. The opposite pattern was found for death. In this case, parents reported that their children had an easier time understanding death in plants rather than for animals or humans.

**Frequency of children’s misconceptions about a specific biological concept**

To begin examining parental reports of children’s misconceptions, we first looked at the frequency of misconceptions reported by parents. Roughly half of the parents (48.5%, or 131 out of 270) stated that “yes,” their children had at least one biological misconception. Misconceptions about reproduction and death were the most common, with 23% of the parents reporting that their children held misconceptions about these concepts. Eighteen per cent of parents reported that their children had misconceptions about ageing and 11% misconceptions about illness. Only 8% of the parents reported that their children had misconceptions about basic life processes.

In order to determine whether parents of older children reported fewer misconceptions than parents of younger children, we conducted a one-way analysis of variance on the total number of misconceptions reported for each child. The results confirmed that parents of 5- to 6-year-old children reported that their children had fewer misconceptions ($M = 0.39$) than parents of 3- to 4-year-old children ($M = 0.59$), $F(1, 268) = 10.99, p < .001$.

**Content of children’s misconceptions**

If parents reported that their child had a misconception about life processes, reproduction, aging, illness, or death, they were asked to provide details about the child’s misconception. For the concept of life processes, most of the misconceptions reported by parents involved living things in general (52%). The remaining misconceptions were coded as involving the child specifically (26%), animals or insects (16%), or plants (6%).

In contrast, for the concept of reproduction, most of the misconceptions reported by parents applied to humans in general (59%). Eighteen per cent of the remaining misconceptions concerned the child specifically or other humans, 14% pertained to animals or insects, and 10% pertained to living things in general. Only one parent reported a misconception regarding the reproduction of plants. A similar pattern of results was obtained for the concept of aging, where parents reported that 65% of the misconceptions involved humans in general. Parents also reported that 29% of the misconceptions about aging involved the child specifically. One parent reported that her child held a misconception of aging related to plants and another parent reported that her child held a misconception of aging with respect to animals or insects. The two remaining parents reported misconceptions about aging for living things in general.

Misconceptions about illness were more evenly divided, with parents reporting that these involved the child specifically (25%), other humans (32%), and living things in general (32%). Two parents each reported misconceptions concerning animals/insects or plants for this concept. Parents reported that misconceptions of death were focused mainly on other humans (38%), living things in general (36%), and other animals or insects (20%). Three parents reported misconceptions concerning plant death. Only one parent reported that her child held a misconception of death that involved the child.

**Specific themes of misconceptions**

For misconceptions concerning reproduction, the majority of the misconceptions (73%) involved a misunderstanding of the causal processes or events involved in reproduction. The remaining misconceptions concerned a misunderstanding of the outcome (27%). In contrast, misconceptions regarding aging were more likely to relate to the outcome (64%) rather than the cause (10%). The remaining 26% of the aging misconceptions involved confusions regarding appearances and reality.

For illness, the majority of misconceptions were coded as relating to its cause (82%). Only one parent reported a misconception that was coded as involving the outcome of illness and another parent reported a misconception concern-
ing a symptom of illness. Two parents provided misconceptions related to the remedies of illness.

The majority of misconceptions involving death concerned the finality of death (74%). An additional 13% involved issues of causality and 13% concerned the inevitability/universality of death.

**Misconceptions at boundaries within and across domains**

One of the goals of this project was to examine the extent to which misconceptions arise at the boundaries within a domain or across domains. Roughly a third (36%) of the misconceptions reported by parents were coded as occurring at boundaries between different domains. Only one reported misconception was coded as occurring within the domain of biology. In this instance, the parent reported that her child “thought babies grew from a seed like plants.”

Twenty-one of the misconceptions were coded as occurring at the boundary between the domains of biology and physics. These included examples such as the belief that “balls rolling are alive,” “cars are alive because they move,” and that a “teddy bear is alive.” Another example was provided by a parent who reported that her child “sometimes seems to think that living things have on/off functions like computers or mechanical toys.”

Fifteen of the misconceptions were coded as occurring at the boundary between the domains of biology and psychology. These included misconceptions involving pretend behaviours and real biological processes (e.g., “He pretends being a baby and believing he will be a baby again seems mixed”), death and sleep (e.g., “Dead people are asleep”), and ones that involved continued sensory experiences following death (e.g., “A dead squirrel could still feel sensation”). Two of these misconceptions involved life processes, four involved illness, five involved reproduction, and the remaining four misconceptions concerned death.

Twenty misconceptions were coded as occurring across the boundary between the domains of biology and religion. Of these explanations, 11 concerned death, 6 reproduction, 1 illness, 1 aging, and 1 general life processes. Examples of these types of misconceptions included statements such as “Our daughter believes that God puts the baby there,” “[You] get sick if you don’t pray to Jesus to prevent it,” “[He] thinks that if God doesn’t like you he makes you die,” and “Things are here because of God.” All of these statements were provided by parents in response to direct questions concerning misconceptions.

**Discussion**

Parents reported a number of biological misconceptions among 3- to 6-year-olds. Just under half of the parents (48.5%) surveyed responded that their children had at least one misconception regarding life processes, ageing, reproduction, illness, or death. In addition, many of these parents reported that their children held more than one biological misconception. Parents of older children generally reported fewer misconceptions than parents of younger children, suggesting that many of these misconceptions are replaced by more accurate knowledge between the ages of 3 and 6 years.

Parents reported a greater number of misconceptions related to reproduction and death than life processes, illness, and aging. Strikingly, the concepts of reproduction and death were also the concepts parents reported as being the least comfortable discussing with their children. Parents also reported that children should learn about these two concepts at a later age than concepts related to life processes, aging, and illness. These results imply that parental input may play a very important role in either indirectly maintaining certain misconceptions or in providing information that enables a child to learn more accurate information regarding biological concepts.

One of the goals of this investigation was to explore the frequency with which misconceptions occur either at boundaries within the domain of biology, such as between plants and animals, or at boundaries across different domains. Only a single misconception was reported that involved a confusion within the domain of biology. This particular misconception referred to a situation where the child appeared to overgeneralise from plants to animals with respect to the concept of reproduction. Interestingly, the majority of misconceptions reported in the literature about plants and animals suggest that young children often misapply properties of humans or animals to plants. A typical example of this type of misconception is Inagaki and Hatano’s (1987) report that 40% of kindergarteners thought that a tulip could “feel happy”. A possible explanation for this discrepancy is that most studies showing that children make analogies from humans to plants have presented children either with questions requiring a “yes” or “no” response, or have involved a forced-choice paradigm (e.g., Carey, 1985).

In contrast, approximately one third of the misconceptions involved boundaries between different domains, such as between biology and physics, biology and psychology, as well as biology and religion. Many of these misconceptions involved cases where children misattributed life processes to inanimate objects or attributed psychological properties to nonsentient entities.

Misconceptions involving religion and biology were quite common. The majority of these misconceptions (55%) involved issues related to children’s understanding of death. Most of the remaining misconceptions in this category concerned reproduction. Parents’ greater difficulty talking about death and reproduction, and the belief that their children should learn about such concepts at a later age than the other concepts, suggest that religious explanations may fill this intellectual vacuum for some children. This particular type of misconception has not been investigated in the past, but deserves additional study given concerns about older school children’s understanding of evolution, a concept where scientific and religious views are often thought to be in conflict (Evans, 2001).

Only a single instance of a misconception involving biology and magic was reported. Given past work on children’s understanding and belief in magic and parental encouragement of these beliefs, this finding is not at all surprising (Rosengren & Hickling, 1994, 2000; Rosengren et al., 1994). Magical statements would typically be found in situations where either a magical context had been set up or where a causal violation has occurred (see also Nguyen & Rosengren, in press). While there may be certain biological phenomena that violate children’s causal explanations (i.e., metamorphosis, or certain rare and strange biological phenomena—see Davis & Park, 1987), we expected that children’s experiences are quite rare with these types of biological events or organisms.
Another issue to be considered is the stability of misconceptions over time. In our view, many of the early misconceptions reported by the parents in this study are open to change. The misconceptions reported by parents are ones that occur just as children are beginning to acquire more knowledge within particular domains. As we have documented, some of these misconceptions stem from misunderstandings and confusions regarding the nature and boundaries of particular phenomena. These misconceptions appear to arise more from limited knowledge and relatively limited experiences with particular biological phenomena. These misconceptions may not be as deeply held, nor resistant to change. The fact that parents of 5- to 6-year-olds reported fewer of these types of misconceptions than parents of 3- to 4-year-olds supports this conclusion. Additional anecdotal support is provided in one parent’s statement that “she [my daughter] probably has some [misconceptions], but as we talk a lot, ideas that are misconceptions do not persist.”

While some misconceptions may arise from limited knowledge or experience, other misconceptions may arise from misinformation provided by parents and the culture at large. One parent, for example, wrote: “We occasionally use anthropomorphism to explain the battle of germs and immune system. All in fun of course.” Several parents identified media as a source of misinformation: “I think death isn’t final to her, à la Sleeping Beauty, Snow White, etc.” and “Dead things can come alive again (reinforced by videos).” Many parents also identified the use of euphemisms in language to explain the concept of death such as “asleep” and “resting.” Research has shown that euphemisms often complicate and confuse children’s understanding of death (e.g., Butler & Lagoni, 1996). Thus, such sources of information that conflict with established scientific views may play an important role in the emergence of some misconceptions.

In this investigation we used a parent survey to gather information regarding children’s misconceptions of a wide range of biological concepts. It is important to consider the validity of parental reports of these misconceptions. Our expectation is that parents were likely to base their judgments of their children’s misconceptions both on spontaneous comments that their children have made and discussions following up these comments. For example, parents reported that their children often or occasionally talked or asked questions about the different biological concepts. Likewise, parents reported varying degrees of comfort speaking with their children about different biological concepts. Another expectation is that the results we obtained in this investigation reflect a relatively conservative estimate of the frequency of young children’s biological misconceptions. It is possible that parents under-reported their children’s misconceptions because of the limitations of parental reports already discussed in the introduction. However, parental reports revealed quite a number of biological misconceptions. Nearly half of the parents reported that their child had at least one biological misconception, with many parents reporting more than one misconception.

We view this report as a starting place for further investigations into children’s biological knowledge and misconceptions. Overall, these data suggest that biological misconceptions are quite common in young children, as reported by parents, but that the overall frequency of misconceptions varies by concept and age. Future research should explore in more depth what parents do when they are confronted with a child’s misconception as well as the relation between parental reports of their children’s misconceptions and children’s own biological knowledge.

References


APPENDIX

Items from questionnaire

1. Is your child interested in plants?
   ___Yes  ___No

2. Is your child interested in animals?
   ___Yes  ___No

3. Does your child have a pet?
   ___Yes  ___No

4. Does your child have a garden (e.g., vegetable, flower)?
   ___Yes  ___No

5. Does your child ask questions or talk about the life processes that make living things alive (e.g., eating, breathing)?
   ___Never
   ___Occasionally (e.g., once or twice a month)
   ___Often (e.g., once or twice a week)
   ___Daily

6. Do you feel comfortable answering questions or talking to your child about the life processes that make living things alive (e.g., eating, breathing)?
   ___Yes
   ___Somewhat
   ___No
   ___ Unsure

7. Does your child ask questions or talk about reproduction (e.g., pollination, conception)?
   ___Never
   ___Occasionally (e.g., once or twice a month)
   ___Often (e.g., once or twice a week)
   ___Daily

8. Do you feel comfortable answering questions or talking to your child about reproduction (e.g., pollination, conception)?
   ___Yes
   ___Somewhat
   ___No
   ___ Unsure

9. Does your child ask questions or talk about the biological changes that occur with age (e.g., growing bigger, developing wrinkles)?
   ___Never
   ___Occasionally (e.g., once or twice a month)
   ___Often (e.g., once or twice a week)
   ___Daily

10. Do you feel comfortable answering questions or talking to your child about the biological changes that occur with age (e.g., growing bigger, developing wrinkles)?
    ___Yes
    ___Somewhat
    ___No
    ___ Unsure

11. Does your child ask questions or talk about the causes of illness (e.g., germs, viruses)?
    ___Never
    ___Occasionally (e.g., once or twice a month)
    ___Often (e.g., once or twice a week)
    ___Daily

12. Do you feel comfortable answering questions or talking to your child about the causes of illness (e.g., germs, viruses)?
    ___Yes
    ___Somewhat
    ___No
    ___ Unsure

13. Does your child ask questions or talk about the biological aspects of death and dying (e.g., heart stops beating, bodily functions stop working)?
    ___Never
    ___Occasionally (e.g., once or twice a month)
    ___Often (e.g., once or twice a week)
    ___Daily

14. Do you feel comfortable answering questions or talking to your child about the biological aspects of death and dying (e.g., heart stops beating, bodily functions stop working)?
    ___Yes
    ___Somewhat
    ___No
    ___ Unsure

15. How do you prefer that your child learn about the biological processes that make living things alive (e.g., eating, breathing)? (Please check as many as you would like.)
    ___School
    ___Media (e.g., books, TV)
    ___Peers
    ___Parents
    ___Experiences with plants and animals
    ___Other (specify)

16. Has your child had any experiences relating to the biological processes that make living things alive (e.g., hearing one’s heart beat, seeing plants grow with sun & water)?
    ___Yes
    ___No
    If yes, please explain:____________________________________
    ______________________________________________________
    ______________________________________________________

17. How do you prefer that your child learn about reproduction (e.g., pollination, conception)? (Please check as many as you would like.)
    ___School
    ___Media (e.g., books, TV)
    ___Peers
    ___Parents
    ___Experiences with plants and animals
    ___Other (specify)

18. Has your child had any experiences relating to reproduction (e.g., seeing bees pollinate flowers, witnessing the birth of a sibling)?
    ___Yes
    ___No
    If yes, please explain:____________________________________
    ______________________________________________________
    ______________________________________________________
    ______________________________________________________

19. How do you prefer that your child learn about the biological changes that occur with age (e.g., growing bigger, developing wrinkles)? (Please check as many as you would like.)
    ___School
    ___Media (e.g., books, TV)
    ___Peers
    ___Parents
    ___Experiences with plants and animals
    ___Other (specify)

20. Has your child had any experiences relating to the biological changes that occur with age (e.g., seeing a kitten become a cat, seeing a grandparent age)?
    ___Yes
    ___No
    If yes, please explain:____________________________________
    ______________________________________________________
    ______________________________________________________

21. How do you prefer that your child learn about the causes of illness (e.g., germs, viruses)? (Please check as many as you would like.)
    ___School
    ___Media (e.g., books, TV)
    ___Peers
    ___Parents
22. Has your child had any experiences relating to the causes of illness (e.g., getting a cold, trying to discover what germs look like)?
   Yes
   No
   If yes, please explain:

23. How do you prefer that your child learn about the biological aspects of death and dying (e.g., heart stops beating, bodily functions stop working)? (Please check as many as you would like.)
   School
   Media (e.g., books, t.v.)
   Peers
   Parents
   Experiences with plants and animals
   Other (specify)

24. Has your child had any experiences relating to the biological aspects of death and dying (e.g., having a pet or relative die, witnessing plants die in the winter)?
   Yes
   No
   If yes, please explain:

25. At what age do you feel your child should have some understanding of the biological processes that make living things alive (e.g., eating, breathing)?
   Age 3–4
   Age 5–6
   Age 7–8
   Other (specify)
   This concept is not important to learn as a child

26. Please circle if it is easy, medium, or hard for your child to understand the life processes that make the following living things alive:
   Plants easy medium hard I'm unsure
   Animals easy medium hard I'm unsure
   Humans easy medium hard I'm unsure

27. Does your child have any misconceptions (concepts that are inaccurate or contrast with the accepted scientific viewpoint) about the life processes that make living things alive?
   Yes
   No
   If yes, please explain:

28. At what age do you feel your child should have some understanding of reproduction (e.g., pollination, conception)?
   Age 3–4
   Age 5–6
   Age 7–8
   Other (specify)
   This concept is not important to learn as a child

29. Please circle if it is easy, medium, or hard for your child to understand the reproduction of the following living things:
   Plants easy medium hard I'm unsure
   Animals easy medium hard I'm unsure
   Humans easy medium hard I'm unsure

30. Does your child have any misconceptions (concepts that are inaccurate or contrast with the accepted scientific viewpoint) about reproduction?
   Yes
   No
   If yes, please explain:

31. At what age do you feel your child should have some understanding of the biological changes that occur with age (e.g., growing bigger, developing wrinkles)?
   Age 3–4
   Age 5–6
   Age 7–8
   Other (specify)
   This concept is not important to learn as a child

32. Please circle if it is easy, medium, or hard for your child to understand the biological changes that occur with age in the following living things:
   Plants easy medium hard I'm unsure
   Animals easy medium hard I'm unsure
   Humans easy medium hard I'm unsure

33. Does your child have any misconceptions (concepts that are inaccurate or contrast with the accepted scientific viewpoint) about the biological changes that occur with age?
   Yes
   No
   If yes, please explain:

34. At what age do you feel your child should have some understanding of the causes of illness (e.g., germs, viruses)?
   Age 3–4
   Age 5–6
   Age 7–8
   Other (specify)
   This concept is not important to learn as a child

35. Please circle if it is easy, medium or hard for your child to understand the causes of illness for the following living things:
   Plants easy medium hard I'm unsure
   Animals easy medium hard I'm unsure
   Humans easy medium hard I'm unsure

36. Does your child have any misconceptions (concepts that are inaccurate or contrast with the accepted scientific viewpoint) about the causes of illness?
   Yes
   No
   If yes, please explain:

37. At what age do you feel your child should have some understanding of the biological aspects of death and dying (e.g., heart stops beating, bodily functions stop working)?
   Age 3–4
   Age 5–6
   Age 7–8
   Other (specify)
   This concept is not important to learn as a child

38. Please circle if it is easy, medium, or hard for your child to understand the biological aspects of death and dying for the following living things:
   Plants easy medium hard I'm unsure
   Animals easy medium hard I'm unsure
   Humans easy medium hard I'm unsure

39. Does your child have any misconceptions (concepts that are inaccurate or contrast with the accepted scientific viewpoint) about the biological aspects of death and dying?
   Yes
   No
   If yes, please explain: